Cisco Wireless LAN Controller Configuration Guide

Software Release 7.0.116.0
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Preface

This preface describes the audience, organization, and conventions of the *Cisco Wireless LAN Controller Configuration Guide*, *Release 7.0.116.0.* It also provides information on how to obtain other documentation. This chapter includes the following sections:

Audience

This publication is for experienced network administrators who configure and maintain Cisco wireless LAN controllers and Cisco lightweight access points.

Purpose

This guide provides the information you need to set up and configure wireless LAN controllers.

Note This version of the *Cisco Wireless LAN Controller Configuration Guide* pertains specifically to controller software release 7.0.116.0. If you are using an earlier version of software, you will notice differences in features, functionality, and GUI pages.

Organization

This guide is organized into these chapters:

Chapter Title	Description
Chapter 1, "Overview"	Provides an overview of the network roles and features of wireless LAN controllers.
Chapter 2, "Using the Web-Browser and CLI Interfaces"	Describes how to initially configure and log into the controller.
Chapter 3, "Configuring Ports and Interfaces"	Describes the controller's physical ports and interfaces and provides instructions for configuring them.
Chapter 4, "Configuring Controller Settings"	Describes how to configure settings on the controllers.
Chapter 5, "Configuring VideoStream"	Describes how to configure VideoStream settings on the controller.
Chapter 6, "Configuring Security Solutions"	Describes application-specific solutions for wireless LANs.
Chapter 7, "Configuring WLANs"	Describes how to configure wireless LANs and SSIDs on your system.
Chapter 8, "Controlling Lightweight Access Points"	Explains how to connect lightweight access points to the controller and manage access point settings.
Chapter 9, "Controlling Mesh Access Points"	Explains how to connect mesh access points to the controller and manage access point settings.
Chapter 10, "Managing Controller Software and Configurations"	Describes how to upgrade and manage controller software and configurations.
Chapter 11, "Managing User Accounts"	Explains how to create and manage guest user accounts, describes the web authentication process, and provides instructions for customizing the web authentication login.
Chapter 13, "Configuring Radio Resource Management"	Describes radio resource management (RRM) and explains how to configure it on the controllers.
Chapter 12, "Configuring Cisco CleanAir"	Describes how to configure Cisco CleanAir functionality on the controller and lightweight access points.
Chapter 14, "Configuring Mobility Groups"	Describes mobility groups and explains how to configure them on the controllers.
Chapter 15, "Configuring Hybrid REAP"	Describes hybrid REAP and explains how to configure this feature on controllers and access points.
Appendix A, "Safety Considerations and Translated Safety Warnings"	Lists safety considerations and translations of the safety warnings that apply to the Cisco Unified Wireless Network solution products.

Chapter Title	Description
Appendix B, "Declarations of Conformity and Regulatory Information"	Provides declarations of conformity and regulatory information for the products in the Cisco Unified Wireless Network solution.
Appendix C, "End User License and Warranty"	Describes the end user license and warranty that apply to the Cisco Unified Wireless Network solution products.
Appendix D, "Troubleshooting"	Describes the LED patterns on controllers and lightweight access points, lists system messages that can appear on the Cisco Unified Wireless Network solution interfaces, and provides CLI commands that can be used to troubleshoot problems on the controller.
Appendix E, "Logical Connectivity Diagrams"	Provides logical connectivity diagrams and related software commands for controllers that are integrated into other Cisco products.

Conventions

This document uses the following conventions:

Convention	Indication
bold font	Commands and keywords and user-entered text appear in **bold** font.
italic font	Document titles, new or emphasized terms, and arguments for which you supply values are in *italic* font.
[ ]	Elements in square brackets are optional.
{x | y | z }	Required alternative keywords are grouped in braces and separated by vertical bars.
[x | y | z]	Optional alternative keywords are grouped in brackets and separated by vertical bars.
string	A nonquoted set of characters. Do not use quotation marks around the string or the string will include the quotation marks.
`courier` font	Terminal sessions and information the system displays appear in `courier` font.
< >	Nonprinting characters such as passwords are in angle brackets.
[ ]	Default responses to system prompts are in square brackets.
!, #	An exclamation point (!) or a pound sign (#) at the beginning of a line of code indicates a comment line.

Note Means *reader take note*.

Tip Means *the following information will help you solve a problem*.

Caution Means *reader be careful*. In this situation, you might perform an action that could result in equipment damage or loss of data.

Timesaver Means *the described action saves time*. You can save time by performing the action described in the paragraph.

Warning **This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. (To see translations of the warnings that appear in this publication, refer to the appendix "Translated Safety Warnings.")**

Waarschuwing **Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van standaard maatregelen om ongelukken te voorkomen. (Voor vertalingen van de waarschuwingen die in deze publicatie verschijnen, kunt u het aanhangsel "Translated Safety Warnings" (Vertalingen van veiligheidsvoorschriften) raadplegen.)**

Varoitus **Tämä varoitusmerkki merkitsee vaaraa. Olet tilanteessa, joka voi johtaa ruumiinvammaan. Ennen kuin työskentelet minkään laitteiston parissa, ota selvää sähkökytkentöihin liittyvistä vaaroista ja tavanomaisista onnettomuuksien ehkäisykeinoista. (Tässä julkaisussa esiintyvien varoitusten käännökset löydät liitteestä "Translated Safety Warnings" (käännetyt turvallisuutta koskevat varoitukset).)**

Attention **Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures. Avant d'accéder à cet équipement, soyez conscient des dangers posés par les circuits électriques et familiarisez-vous avec les procédures courantes de prévention des accidents. Pour obtenir les traductions des mises en garde figurant dans cette publication, veuillez consulter l'annexe intitulée « Translated Safety Warnings » (Traduction des avis de sécurité).**

Warnung **Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu einer Körperverletzung führen könnte. Bevor Sie mit der Arbeit an irgendeinem Gerät beginnen, seien Sie sich der mit elektrischen Stromkreisen verbundenen Gefahren und der Standardpraktiken zur Vermeidung von Unfällen bewußt. (Übersetzungen der in dieser Veröffentlichung enthaltenen Warnhinweise finden Sie im Anhang mit dem Titel "Translated Safety Warnings" (Übersetzung der Warnhinweise).)**

Avvertenza **Questo simbolo di avvertenza indica un pericolo. Si è in una situazione che può causare infortuni. Prima di lavorare su qualsiasi apparecchiatura, occorre conoscere i pericoli relativi ai circuiti elettrici ed essere al corrente delle pratiche standard per la prevenzione di incidenti. La traduzione delle avvertenze riportate in questa pubblicazione si trova nell'appendice, "Translated Safety Warnings" (Traduzione delle avvertenze di sicurezza).**

Advarsel **Dette varselsymbolet betyr fare. Du befinner deg i en situasjon som kan føre til personskade. Før du utfører arbeid på utstyr, må du være oppmerksom på de faremomentene som elektriske kretser innebærer, samt gjøre deg kjent med vanlig praksis når det gjelder å unngå ulykker. (Hvis du vil se oversettelser av de advarslene som finnes i denne publikasjonen, kan du se i vedlegget "Translated Safety Warnings" [Oversatte sikkerhetsadvarsler].)**

Aviso **Este símbolo de aviso indica perigo. Encontra-se numa situação que lhe poderá causar danos fisicos. Antes de começar a trabalhar com qualquer equipamento, familiarize-se com os perigos relacionados com circuitos eléctricos, e com quaisquer práticas comuns que possam prevenir possíveis acidentes. (Para ver as traduções dos avisos que constam desta publicação, consulte o apêndice "Translated Safety Warnings" - "Traduções dos Avisos de Segurança").**

¡Advertencia! **Este símbolo de aviso significa peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considerar los riesgos que entraña la corriente eléctrica y familiarizarse con los procedimientos estándar de prevención de accidentes. (Para ver traducciones de las advertencias que aparecen en esta publicación, consultar el apéndice titulado "Translated Safety Warnings.")**

Varning! **Denna varningssymbol signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanligt förfarande för att förebygga skador. (Se förklaringar av de varningar som förekommer i denna publikation i appendix "Translated Safety Warnings" [Översatta säkerhetsvarningar].)**

Related Documentation

These documents provide complete information about the Cisco Unified Wireless Network solution:

- *Quick Start Guide: Cisco 2100 Series Wireless LAN Controllers*
- *Quick Start Guide: Cisco 4400 Series Wireless LAN Controllers*
- *Cisco 5500 Series Wireless Controller Installation Guide*
- *Cisco Wireless LAN Controller Command Reference*
- *Cisco Wireless Control System Configuration Guide*
- *Release Noted for Cisco Wireless LAN Controllers and Lightweight Access Points, Release 7.0.116.0*
- *Quick Start Guide: Cisco Wireless Control System*
- Quick start guide and hardware installation guide for your specific lightweight access point

Click this link to browse to user documentation for the Cisco Unified Wireless Network solution:

http://www.cisco.com/cisco/web/psa/default.html?mode=prod

Obtaining Documentation and Submitting a Service Request

For information on obtaining documentation, submitting a service request, and gathering additional information, see monthly *What's New in Cisco Product Documentation*, which also lists all new and revised Cisco technical documentation, at:

http://www.cisco.com/en/US/docs/general/whatsnew/whatsnew.html

Subscribe to the *What's New in Cisco Product Documentation* as a Really Simple Syndication (RSS) feed and set content to be delivered directly to your desktop using a reader application. The RSS feeds are a free service and Cisco currently supports RSS version 2.0.

CHAPTER 1

Overview

This chapter describes the controller components and features. It contains these sections:

Cisco Unified Wireless Network Solution Overview

The Cisco Unified Wireless Network (Cisco UWN) solution is designed to provide 802.11 wireless networking solutions for enterprises and service providers. The Cisco UWN solution simplifies deploying and managing large-scale wireless LANs and enables a unique best-in-class security infrastructure. The operating system manages all data client, communications, and system administration functions, performs radio resource management (RRM) functions, manages system-wide mobility policies using the operating system security solution, and coordinates all security functions using the operating system security framework.

The Cisco UWN solution consists of Cisco wireless LAN controllers and their associated lightweight access points controlled by the operating system, all concurrently managed by any or all of the operating system user interfaces:

- An HTTP and/or HTTPS full-featured Web User Interface hosted by Cisco wireless LAN controllers can be used to configure and monitor individual controllers. See Chapter 2, “Using the Web-Browser and CLI Interfaces.”

- A full-featured command-line interface (CLI) can be used to configure and monitor individual Cisco wireless LAN controllers. See Chapter 2, "Using the Web-Browser and CLI Interfaces."
- The Cisco Wireless Control System (WCS), which you use to configure and monitor one or more Cisco wireless LAN controllers and associated access points. WCS has tools to facilitate large-system monitoring and control. WCS runs on Windows 2000, Windows 2003, and Red Hat Enterprise Linux ES servers.

Note WCS software release 7.0.172.0, must be used with controllers that run controller software release 7.0.116.0. Do not attempt to use older versions of the WCS software with controllers that run controller software release 7.0.116.0.

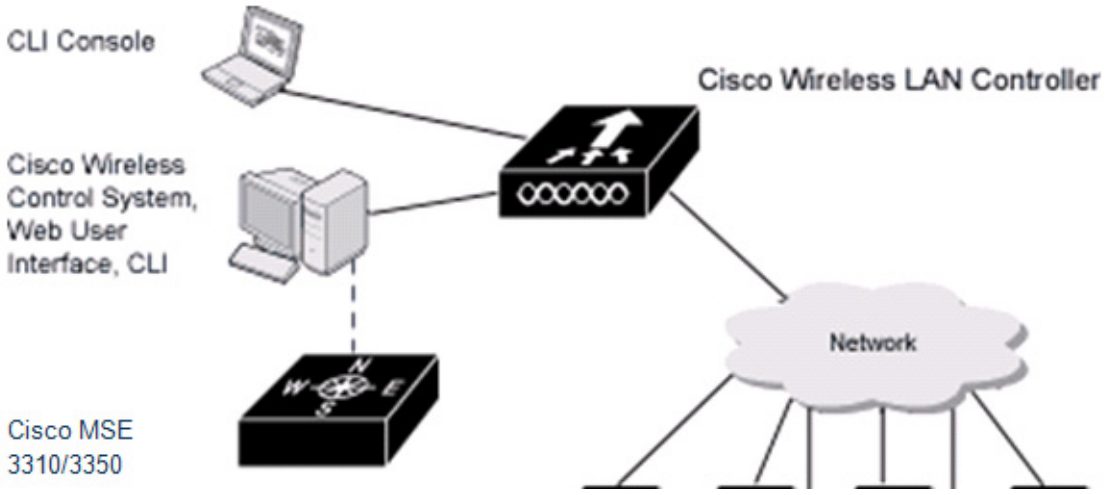
- An industry-standard SNMP V1, V2c, and V3 interface can be used with any SNMP-compliant third-party network management system.

The Cisco UWN solution supports client data services, client monitoring and control, and all rogue access point detection, monitoring, and containment functions. It uses lightweight access points, Cisco wireless LAN controllers, and the optional Cisco WCS to provide wireless services to enterprises and service providers.

Note Unless otherwise noted in this publication, all of the Cisco wireless LAN controllers are referred to as *controllers*, and all of the Cisco lightweight access points are referred to as *access points.*

Figure 1-1 shows the Cisco wireless LAN controller components, which can be simultaneously deployed across multiple floors and buildings.

Figure 1-1 Cisco UWN Solution Components



Single-Controller Deployments

A standalone controller can support lightweight access points across multiple floors and buildings simultaneously and support the following features:

- Autodetecting and autoconfiguring lightweight access points as they are added to the network.

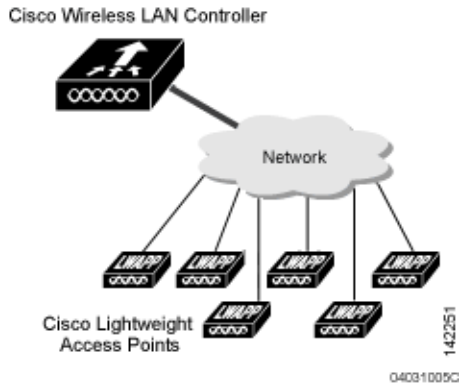
- Full control of lightweight access points.
- Lightweight access points connect to controllers through the network. The network equipment may or may not provide Power over Ethernet (PoE) to the access points.

Some controllers use redundant Gigabit Ethernet connections to bypass single network failures.

Note Some controllers can connect through multiple physical ports to multiple subnets in the network. This feature can be helpful when you want to confine multiple VLANs to separate subnets.

Figure 1-2 shows a typical single-controller deployment.

Figure 1-2 Single-Controller Deployment



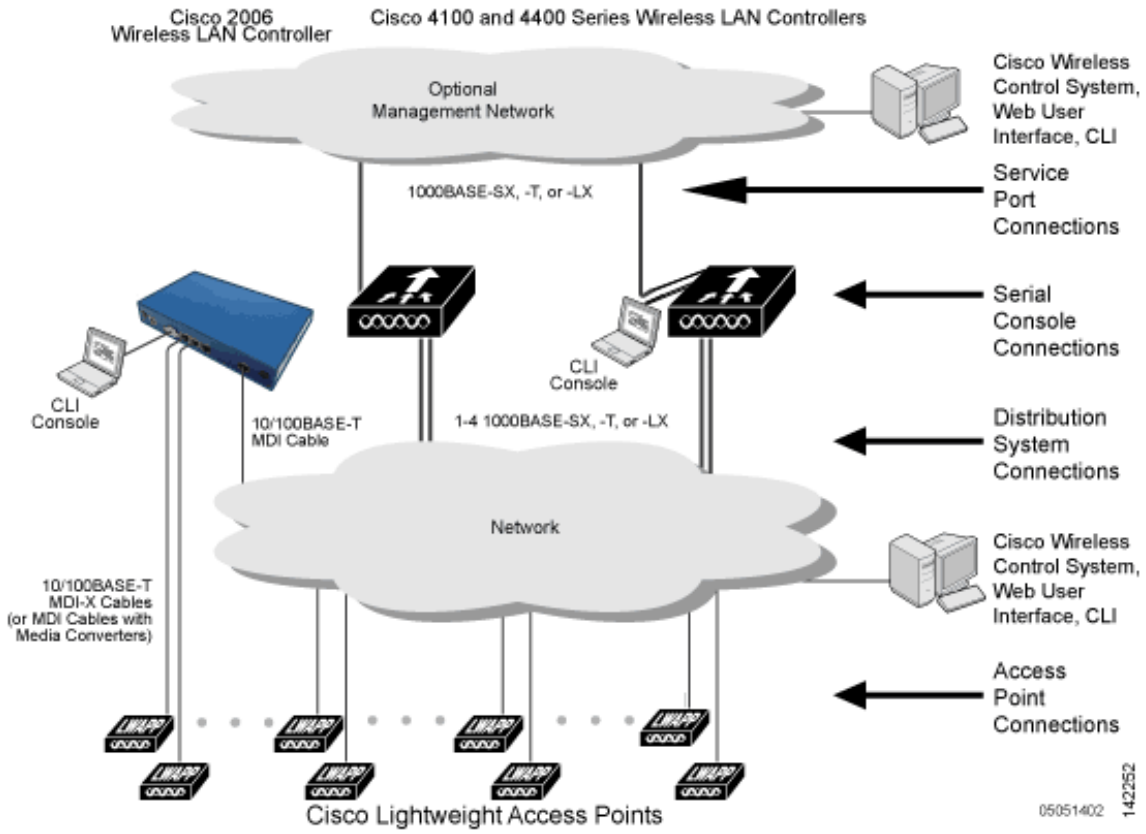
Multiple-Controller Deployments

Each controller can support lightweight access points across multiple floors and buildings simultaneously. However, full functionality of the Cisco wireless LAN solution occurs when it includes multiple controllers. A multiple-controller system has the following additional features:

- Autodetecting and autoconfiguring RF parameters as the controllers are added to the network.
- Same-subnet (Layer 2) roaming and inter-subnet (Layer 3) roaming.
- Automatic access point failover to any redundant controller with a reduced access point load (see the Cisco Wireless LAN Controller Failover Protection, page 1-15).

Figure 1-3 shows a typical multiple-controller deployment. The figure also shows an optional dedicated management network and the three physical connection types between the network and the controllers.

Figure 1-3 Typical Multiple-Controller Deployment



Operating System Software

The operating system software controls controllers and lightweight access points. It includes full operating system security and radio resource management (RRM) features.

Operating System Security

Operating system security bundles Layer 1, Layer 2, and Layer 3 security components into a simple, Cisco WLAN solution-wide policy manager that creates independent security policies for each of up to 16 wireless LANs. See "Cisco UWN Solution WLANs" section on page 1-14.

The 802.11 Static WEP weaknesses can be overcome using the following robust industry-standard security solutions:

- 802.1X dynamic keys with extensible authentication protocol (EAP).
- Wi-Fi protected access (WPA) dynamic keys. The Cisco WLAN solution WPA implementation includes:
  - Temporal key integrity protocol (TKIP) and message integrity code checksum dynamic keys
  - WEP keys, with or without a preshared key passphrase
- RSN with or without a preshared key

- Optional MAC filtering

The WEP problem can be further solved using the following industry-standard Layer 3 security solutions:

- Passthrough VPNs
- Local and RADIUS MAC address filtering
- Local and RADIUS user/password authentication
- Manual and automated disabling to block access to network services. In manual disabling, you block access using client MAC addresses. In automated disabling, which is always active, the operating system software automatically blocks access to network services for a user-defined period of time when a client fails to authenticate for a fixed number of consecutive attempts. This feature can be used to deter brute-force login attacks.

These and other security features use industry-standard authorization and authentication methods to ensure the highest possible security for your business-critical wireless LAN traffic.

Cisco WLAN Solution Wired Security

Each controller and lightweight access point is manufactured with a unique, signed X.509 certificate. These signed certificates are used to verify downloaded code before it is loaded, ensuring that hackers do not download malicious code into any controller or lightweight access point.

The controllers and lightweight access points also use the signed certificates to verify the downloaded code before it is loaded, ensuring that hackers do not download malicious code into any Cisco wireless controller or lightweight access point.

Layer 2 and Layer 3 Operation

Lightweight Access Point Protocol (LWAPP) communications between the controller and lightweight access points can be conducted at Layer 2 or Layer 3. Control and Provisioning of Wireless Access Points protocol (CAPWAP) communications between the controller and lightweight access points are conducted at Layer 3. Layer 2 mode does not support CAPWAP.

Note Controller software release 5.2 or later releases support only Layer 3 CAPWAP mode, controller software releases 5.0 and 5.1 support only Layer 3 LWAPP mode, and controller software releases prior to 5.0 support Layer 2 or Layer 3 LWAPP mode.

Note The IPv4 network layer protocol is supported for transport through a CAPWAP or LWAPP controller system. IPv6 (for clients only) and Appletalk are also supported but only on Cisco 5500 Series Controllers, Cisco 4400 Series Controllers, and the Cisco WiSM. Other Layer 3 protocols (such as IPX, DECnet Phase IV, OSI CLNP, and so on) and Layer 2 (bridged) protocols (such as LAT and NetBeui) are not supported.

Operational Requirements

The requirement for Layer 3 LWAPP communications is that the controller and lightweight access points can be connected through Layer 2 devices on the same subnet or connected through Layer 3 devices across subnets. Another requirement is that the IP addresses of access points should be either statically assigned or dynamically assigned through an external DHCP server.

The requirement for Layer 3 CAPWAP communications across subnets is that the controller and lightweight access points are connected through Layer 3 devices. Another requirement is that the IP addresses of access points should be either statically assigned or dynamically assigned through an external DHCP server.

Configuration Requirements

When you are operating the Cisco wireless LAN solution in Layer 2 mode, you must configure a management interface to control your Layer 2 communications.

When you are operating the Cisco wireless LAN solution in Layer 3 mode, you must configure an AP-manager interface to control lightweight access points and a management interface as configured for Layer 2 mode.

Cisco Wireless LAN Controllers

When you are adding lightweight access points to a multiple-controller deployment network, it is convenient to have all lightweight access points associate with one master controller on the same subnet. That way, the you do not have to log into multiple controllers to find out which controller newly-added lightweight access points associated with.

One controller in each subnet can be assigned as the master controller while adding lightweight access points. As long as a master controller is active on the same subnet, all new access points without a primary, secondary, and tertiary controller assigned automatically attempt to associate with the master controller. This process is described in the "Cisco Wireless LAN Controller Failover Protection" section on page 1-15.

You can monitor the master controller using the WCS Web User Interface and watch as access points associate with the master controller. You can then verify the access point configuration and assign a primary, secondary, and tertiary controller to the access point, and reboot the access point so it reassociates with its primary, secondary, or tertiary controller.

Note Lightweight access points without a primary, secondary, and tertiary controller assigned always search for a master controller first upon reboot. After adding lightweight access points through the master controller, you should assign primary, secondary, and tertiary controllers to each access point. We recommend that you disable the master setting on all controllers after initial configuration.

Client Location

When you use Cisco WCS in your Cisco wireless LAN solution, controllers periodically determine the client, rogue access point, rogue access point client, radio frequency ID (RFID) tag location and store the locations in the Cisco WCS database. For more information on location solutions, see these documents:

Cisco Wireless Control System Configuration Guide:

http://www.cisco.com/en/US/products/ps6305/products_installation_and_configuration_guides_list.html

Cisco Location Appliance Configuration Guide:

http://www.cisco.com/en/US/products/ps6386/products_installation_and_configuration_guides_list.html

Cisco 3300 Series Mobility Services Engine Configuration Guide:

http://www.cisco.com/en/US/products/ps9742/products_installation_and_configuration_guides_list.html

Controller Platforms

Controllers are enterprise-class high-performance wireless switching platforms that support 802.11a/n and 802.11b/g/n protocols. They operate under control of the operating system, which includes the radio resource management (RRM), creating a Cisco UWN solution that can automatically adjust to real-time changes in the 802.11 RF environment. Controllers are built around high-performance network and security hardware, resulting in highly reliable 802.11 enterprise networks with unparalleled security.

The following controllers are supported for use with software release 7.0.116.0:

- Cisco 2100 Series Controller
- Cisco 2500 Series Controller
- Cisco 4400 Series Controller
- Cisco 5500 Series Controller
- Catalyst 6500 series switch Wireless Services Module (WiSM2s)
- Cisco 7600 Series Router Wireless Services Module (WiSM)
- Cisco 28/37/38xx Series Integrated Services Router with Controller Network Module
- Catalyst 3750G Integrated Wireless LAN Controller Switch
- Cisco Flex 7500 Series Controller

Cisco 2100 Series Controller

The Cisco 2100 Series Wireless LAN Controllers work with Cisco lightweight access points and the Cisco Wireless Control System (WCS) to provide system-wide wireless LAN functions. Each controller controls up to 6, 12, or 25 lightweight access points for multiple-controller architectures that are typical of enterprise branch deployments. It may also be used for single controller deployments for small and medium-sized environments.

Caution Do not connect a Power-over-Ethernet (PoE) cable to the controller's console port. Doing so may damage the controller.

Note Wait at least 20 seconds before reconnecting an access point to the controller. Otherwise, the controller may fail to detect the device.

Features Not Supported

This hardware feature is not supported on Cisco 2100 Series Controllers:

- Service port (separate out-of-band management 10/100-Mbps Ethernet interface)
- Cisco 2100 Series Controller does not support the access point AP802.

These software features are not supported on Cisco 2100 Series Controllers:

- VPN termination (such as IPsec and L2TP)
- VPN passthrough option

  Note You can replicate this functionality on a Cisco 2100 Series Controller by creating an open WLAN using an ACL.

- Termination of guest controller tunnels (origination of guest controller tunnels is supported)
- External web authentication web server list
- Spanning Tree Protocol (STP)
- Port mirroring
- AppleTalk
- QoS per-user bandwidth contracts
- IPv6 pass-through
- Link aggregation (LAG)
- Multicast-unicast mode

Cisco 2500 Series Controller

The Cisco 2500 Series Wireless Controller works in conjunction with Cisco lightweight access points and the Cisco Wireless Control System (WCS) to provide system-wide wireless LAN functions. As a component of the Cisco Unified Wireless Network (CUWN), the Cisco 2500 Series controller provides real-time communication between a wireless access points and other devices to deliver centralized security policies, guest access, wireless intrusion prevention system (wIPS), context-aware (location), RF management, quality of services for mobility services such as voice and video, and OEAP support for the teleworker solution.

Cisco 2500 Series Wireless Controllers support up to 50 lightweight access points in increments of 5 and 25 access points with a minimum of 5 access points. The Cisco 2504 Wireless Controller comes with four 4 Giga bit Ethernet ports, two of which can provide power directly to Cisco lightweight access points.

The Cisco 2500 Series Controller offers robust coverage with 802.11 a/b/g or delivers reliability using 802.11n and Cisco Next-Generation Wireless Solutions and Cisco Enterprise Wireless Mesh.

The Cisco 2500 Series Controller has the following limitations:

- Does not support wired guest access
- Cannot be configured as an auto anchor controller. However you can configure it as a foreign controller
- Supports only multicast-multicast mode
- Does not support bandwidth contract feature
- Does not support access points in direct connect mode
- Does not support service port
- Apple Talk Bridging
- LAG
- Wired Guest

Cisco 4400 Series Controllers

The Cisco 4400 Series Wireless LAN Controller is available in two models: 4402 and 4404. The 4402 supports up to 50 lightweight access points while the 4404 supports up to 100, making it ideal for large enterprises and high-density applications.

The Cisco 4400 Series Controller can be equipped with one or two power supplies. When the controller is equipped with two power supplies, the power supplies are redundant, and either power supply can continue to power the controller if the other power supply fails.

Cisco 5500 Series Controllers

The Cisco 5500 Series Wireless LAN Controller is currently available in one model: 5508. The 5508 controller supports up to 500 lightweight access points and 7000 wireless clients (or 5000 wireless clients and 2500 RFID tags when using the client location feature), making it ideal for large enterprises and high-density applications.

The Cisco 5500 Series Controller can be equipped with one or two power supplies. When the controller is equipped with two power supplies, the power supplies are redundant, and either power supply can continue to power the controller if the other power supply fails.

Features Not Supported

These software features are not supported on Cisco 5500 Series Controllers:

- Static AP-manager interface

Note For Cisco 5500 Series Controllers, you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default, and the access points can join on this interface.

- Asymmetric mobility tunneling

- Spanning Tree Protocol (STP)
- Port mirroring
- Layer 2 access control list (ACL) support
- VPN termination (such as IPsec and L2TP)
- VPN passthrough option

Note You can replicate this functionality on a Cisco 5500 Series Controller by creating an open WLAN using an ACL.

- Configuration of 802.3 bridging, AppleTalk, and Point-to-Point Protocol over Ethernet (PPPoE)

Note The Cisco 5500 Series Controllers bridge these packets by default. If desired, you can use ACLs to block the bridging of these protocols.

Cisco Flex 7500 Series Controller

The Cisco Flex 7500 Series Controller enables you to deploy full featured, scalable, and secure hybrid REAP network services across geographic locations. Cisco Flex 7500 Series Controller virtualizes the complex security, management, configuration and troubleshooting operations within the data center and then transparently extends those services to each store. Deployments using Cisco Flex 7500 Series Controller are easier for IT to set up, manage and scale.

The Cisco Flex 7500 Series Controller is designed to meet the scaling requirements to deploy the hybrid REAP solution in branch networks. Cisco Unified Wireless Solution supports two major deployment models: hybrid REAP and monitor mode. Hybrid REAP is designed to support wireless branch networks by allowing the data to be switched locally while the access points are being controlled and managed by a centralized controller. It aims at delivering a cost effective hybrid REAP solution on a large scale.

Cisco Flex 7500 Series Controller supports the following access points: 1140, 3500, 1250, 1260, 1040, 1130, 1240, and ISR 891.

The Cisco Flex 7500 Series Controller provides the following features:

- Increases scalability with 2000 AP support.
- Increased resiliency using controller redundancy and hybrid REAP Fault Tolerance.
- Increased traffic segmentation using hybrid-REAP (central and local switching).
- Increased security (PCI compliance) by supporting Enhanced wIPS for hybrid REAP (ELM).
- Replicates store designs using AP groups and hybrid REAP groups.

Catalyst 6500 Series Switch Wireless Services Module

The Catalyst 6500 series switch Wireless Services Module (WiSM) is an integrated Catalyst 6500 series switch and two Cisco 4404 controllers that supports up to 300 lightweight access points. The switch has eight internal Gigabit Ethernet ports that connect the switch and the controller. The switch and the internal controller run separate software versions, which must be upgraded separately.

Note Without any other service module installed, the Catalyst 6509 switch chassis can support up to seven Cisco WiSMs, and the Catalyst 6506 with a Supervisor 720 can support up to four Cisco WiSMs. If one or more service modules are installed, the chassis can support up to a maximum of four service modules (WiSMs included). Redundant supervisors cannot be used with these maximum configurations.

Note The Cisco WiSM controllers do not support port mirroring.

Note The Cisco WiSM module has two controllers and if you use the **hw-module module** command to reboot the module from the Catalyst 6K console, both controllers are rebooted. Alternatively, WISM controllers can be rebooted by creating a session to the controller and resetting it. It is only when you boot the WiSM module from the Catalyst 6K console, that both the controllers are rebooted.

See the following documents for additional information:

- *Catalyst 6500 Series Switch Installation Guide*
- *Catalyst 6500 Series Switch Wireless Services Module Installation and Configuration Note*
- *Release Notes for Catalyst 6500 Series Switch Wireless LAN Services Module*
- *Configuring a Cisco Wireless Services Module and Wireless Control System*
- *Catalyst 6500 Series Switch and Cisco 7600 Series Router Wireless Services Module Installation and Verification Note*

You can find these documents at these URLs:

http://www.cisco.com/en/US/products/hw/switches/ps708/tsd_products_support_series_home.html

http://www.cisco.com/en/US/docs/wireless/technology/wism/technical/reference/appnote.html

http://www.cisco.com/en/US/docs/wireless/technology/wism/installation/note/78_17121.html

Cisco 7600 Series Router Wireless Services Module

The Cisco 7600 series Router Wireless Services Module (WiSM) is an integrated Cisco 7600 series router and two Cisco 4404 Controllers that supports up to 300 lightweight access points. The router has eight internal Gigabit Ethernet ports that connect the router and the controller. The router and the internal controller run separate software versions, which must be upgraded separately.

Note The WiSM is supported on Cisco 7600 series routers running only Cisco IOS Release 12.2(18)SXF5 or later.

Note The Cisco WiSM controllers do not support port mirroring.

Note The Cisco WiSM module has two controllers and if you use the **hw-module module** command to reboot the module from the Catalyst 6K console, both controllers are rebooted. Alternatively, WISM controllers can be rebooted by creating a session to the controller and resetting it. It is only when you boot the WiSM module from the Catalyst 6K console, that both the controllers are rebooted.

See the following documents for additional information:

- *Cisco 7600 Series Router Installation Guide*
- *Cisco 7600 Series Router Software Configuration Guide*
- *Cisco 7600 Series Router Command Reference*
- *Configuring a Cisco Wireless Services Module and Wireless Control System*
- *Catalyst 6500 Series Switch and Cisco 7600 Series Router Wireless Services Module Installation and Verification Note*

You can find these documents at these URLs:

http://www.cisco.com/en/US/products/hw/routers/ps368/tsd_products_support_series_home.html

http://www.cisco.com/en/US/docs/wireless/technology/wism/technical/reference/appnote.html

http://www.cisco.com/en/US/docs/wireless/technology/wism/installation/note/78_17121.html

Cisco 28/37/38xx Series Integrated Services Router

The Cisco 28/37/38xx Series Integrated Services Router is an integrated 28/37/38xx router and Cisco controller network module that support up to 6, 8, 12, or 25 lightweight access points, depending on the version of the network module. The versions that support 8, 12, or 25 access points and the NME-AIR-WLC6-K9 6-access-point version feature a high-speed processor and more onboard memory than the NM-AIR-WLC6-K9 6-access-point version. An internal Fast Ethernet port (on the NM-AIR-WLC6-K9 6-access-point version) or an internal Gigabit Ethernet port (on the 8-, 12-, and 25-access-point versions and on the NME-AIR-WLC6-K9 6-access-point version) connects the router and the integrated controller. The router and the internal controller run separate software versions, which must be upgraded separately. See the following documents for additional information:

- *Cisco Wireless LAN Controller Network Module Feature Guide*
- *Cisco 28/37/38xx Series Hardware Installation Guide*

You can find these documents at this URL:

http://www.cisco.com/en/US/products/hw/wireless/index.html

Note The controller network module does not support port mirroring.

Note The Cisco 2801 Integrated Services Router does not support the controller network module.

Catalyst 3750G Integrated Wireless LAN Controller Switch

The Catalyst 3750G Integrated Wireless LAN Controller Switch is an integrated Catalyst 3750 switch and Cisco 4400 Series Controller that support up to 25 or 50 lightweight access points. The switch has two internal Gigabit Ethernet ports that connect the switch and the controller. The switch and the internal controller run separate software versions, which must be upgraded separately.

Note The controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch does not support the Spanning Tree Protocol (STP).

See the following documents for additional information:

- *Catalyst 3750G Integrated Wireless LAN Controller Switch Getting Started Guide*
- *Catalyst 3750 Switch Hardware Installation Guide*
- *Release Notes for the Catalyst 3750 Integrated Wireless LAN Controller Switch, Cisco IOS Release 12.2(25)FZ*

You can find these documents at this URL:

http://www.cisco.com/en/US/products/hw/switches/ps5023/tsd_products_support_series_home.html

Cisco UWN Solution Wired Connections

The Cisco UWN solution components communicate with each other using industry-standard Ethernet cables and connectors. Details of the wired connections are as follows:

- The Cisco 2100 Series Controller connects to the network using from one to six 10/100BASE-T Ethernet cables.
- The Cisco 4402 Controller connects to the network using one or two fiber-optic Gigabit Ethernet cables, and the Cisco 4404 Controller connects to the network using up to four fiber-optic Gigabit Ethernet cables.
- The Cisco 5508 Controller connects to the network using up to eight fiber-optic Gigabit Ethernet cables.
- The controllers in the Wireless Services Module (WiSM), installed in a Catalyst 6500 series switch or a Cisco 7600 series router, connect to the network through ports on the switch or router.
- The Wireless LAN Controller Network Module, installed in a Cisco Integrated Services Router, connects to the network through the ports on the router.
- The controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch connects to the network through the ports on the switch.
- Cisco lightweight access points connect to the network using 10/100BASE-T Ethernet cables. The standard CAT-5 cable can also be used to conduct power for the lightweight access points from a network device equipped with Power over Ethernet (PoE) capability. This power distribution plan can be used to reduce the cost of individual AP power supplies and related cabling.

Cisco UWN Solution WLANs

The Cisco UWN solution can control up to 512 WLANs for lightweight access points. Each WLAN has a separate WLAN ID (1 through 512), a separate profile name, and a WLAN SSID and can be assigned with unique security policies. The lightweight access points broadcast all active Cisco UWN solution WLAN SSIDs and enforce the policies defined for each WLAN.

Note Cisco 2106, 2112, and 2125 Controllers support only up to 16 WLANs.

Note We recommend that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that controllers operate with optimum performance and ease of management.

If management over wireless is enabled across the Cisco UWN solution, you can manage the system across the enabled WLAN using CLI and Telnet, http/https, and SNMP.

To configure WLANs, see Chapter 7, "Configuring WLANs."

File Transfers

You can upload and download operating system code, configuration, and certificate files to and from the controller using the GUI, CLI, or Cisco WCS as follows:

- To use the controller GUI or CLI, see Chapter 10, "Managing Controller Software and Configurations."
- To use Cisco WCS to upgrade software, see the *Cisco Wireless Control System Configuration Guide* at: http://www.cisco.com/en/US/products/ps6305/products_installation_and_configuration_guides_list.html

Power Over Ethernet

Lightweight access points can receive power through their Ethernet cables from 802.3af-compatible Power over Ethernet (PoE) devices, which can reduce the cost of discrete power supplies, additional wiring, conduits, outlets, and installation time. PoE frees you from having to mount lightweight access points or other powered equipment near AC outlets, which provides greater flexibility in positioning the access points for maximum coverage.

When you are using PoE, you run a single CAT-5 cable from each lightweight access point to PoE-equipped network elements, such as a PoE power hub or a Cisco WLAN Solution single-line PoE injector. When the PoE equipment determines that the lightweight access point is PoE-enabled, it sends 48 VDC over the unused pairs in the Ethernet cable to power the access point.

The PoE cable length is limited by the 100BASE-T or 10BASE-T specification to 100 m or 200 m, respectively.

Lightweight access points can receive power from an 802.3af-compliant device or from the external power supply.

Cisco Wireless LAN Controller Memory

The controller contains two kinds of memory: volatile RAM, which holds the current, active controller configuration, and NVRAM (nonvolatile RAM), which holds the reboot configuration. When you are configuring the operating system in controller, you are modifying volatile RAM; you must save the configuration from the volatile RAM to the NVRAM to ensure that the controller reboots in the current configuration.

Knowing which memory you are modifying is important when you are doing the following tasks:

- Using the configuration wizard
- Clearing the controller configuration
- Saving configurations
- Resetting the controller
- Logging out of the CLI

Cisco Wireless LAN Controller Failover Protection

During installation, we recommend that you connect all lightweight access points to a dedicated controller, and configure each lightweight access point for final operation. This step configures each lightweight access point for a primary, secondary, and tertiary controller and allows it to store the configured mobility group information.

During failover recovery, the following tasks are performed:

- The configured access point attempts to contact the primary, secondary, and tertiary controllers, and then attempts to contact the IP addresses of the other controllers in the mobility group.
- DNS is resolved with controller IP address.
- DHCP servers get the controller IP Addresses (vendor specific option 43 in DHCP offer).

In multiple-controller deployments, if one controller fails, the access points perform the following tasks:

- If the lightweight access point has a primary, secondary, and tertiary controller assigned, it attempts to associate with that controller.
- If the access point has no primary, secondary, or tertiary controllers assigned or if its primary, secondary, or tertiary controllers are unavailable, it attempts to associate with a master controller.
- If the access point finds no master controller, it attempts to contact stored mobility group members by the IP address.
- If the mobility group members are available, and if the lightweight access point has no primary, secondary, and tertiary controllers assigned and there is no master controller active, it attempts to associate with the least-loaded controller to respond to its discovery messages.

When sufficient controllers are deployed, if one controller fails, active access point client sessions are momentarily dropped while the dropped access point associates with another controller, allowing the client device to immediately reassociate and reauthenticate.

To know more about high availability, see
http://www.cisco.com/en/US/products/ps6366/products_tech_note09186a00809a3f5d.shtml

Network Connections to Cisco Wireless LAN Controllers

Regardless of the operating mode, all controllers use the network as an 802.11 distribution system. Regardless of the Ethernet port type or speed, each controller monitors and communicates with its related controllers across the network. The following sections give details of these network connections:

- Cisco 2100 Series Wireless LAN Controllers, page 1-16
- Cisco 4400 Series Wireless LAN Controllers, page 1-17
- Cisco 5500 Series Wireless LAN Controllers, page 1-17

Note Chapter 3, "Configuring Ports and Interfaces," provides information on how to configure the controller's ports and how to assign interfaces to them.

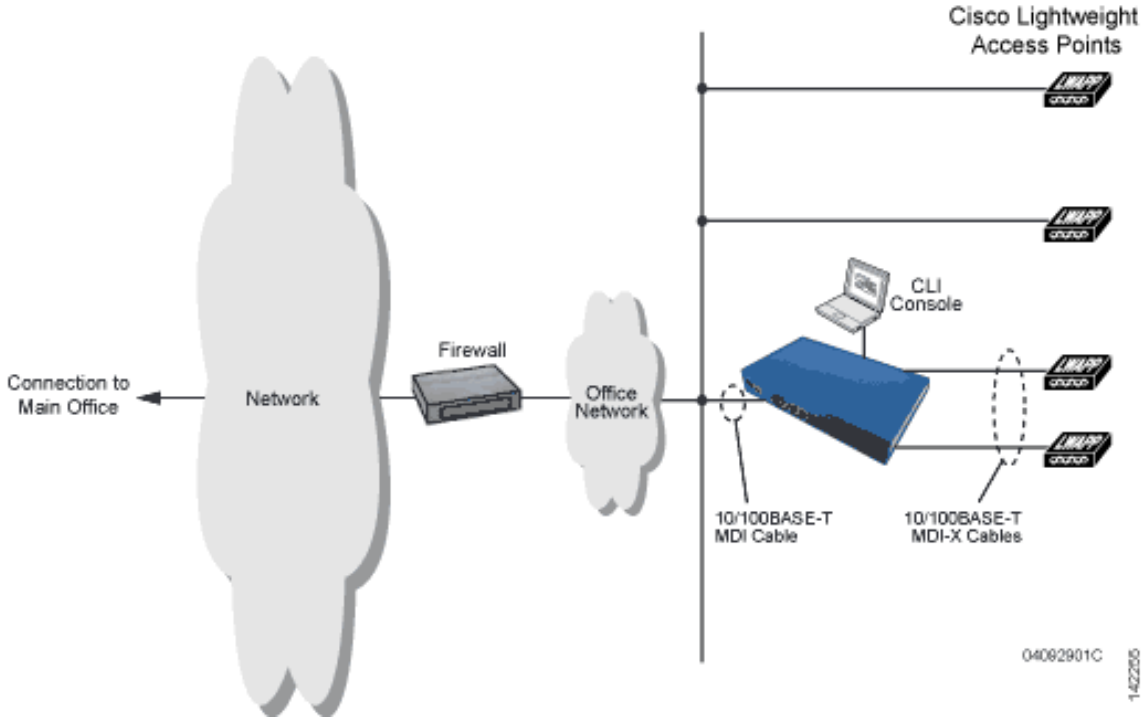
Cisco 2100 Series Wireless LAN Controllers

Cisco 2100 Series Controller can communicate with the network through any one of their physical data ports, because the logical management interface can be assigned to one of the ports. The physical port description is as follows:

- Up to six 10/100BASE-T cables can plug into the six back-panel data ports on the Cisco 2100 series controller chassis. The Cisco 2100 series also has two PoE ports (ports 7 and 8).

Figure 1-4 shows connections to the Cisco 2100 Series Controller.

Figure 1-4 Physical Network Connections to the Cisco 2100 Series Controller



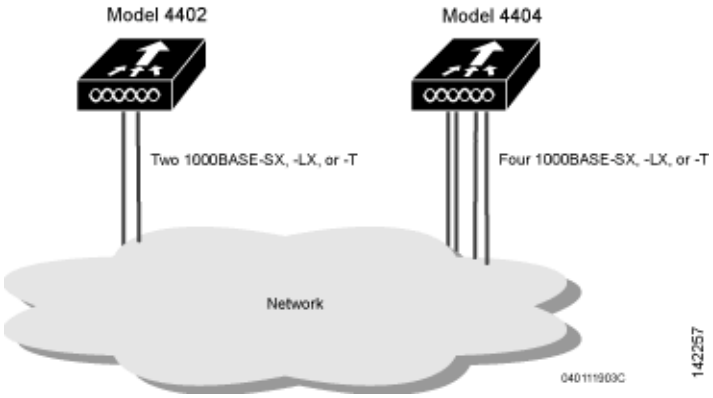
Cisco 4400 Series Wireless LAN Controllers

Cisco 4400 Series Controllers can communicate with the network through one or two pairs of physical data ports, and the logical management interface can be assigned to the ports.

- For the Cisco 4402 Controller, up to two of the following connections are supported in any combination:
  - 1000BASE-T (Gigabit Ethernet, front panel, RJ-45 physical port, UTP cable).
  - 1000BASE-SX (Gigabit Ethernet, front panel, LC physical port, multimode 850nM (SX) fiber-optic links using LC physical connectors).
  - 1000BASE-LX (Gigabit Ethernet, front panel, LC physical port, multimode 1300nM (LX/LH) fiber-optic links using LC physical connectors).
- For the Cisco 4404 Controller, up to four of the following connections are supported in any combination:
  - 1000BASE-T (Gigabit Ethernet, front panel, RJ-45 physical port, UTP cable).
  - 1000BASE-SX (Gigabit Ethernet, front panel, LC physical port, multi-mode 850nM (SX) fiber-optic links using LC physical connectors).
  - 1000BASE-LX (Gigabit Ethernet, front panel, LX physical port, multi-mode 1300nM (LX/LH) fiber-optic links using LC physical connectors).

Figure 1-5 shows connections to the Cisco 4400 Series Controller.

Figure 1-5 Physical Network Connections to Cisco 4402 and 4404 Controllers



Cisco 5500 Series Wireless LAN Controllers

Cisco 5500 Series Controllers can communicate with the network through up to eight physical data ports, and the logical management interface can be assigned to the ports.

For the Cisco 5508 Controller, up to eight of the following connections are supported in any combination:

- 1000BASE-T (Gigabit Ethernet, front panel, RJ-45 physical port, UTP cable).

- 1000BASE-SX (Gigabit Ethernet, front panel, LC physical port, multi-mode 850nM (SX) fiber-optic links using LC physical connectors).
- 1000BASE-LX (Gigabit Ethernet, front panel, LX physical port, multi-mode 1300nM (LX/LH) fiber-optic links using LC physical connectors).

CHAPTER 2

Using the Web-Browser and CLI Interfaces

This chapter describes how to initially configure and log into the controller. It contains these sections:

Using the Configuration Wizard

Note Before you configure your controller for basic operation, see quick start guide or installation guide for your controller to complete any necessary hardware procedures.

The configuration wizard enables you to configure basic settings on the controller. You can run the wizard after you receive the controller from the factory or after the controller has been reset to factory defaults. The configuration wizard is available in GUI or CLI format.

Note To configure the controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch, we recommend that you use the GUI configuration wizard that launches from the 3750 Device Manager. See the *Catalyst 3750G Integrated Wireless LAN Controller Switch Getting Started Guide* for instructions.

Note See the "Resetting the Controller to Default Settings" section on page 4-124 for instructions on returning the controller to factory defaults.

Connecting the Controller's Console Port

Before you can configure the controller for basic operations, you need to connect it to a PC that uses a VT-100 terminal emulation program (such as HyperTerminal, ProComm, Minicom, or Tip).

To connect to the controller's console port, follow these steps:

Step 1 Connect one end of a null-modem serial cable to the controller's console port and the other end to your PC's serial port.

Note On Cisco 5500 Series Controllers, you can use either the RJ-45 console port or the USB console port. If you use the USB console port, plug the 5-pin mini Type B connector into the controller's USB console port and the other end of the cable into the PC's USB Type A port. The first time that you connect a Windows PC to the USB console port, you are prompted to install the USB console driver. Follow the installation prompts to install the driver. The USB console driver maps to a COM port on your PC; you then need to map the terminal emulator application to the COM port.

Step 2 Start the PC's VT-100 terminal emulation program.

Step 3 Configure the terminal emulation program for these parameters:

- 9600 baud
- 8 data bits
- 1 stop bit
- No parity
- No hardware flow control

Step 4 Plug the AC power cord into the controller and a grounded 100 to 240 VAC, 50/60-Hz electrical outlet.

Step 5 Turn on the power supply. The bootup script displays operating system software initialization (code download and power-on self test verification) and basic configuration.

If the controller passes the power-on self test, the bootup script runs the configuration wizard, which prompts you for basic configuration input.

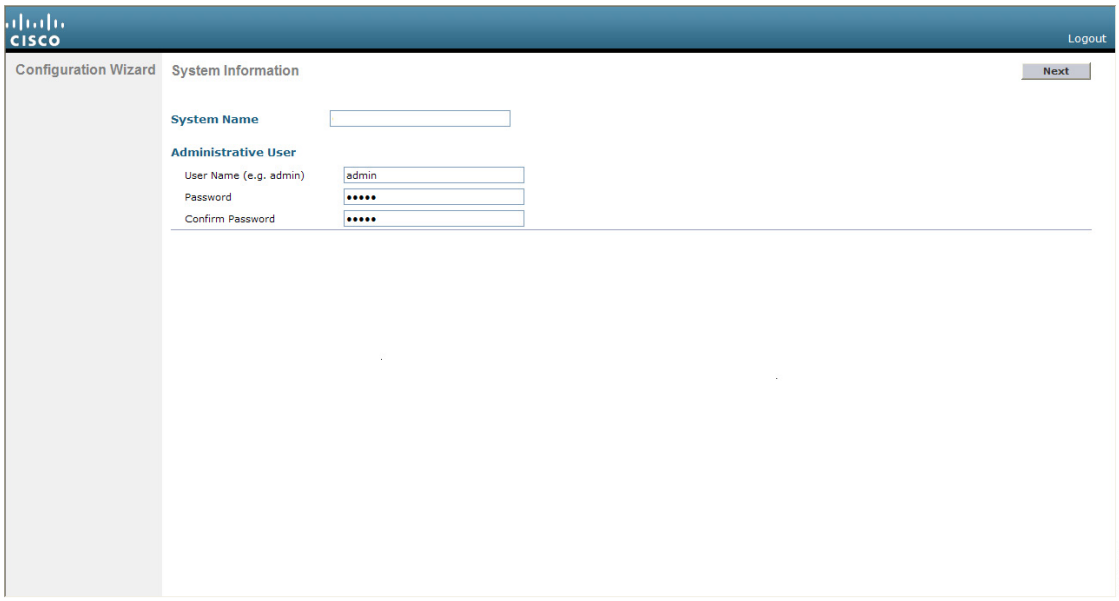
Using the GUI Configuration Wizard

To configure the controller using the controller GUI configuration wizard, follow these steps:

Step 1 Connect your PC to the service port and configure it to use the same subnet as the controller (for example, 192.168.10.1).

Step 2 Start Internet Explorer 6.0 SP1 (or later) or Firefox 2.0.0.11 (or later) on your PC and browse to http://192.168.1.1. The configuration wizard appears (see Figure 2-1).

Figure 2-1 Configuration Wizard — System Information Screen



Step 3 In the System Name text box, enter the name that you want to assign to this controller. You can enter up to 31 ASCII characters.

Step 4 In the User Name text box, enter the administrative username to be assigned to this controller. You can enter up to 24 ASCII characters. The default username is *admin*.

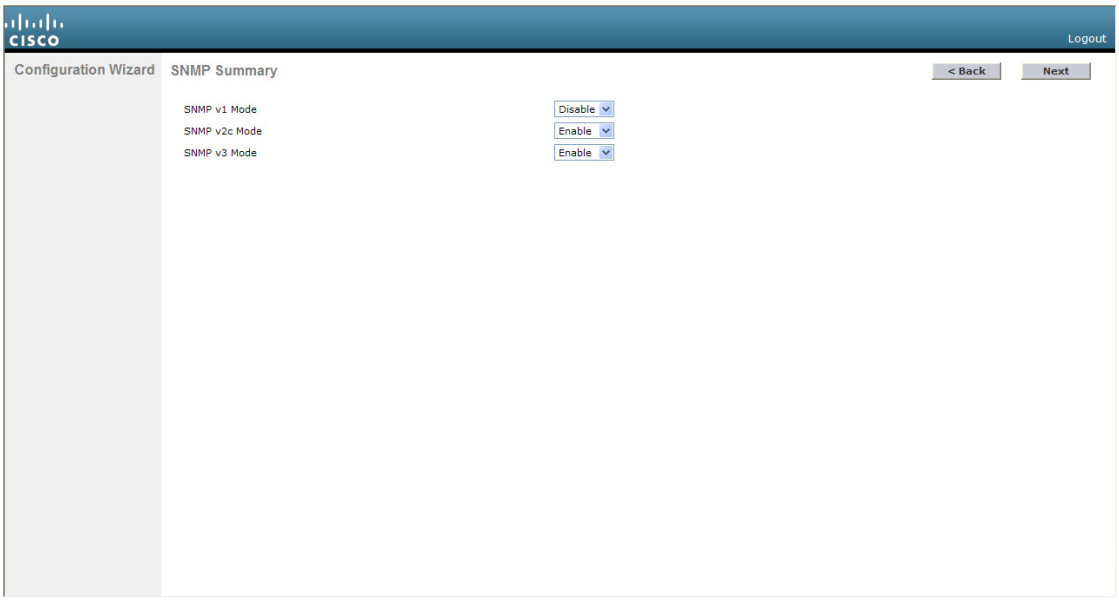
Step 5 In the Password and Confirm Password text boxes, enter the administrative password to be assigned to this controller. You can enter up to 24 ASCII characters. The default password is *admin*.

Starting in release 7.0.116.0, the following password policy has been implemented:

- The password must contain characters from at least three of the following classes:
  - Lowercase letters
  - Uppercase letters
  - Digits
  - Special characters.
- No character in the password must be repeated more than three times consecutively.
- The new password must not be the same as the associated username and not be the username reversed.
- The password must not be cisco, ocsic, or any variant obtained by changing the capitalization of letters of the word Cisco. In addition, you cannot substitute 1, I, or ! for i, 0 for o, or $ for s..

Step 6 Click **Next**. The SNMP Summary screen appears (see Figure 2-2).

Figure 2-2 Configuration Wizard — SNMP Summary Screen



Step 7 If you want to enable Simple Network Management Protocol (SNMP) v1 mode for this controller, choose **Enable** from the SNMP v1 Mode drop-down list. Otherwise, leave this parameter set to Disable.

Note SNMP manages nodes (servers, workstations, routers, switches, and so on) on an IP network. Currently, there are three versions of SNMP: SNMPv1, SNMPv2c, and SNMPv3.

Step 8 If you want to enable SNMPv2c mode for this controller, leave this parameter set to Enable. Otherwise, choose **Disable** from the SNVP v2c Mode drop-down list.

Step 9 If you want to enable SNMPv3 mode for this controller, leave this parameter set to Enable. Otherwise, choose **Disable** from the SNVP v3 Mode drop-down list.

Step 10 Click **Next**.

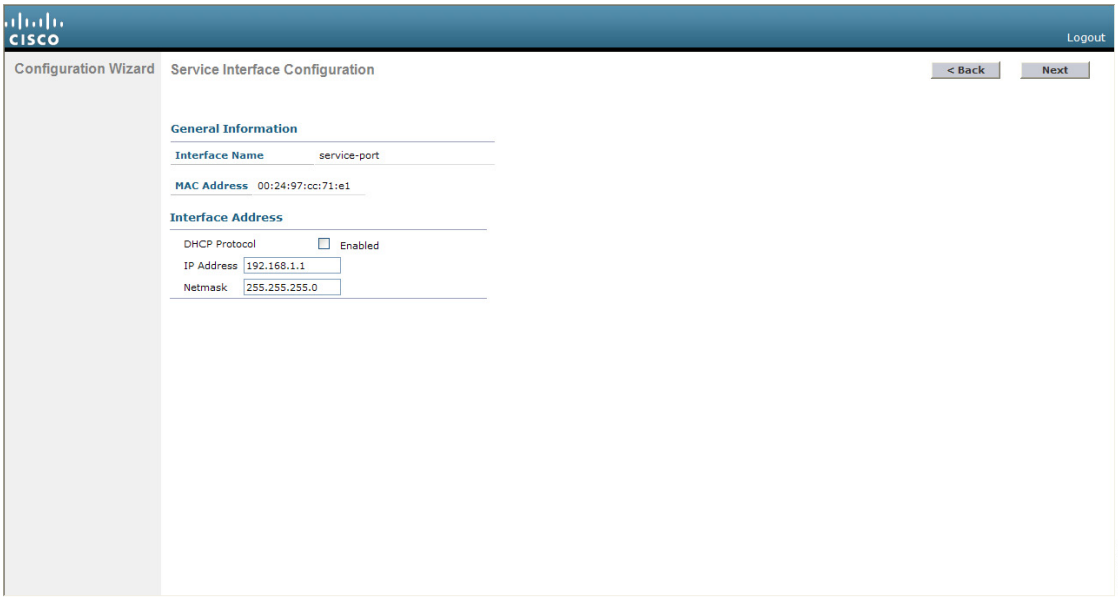
Step 11 When the following message appears, click **OK**:

```
Default values are present for v1/v2c community strings. Please make sure to create new
v1/v2c community strings once the system comes up. Please make sure to create new v3 users
once the system comes up.
```

Note See the"Changing the Default Values of SNMP Community Strings" section on page 4-43 and the "Changing the Default Values for SNMP v3 Users" section on page 4-45 for instructions.

The Service Interface Configuration screen appears (see Figure 2-3).

Figure 2-3 Configuration Wizard — Service Interface Configuration Screen



Step 12 If you want the controller's service-port interface to obtain an IP address from a DHCP server, select the **DHCP Protocol Enabled** check box. If you do not want to use the service port or if you want to assign a static IP address to the service port, leave the check box unselected.

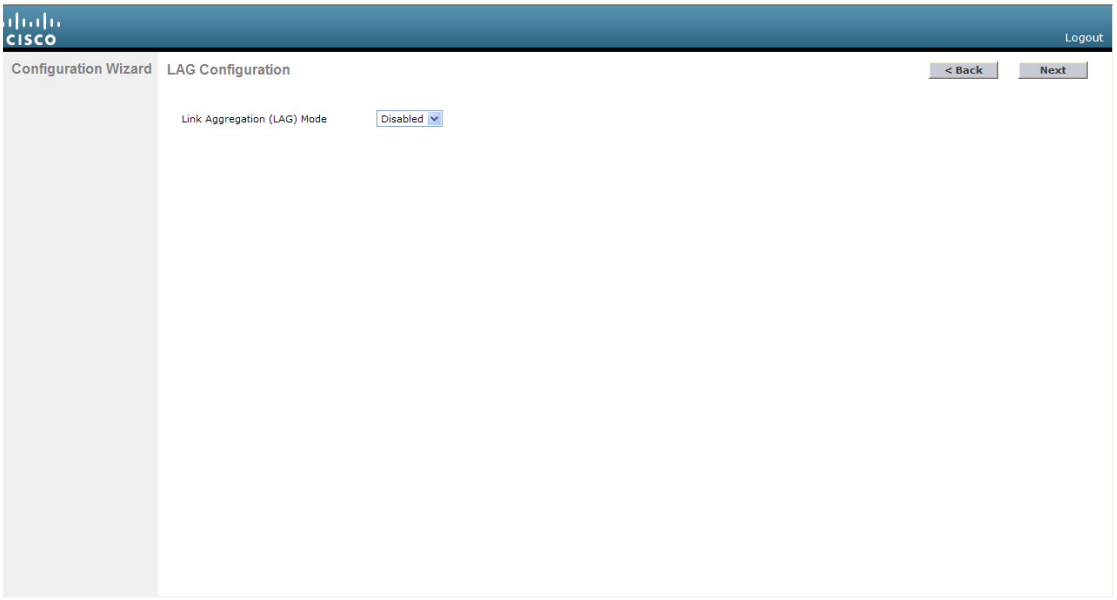
Note The service-port interface controls communications through the service port. Its IP address must be on a different subnet from the management interface. This configuration enables you to manage the controller directly or through a dedicated management network to ensure service access during network downtime.

Step 13 Perform one of the following:

- If you enabled DHCP in Step 12, clear out any entries in the IP Address and Netmask text boxes, leaving them blank.
- If you disabled DHCP in Step 12, enter the static IP address and netmask for the service port in the IP Address and Netmask text boxes.

Step 14 Click **Next**. The LAG Configuration screen appears (see Figure 2-4).

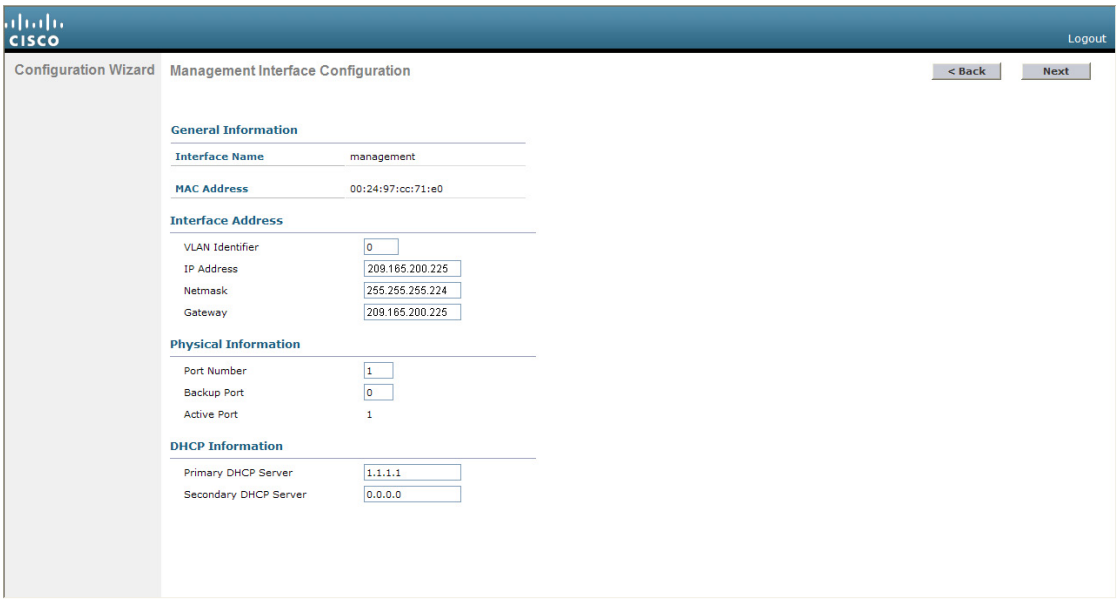
Figure 2-4 Configuration Wizard — LAG Configuration Screen



Step 15 To enable link aggregation (LAG), choose **Enabled** from the Link Aggregation (LAG) Mode drop-down list. To disable LAG, leave this text box set to **Disabled**.

Step 16 Click **Next**. The Management Interface Configuration screen appears (see Figure 2-5).

Figure 2-5 Configuration Wizard — Management Interface Configuration Screen



Note The management interface is the default interface for in-band management of the controller and connectivity to enterprise services such as AAA servers.

Step 17 In the VLAN Identifier text box, enter the VLAN identifier of the management interface (either a valid VLAN identifier or **0** for an untagged VLAN). The VLAN identifier should be set to match the switch interface configuration.

Step 18 In the IP Address text box, enter the IP address of the management interface.

Step 19 In the Netmask text box, enter the IP address of the management interface netmask.

Step 20 In the Gateway text box, enter the IP address of the default gateway.

Step 21 In the Port Number text box, enter the number of the port assigned to the management interface. Each interface is mapped to at least one primary port.

Step 22 In the Backup Port text box, enter the number of the backup port assigned to the management interface. If the primary port for the management interface fails, the interface automatically moves to the backup port.

Step 23 In the Primary DHCP Server text box, enter the IP address of the default DHCP server that will supply IP addresses to clients, the controller's management interface, and optionally, the service port interface.

Step 24 In the Secondary DHCP Server text box, enter the IP address of an optional secondary DHCP server that will supply IP addresses to clients, the controller's management interface, and optionally, the service port interface.

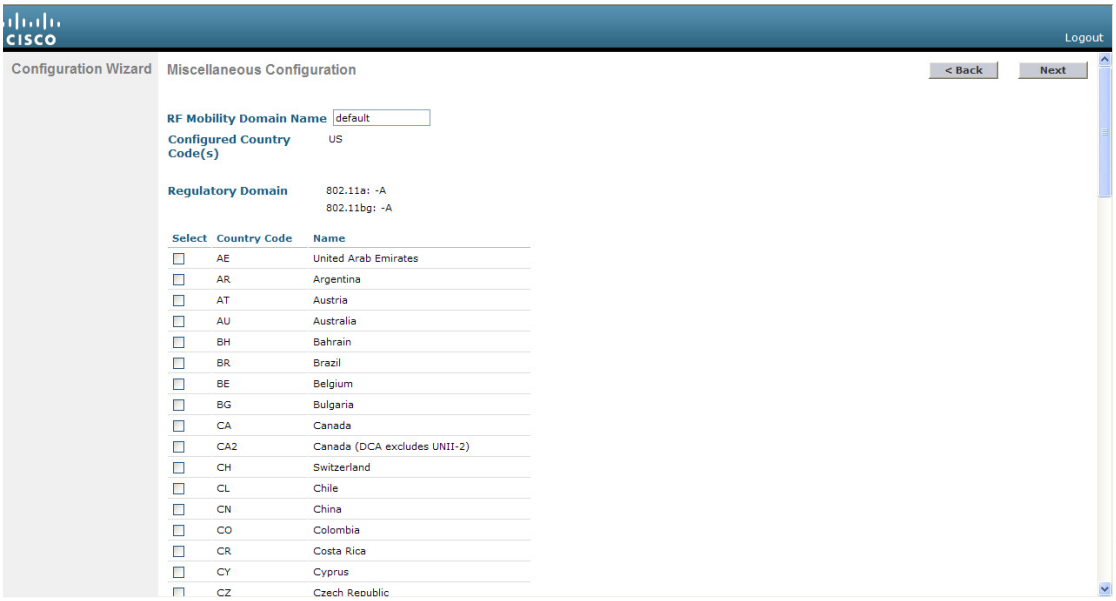
Step 25 Click **Next**. The AP-Manager Interface Configuration screen appears.

Note This screen does not appear for Cisco 5500 Series Controllers because you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default.

Step 26 In the IP Address text box, enter the IP address of the AP-manager interface.

Step 27 Click **Next**. The Miscellaneous Configuration screen appears (see Figure 2-6).

Figure 2-6 Configuration Wizard — Miscellaneous Configuration Screen



Step 28 In the RF Mobility Domain Name text box, enter the name of the mobility group/RF group to which you want the controller to belong.

Note Although the name that you enter here is assigned to both the mobility group and the RF group, these groups are not identical. Both groups define clusters of controllers, but they have different purposes. All of the controllers in an RF group are usually also in the same mobility group and vice versa. However, a mobility group facilitates scalable, system-wide mobility and controller redundancy while an RF group facilitates scalable, system-wide dynamic RF management. See Chapter 13, "Configuring Radio Resource Management," and Chapter 14, "Configuring Mobility Groups," for more information.

Step 29 The Configured Country Code(s) text box shows the code for the country in which the controller will be used. If you want to change the country of operation, select the check box for the desired country.

Note You can choose more than one country code if you want to manage access points in multiple countries from a single controller. After the configuration wizard runs, you need to assign each access point joined to the controller to a specific country. See the "Configuring Country Codes" section on page 8-106 for instructions.

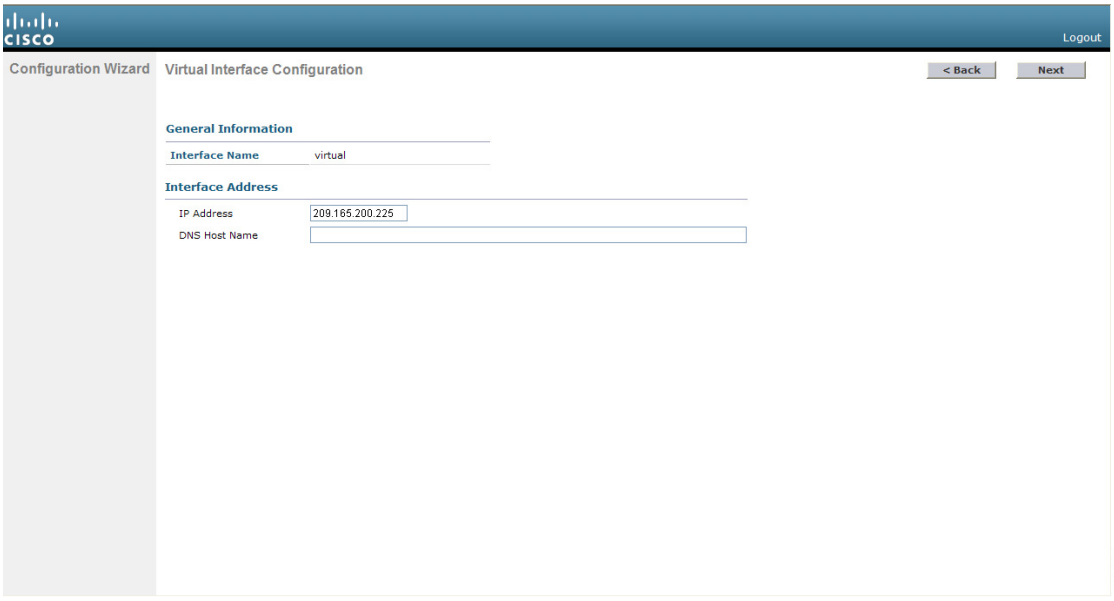
Step 30 Click **Next**.

Step 31 When the following message appears, click **OK**:

```
Warning! To maintain regulatory compliance functionality, the country code setting may
only be modified by a network administrator or qualified IT professional. Ensure that
proper country codes are selected before proceeding.
```

The Virtual Interface Configuration screen appears (see Figure 2-7).

Figure 2-7 Configuration Wizard — Virtual Interface Configuration Screen



Step 32 In the IP Address text box, enter the IP address of the controller's virtual interface. You should enter a fictitious, unassigned IP address such as 1.1.1.1.

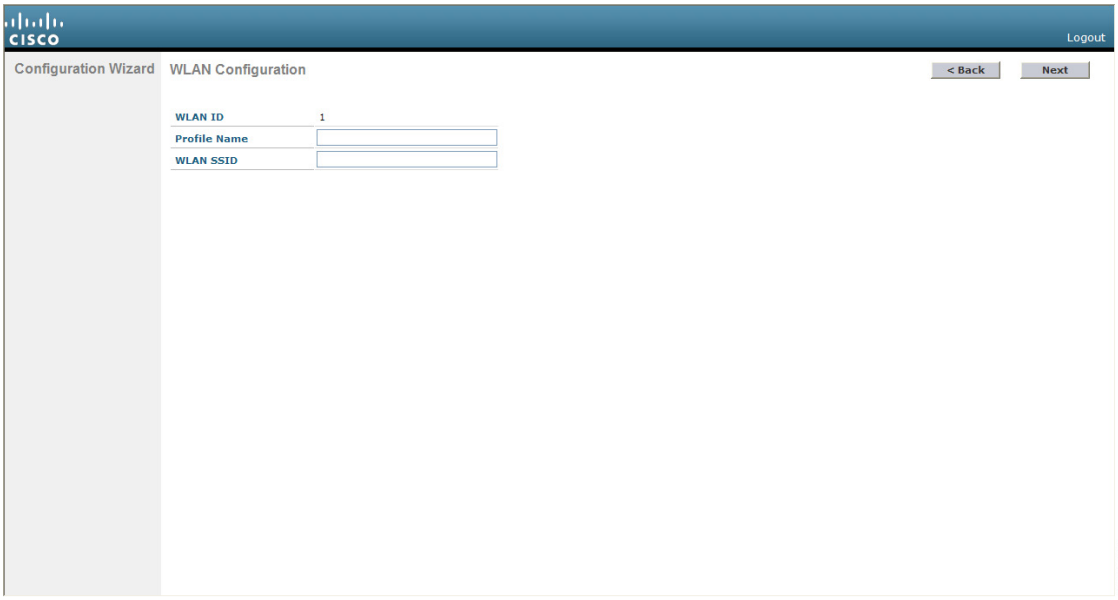
Note The virtual interface is used to support mobility management, DHCP relay, and embedded Layer 3 security such as guest web authentication and VPN termination. All controllers within a mobility group must be configured with the same virtual interface IP address.

Step 33 In the DNS Host Name text box, enter the name of the Domain Name System (DNS) gateway used to verify the source of certificates when Layer 3 web authorization is enabled.

Note To ensure connectivity and web authentication, the DNS server should always point to the virtual interface. If a DNS host name is configured for the virtual interface, then the same DNS host name must be configured on the DNS servers used by the client.

Step 34 Click **Next**. The WLAN Configuration screen appears (see Figure 2-8).

Figure 2-8 Configuration Wizard — WLAN Configuration Screen



Step 35 In the Profile Name text box, enter up to 32 alphanumeric characters for the profile name to be assigned to this WLAN.

Step 36 In the WLAN SSID text box, enter up to 32 alphanumeric characters for the network name, or service set identifier (SSID). The SSID enables basic functionality of the controller and allows access points that have joined the controller to enable their radios.

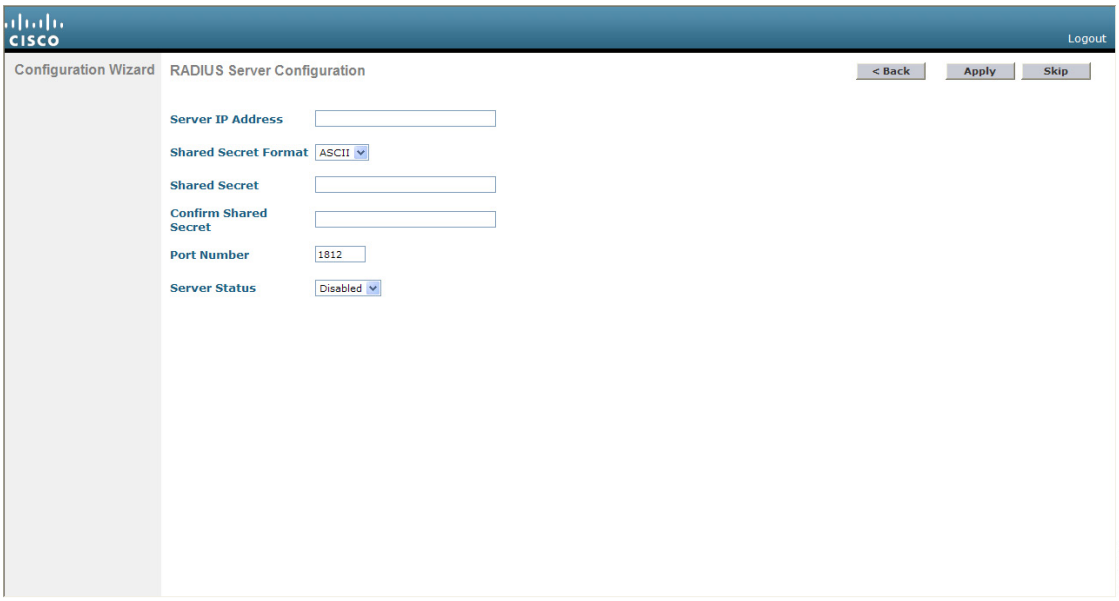
Step 37 Click **Next**.

Step 38 When the following message appears, click **OK**:

```
Default Security applied to WLAN is: [WPA2(AES)][Auth(802.1x)]. You can change this after
the wizard is complete and the system is rebooted.
```

The RADIUS Server Configuration screen appears (see Figure 2-9).

Figure 2-9 Configuration Wizard — RADIUS Server Configuration Screen



Step 39 In the Server IP Address text box, enter the IP address of the RADIUS server.

Step 40 From the Shared Secret Format drop-down list, choose **ASCII** or **Hex** to specify the format of the shared secret.

Note Due to security reasons, the RADIUS shared secret key reverts to ASCII mode even if you have selected HEX as the shared secret format from the Shared Secret Format drop-down list.

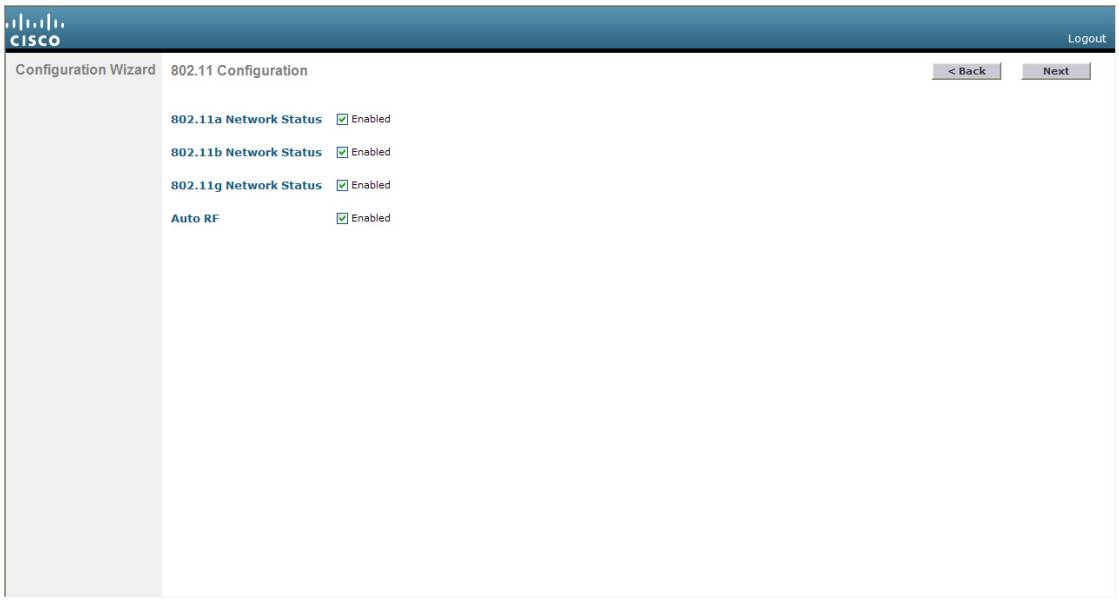
Step 41 In the Shared Secret and Confirm Shared Secret text boxes, enter the secret key used by the RADIUS server.

Step 42 In the Port Number text box, enter the communication port of the RADIUS server. The default value is 1812.

Step 43 To enable the RADIUS server, choose **Enabled** from the Server Status drop-down list. To disable the RADIUS server, leave this text box set to **Disabled**.

Step 44 Click **Apply**. The 802.11 Configuration screen appears (see Figure 2-10).

Figure 2-10 Configuration Wizard — 802.11 Configuration Screen



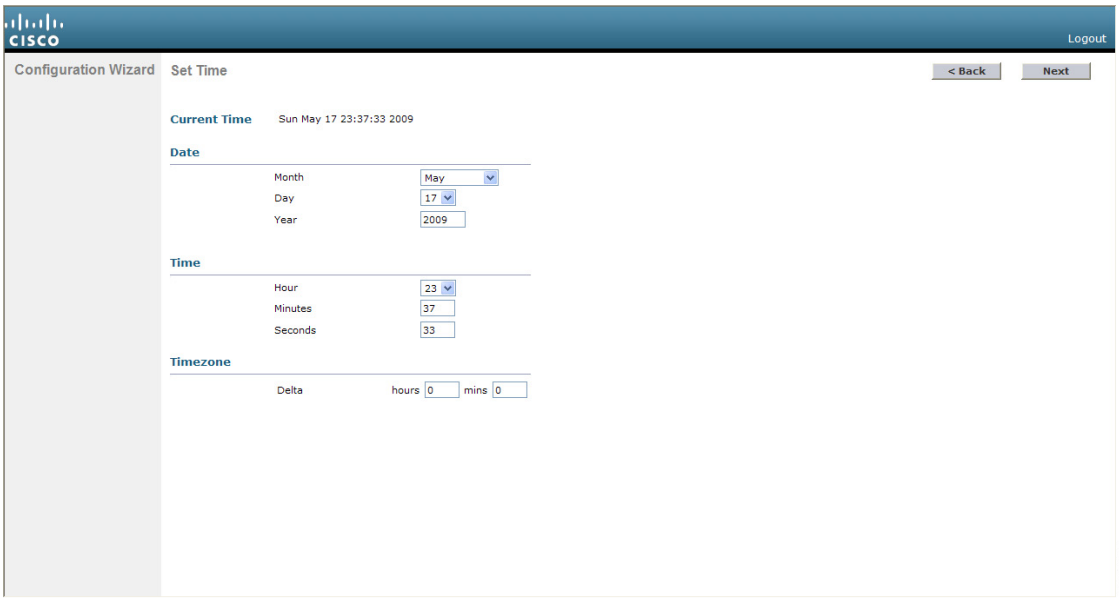
Step 45 To enable the 802.11a, 802.11b, and 802.11g lightweight access point networks, leave the **802.11a Network Status**, **802.11b Network Status**, and **802.11g Network Status** check boxes selected. To disable support for any of these networks, unselect the check boxes.

Step 46 To enable the controller's radio resource management (RRM) auto-RF feature, leave the **Auto RF** check box selected. To disable support for the auto-RF feature, unselect this check box. See Chapter 13, "Configuring Radio Resource Management," for more information on RRM.

Note The auto-RF feature enables the controller to automatically form an RF group with other controllers. The group dynamically elects a leader to optimize RRM parameter settings, such as channel and transmit power assignment, for the group.

Step 47 Click **Next**. The Set Time screen appears (see Figure 2-11).

Figure 2-11 Configuration Wizard — Set Time Screen



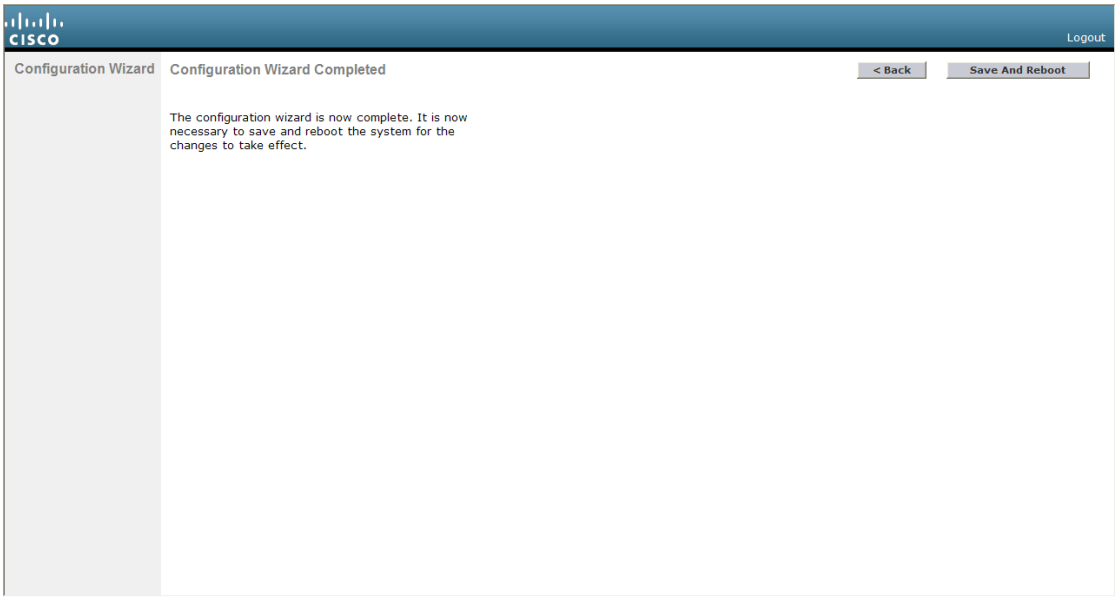
Step 48 To manually configure the system time on your controller, enter the current date in Month/DD/YYYY format and the current time in HH:MM:SS format.

Step 49 To manually set the time zone so that Daylight Saving Time (DST) is not set automatically, enter the local hour difference from Greenwich Mean Time (GMT) in the Delta Hours text box and the local minute difference from GMT in the Delta Mins text box.

Note When manually setting the time zone, enter the time difference of the local current time zone with respect to GMT (+/–). For example, Pacific time in the United States is 8 hours behind GMT. Therefore, it is entered as –8.

Step 50 Click **Next**. The Configuration Wizard Completed screen appears (see Figure 2-12).

Figure 2-12 Configuration Wizard — Configuration Wizard Completed Screen



Step 51 Click **Save and Reboot** to save your configuration and reboot the controller.

Step 52 When the following message appears, click **OK**:

```
Configuration will be saved and the controller will be rebooted. Click ok to confirm.
```

Step 53 The controller saves your configuration, reboots, and prompts you to log in. Follow the instructions in the "Using the GUI" section on page 2-16 to log into the controller.

Using the CLI Configuration Wizard

Note The available options appear in brackets after each configuration parameter. The default value appears in all uppercase letters.

Note If you enter an incorrect response, the controller provides you with an appropriate error message, such as "Invalid Response," and returns you to the wizard prompt.

Note Press the hyphen key if you ever need to return to the previous command line.

To configure the controller using the CLI configuration wizard, follow these steps:

Step 1 When prompted to terminate the AutoInstall process, enter **yes**. If you do not enter **yes**, the AutoInstall process begins after 30 seconds.

Note The AutoInstall feature downloads a configuration file from a TFTP server and then loads the configuration onto the controller automatically. See the "Using the AutoInstall Feature for Controllers Without a Configuration" section on page 2-26 for more information.

Note The Cisco WiSM controllers do not support the AutoInstall feature.

Step 2 Enter the system name, which is the name that you want to assign to the controller. You can enter up to 31 ASCII characters.

Step 3 Enter the administrative username and password to be assigned to this controller. You can enter up to 24 ASCII characters for each.

Starting in release 7.0.116.0, the following password policy has been implemented:

- The password must contain characters from at least three of the following classes:
  - Lowercase letters
  - Uppercase letters
  - Digits
  - Special characters.
- No character in the password must be repeated more than three times consecutively.
- The new password must not be the same as the associated username and not be the username reversed.
- The password must not be cisco, ocsic, or any variant obtained by changing the capitalization of letters of the word Cisco. In addition, you cannot substitute 1, I, or ! for i, 0 for o, or $ for s.

Step 4 If you want the controller's service-port interface to obtain an IP address from a DHCP server, enter **DHCP**. If you do not want to use the service port or if you want to assign a static IP address to the service port, enter **none**.

Note The service-port interface controls communications through the service port. Its IP address must be on a different subnet from the management interface. This configuration enables you to manage the controller directly or through a dedicated management network to ensure service access during network downtime.

Step 5 If you entered **none** in Step 4, enter the IP address and netmask for the service-port interface on the next two lines.

Step 6 Enable or disable link aggregation (LAG) by choosing **yes** or **NO**. See Chapter 3, "Configuring Ports and Interfaces," for more information on LAG.

Step 7 Enter the IP address of the management interface.

Note The management interface is the default interface for in-band management of the controller and connectivity to enterprise services such as AAA servers.

Step 8 Enter the IP address of the management interface netmask.

Step 9 Enter the IP address of the default router.

Step 10 Enter the VLAN identifier of the management interface (either a valid VLAN identifier or **0** for an untagged VLAN). The VLAN identifier should be set to match the switch interface configuration.

Step 11 Enter the IP address of the default DHCP server that will supply IP addresses to clients, the controller's management interface, and optionally, the service port interface.Enter the IP address of the AP-manager interface.

Note This prompt does not appear for Cisco 5500 Series Controllers because you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default.

Step 12 Enter the IP address of the controller's virtual interface. You should enter a fictitious, unassigned IP address such as 1.1.1.1.

Note The virtual interface is used to support mobility management, DHCP relay, and embedded Layer 3 security such as guest web authentication and VPN termination. All controllers within a mobility group must be configured with the same virtual interface IP address.

Step 13 If desired, enter the name of the mobility group/RF group to which you want the controller to belong.

Note Although the name that you enter here is assigned to both the mobility group and the RF group, these groups are not identical. Both groups define clusters of controllers, but they have different purposes. All of the controllers in an RF group are usually also in the same mobility group and vice versa. However, a mobility group facilitates scalable, system-wide mobility and controller redundancy while an RF group facilitates scalable, system-wide dynamic RF management. See Chapter 13, "Configuring Radio Resource Management," and Chapter 14, "Configuring Mobility Groups," for more information.

Step 14 Enter the network name or service set identifier (SSID). The SSID enables basic functionality of the controller and allows access points that have joined the controller to enable their radios.

Step 15 Enter **YES** to allow clients to assign their own IP address or **no** to require clients to request an IP address from a DHCP server.

Step 16 To configure a RADIUS server now, enter **YES** and then enter the IP address, communication port, and secret key of the RADIUS server. Otherwise, enter **no**. If you enter no, the following message appears: "Warning! The default WLAN security policy requires a RADIUS server. Please see the documentation for more details."

Step 17 Enter the code for the country in which the controller will be used.

Note Enter **help** to view the list of available country codes.

Note You can enter more than one country code if you want to manage access points in multiple countries from a single controller. To do so, separate the country codes with a comma (for example, US,CA,MX). After the configuration wizard runs, you need to assign each access point joined to the controller to a specific country. See the "Configuring Country Codes" section on page 8-106 for instructions.

Step 18 Enable or disable the 802.11b, 802.11a, and 802.11g lightweight access point networks by entering **YES** or **no**.

Step 19 Enable or disable the controller's radio resource management (RRM) auto-RF feature by entering **YES** or **no**. See Chapter 13, "Configuring Radio Resource Management," for more information on RRM.

Note The auto-RF feature enables the controller to automatically form an RF group with other controllers. The group dynamically elects a leader to optimize RRM parameter settings, such as channel and transmit power assignment, for the group.

Step 20 If you want the controller to receive its time setting from an external Network Time Protocol (NTP) server when it powers up, enter **YES** to configure an NTP server. Otherwise, enter **no**.

Note The controller network module installed in a Cisco Integrated Services Router does not have a battery and cannot save a time setting. Therefore, it must receive a time setting from an external NTP server when it powers up.

Step 21 If you entered **no** in Step 20 and want to manually configure the system time on your controller now, enter **YES**. If you do not want to configure the system time now, enter **no**.

Step 22 If you entered **YES** in Step 21, enter the current date in MM/DD/YY format and the current time in HH:MM:SS format.

Step 23 When prompted to verify that the configuration is correct, enter **yes** or **NO**.

The controller saves your configuration, reboots, and prompts you to log in. Follow the instructions in the "Using the CLI" section on page 2-22 to log into the controller.

Using the GUI

A web browser, or graphical user interface (GUI), is built into each controller. It allows up to five users to simultaneously browse into the controller HTTP or HTTPS (HTTP + SSL) management pages to configure parameters and monitor the operational status for the controller and its associated access points.

Note We recommend that you enable the HTTPS interface and disable the HTTP interface to ensure more robust security for your Cisco UWN solution.

Guidelines for Using the GUI

Follow these guidelines when using the controller GUI:

- The GUI must be used on a PC running Windows XP SP1 (or later) or Windows 2000 SP4 (or later).
- The GUI is fully compatible with Microsoft Internet Explorer version 6.0 SP1 (or later) or Mozilla Firefox 2.0.0.11 (or later).

Note Opera and Netscape are not supported.

Note Internet Explorer 6.0 SP1 (or later) and Mozilla Firefox 2.0.0.11 (or later) are the only browsers supported for accessing the controller GUI and for using web authentication.

- You can use either the service port interface or the management interface to access the GUI. We recommend that you use the service-port interface. See Chapter 3, "Configuring Ports and Interfaces," for instructions on configuring the service port interface.
- Click **Help** at the top of any page in the GUI to display online help. You might need to disable your browser's pop-up blocker to view the online help.

Logging into the GUI

To log into the controller GUI, follow these steps:

Step 1 Enter the controller IP address in your browser's address line. For a secure connection, enter **https://***ip-address*. For a less secure connection, enter **http://***ip-address*.

Note See the "Using the GUI to Enable Web and Secure Web Modes" section on page 2-18 for instructions on setting up HTTPS.

Step 2 When prompted, enter a valid username and password and click **OK**. The controller Summary page appears.

Note The administrative username and password that you created in the configuration wizard are case sensitive. The default username is *admin*, and the default password is *admin*.

Logging Out of the GUI

To log out of the controller GUI, follow these steps:

Step 1 Click **Logout** in the top right corner of the page.

Step 2 Click **Close** to complete the logoff process and prevent unauthorized users from accessing the controller GUI.

Step 3 When prompted to confirm your decision, click **Yes**.

Enabling Web and Secure Web Modes

This section provides instructions for enabling the distribution system port as a web port (using HTTP) or as a secure web port (using HTTPS). You can protect communication with the GUI by enabling HTTPS. HTTPS protects HTTP browser sessions by using the Secure Sockets Layer (SSL) protocol. When you enable HTTPS, the controller generates its own local web administration SSL certificate and automatically applies it to the GUI. You also have the option of downloading an externally generated certificate.

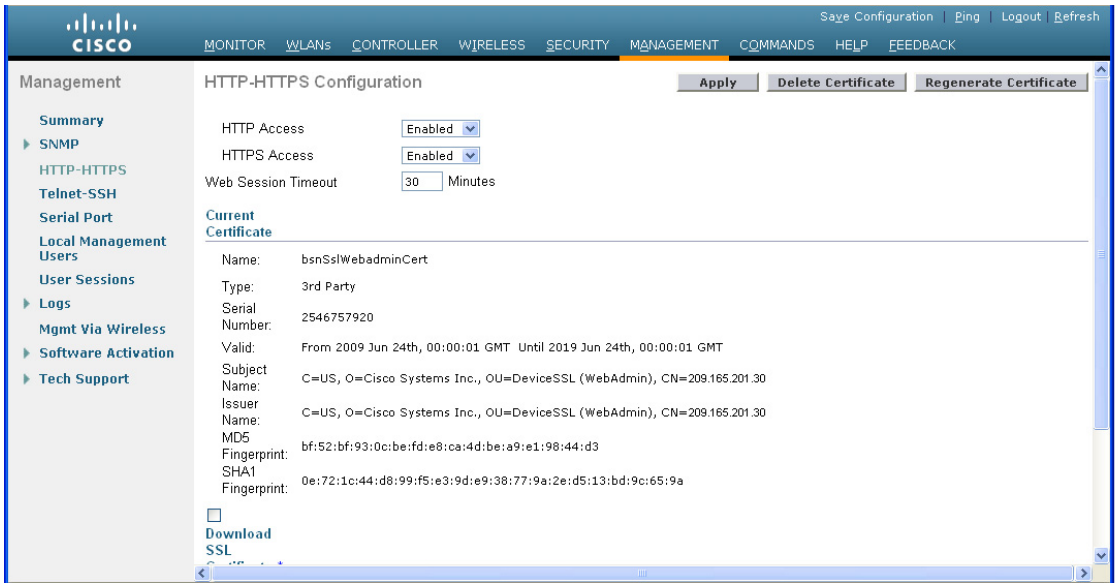
You can configure web and secure web mode using the controller GUI or CLI.

Using the GUI to Enable Web and Secure Web Modes

To enable web mode, secure web mode, or both using the controller GUI, follow these steps:

Step 1 Choose **Management** > **HTTP** to open the HTTP Configuration page (see Figure 2-13).

Figure 2-13 HTTP Configuration Page



Step 2 To enable web mode, which allows users to access the controller GUI using "http://*ip-address*," choose **Enabled** from the HTTP Access drop-down list. Otherwise, choose **Disabled**. The default value is Disabled. Web mode is not a secure connection.

Step 3 To enable secure web mode, which allows users to access the controller GUI using "https://*ip-address*," choose **Enabled** from the HTTPS Access drop-down list. Otherwise, choose **Disabled**. The default value is Enabled. Secure web mode is a secure connection.

Step 4 In the Web Session Timeout text box, enter the amount of time (in minutes) before the web session times out due to inactivity. You can enter a value between 30 and 160 minutes (inclusive), and the default value is 30 minutes.

Step 5 Click **Apply** to commit your changes.

Step 6 If you enabled secure web mode in Step 3, the controller generates a local web administration SSL certificate and automatically applies it to the GUI. The details of the current certificate appear in the middle of the HTTP Configuration page (see Figure 2-13).

Note If you want to download your own SSL certificate to the controller, follow the instructions in the "Loading an Externally Generated SSL Certificate" section on page 2-20.

Note If desired, you can delete the current certificate by clicking **Delete Certificate** and have the controller generate a new certificate by clicking **Regenerate Certificate**.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Enable Web and Secure Web Modes

To enable web mode, secure web mode, or both using the controller CLI, follow these steps:

Step 1 To enable or disable web mode, enter this command:

config network webmode {**enable** | **disable**}

This command allows users to access the controller GUI using "http://*ip-address*." The default value is disabled. Web mode is not a secure connection.

Step 2 To enable or disable secure web mode, enter this command:

config network secureweb {**enable** | **disable**}

This command allows users to access the controller GUI using "https://*ip-address*." The default value is enabled. Secure web mode is a secure connection.

Step 3 To enable or disable secure web mode with increased security, enter this command:

config network secureweb cipher-option high {**enable** | **disable**}

This command allows users to access the controller GUI using "https://*ip-address*" but only from browsers that support 128-bit (or larger) ciphers. The default value is disabled.

Step 4 To enable or disable SSLv2 for web administration, enter this command:

config network secureweb cipher-option sslv2 {**enable** | **disable**}

If you disable SSLv2, users cannot connect using a browser configured with SSLv2 only. They must use a browser that is configured to use a more secure protocol such as SSLv3 or later. The default value is enabled.

Step 5 To verify that the controller has generated a certificate, enter this command:

show certificate summary

Information similar to the following appears:

```
Web Administration Certificate..................... Locally Generated
Web Authentication Certificate..................... Locally Generated
Certificate compatibility mode:.................... off
```

Note If you want to download your own SSL certificate to the controller, follow the instructions in the "Loading an Externally Generated SSL Certificate" section on page 2-20.

Step 6 (Optional) If you need to generate a new certificate, enter this command:

config certificate generate webadmin

After a few seconds, the controller verifies that the certificate has been generated.

Step 7 To save the SSL certificate, key, and secure web password to nonvolatile RAM (NVRAM) so that your changes are retained across reboots, enter this command:

save config

Step 8 To reboot the controller, enter this command:

reset system

Loading an Externally Generated SSL Certificate

You can use a TFTP server to download an externally generated SSL certificate to the controller. Follow these guidelines for using TFTP:

- If you load the certificate through the service port, the TFTP server must be on the same subnet as the controller because the service port is not routable, or you must create static routes on the controller. Also, if you load the certificate through the distribution system network port, the TFTP server can be on any subnet.
- A third-party TFTP server cannot run on the same PC as the Cisco WCS because the WCS built-in TFTP server and the third-party TFTP server require the same communication port.

Note Chained certificates are supported for web authentication only and not for the management certificate.

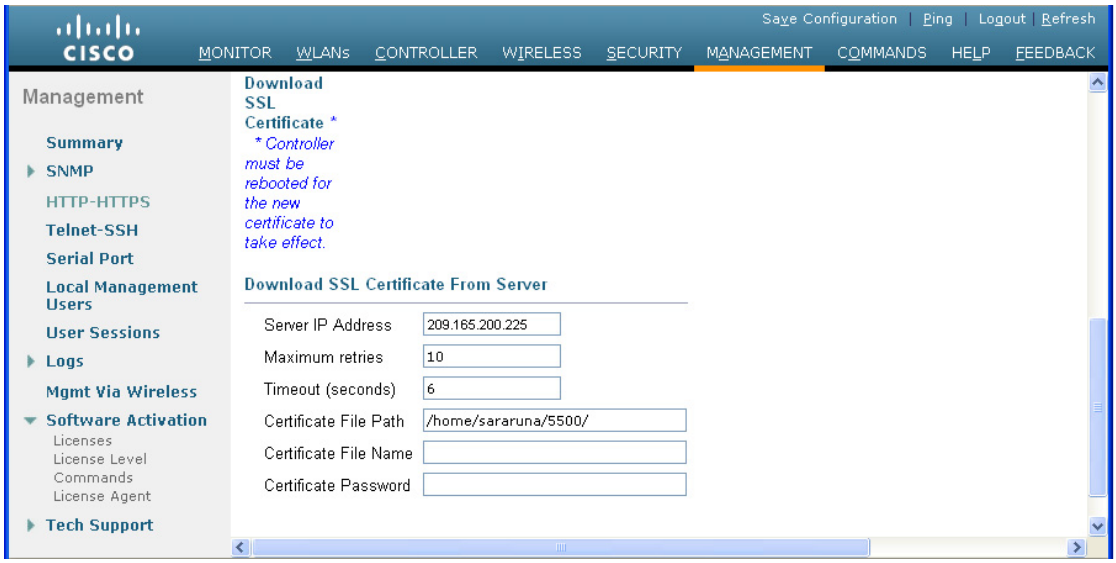
Note Every HTTPS certificate contains an embedded RSA key. The length of the key can vary from 512 bits, which is relatively insecure, to thousands of bits, which is very secure. When you obtain a new certificate from a Certificate Authority, make sure that the RSA key embedded in the certificate is at least 768 bits long.

Using the GUI to Load an SSL Certificate

To load an externally generated SSL certificate using the controller GUI, follow these steps:

Step 1 On the HTTP Configuration page, select the **Download SSL Certificate** check box (see Figure 2-14).

Figure 2-14 HTTP Configuration Page



Step 2 In the Server IP Address text box, enter the IP address of the TFTP server.

Step 3 In the Maximum Retries text box, enter the maximum number of times that the TFTP server attempts to download the certificate.

Step 4 In the Timeout text box, enter the amount of time (in seconds) that the TFTP server attempts to download the certificate.

Step 5 In the Certificate File Path text box, enter the directory path of the certificate.

Step 6 In the Certificate File Name text box, enter the name of the certificate (*webadmincert_name*.pem).

Step 7 (Optional) In the Certificate Password text box, enter a password to encrypt the certificate.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Step 10 To reboot the controller for your changes to take effect, choose **Commands > Reboot > Reboot > Save and Reboot**.

Using the CLI to Load an SSL Certificate

To load an externally generated SSL certificate using the controller CLI, follow these steps:

Step 1 Use a password to encrypt the HTTPS certificate in a .PEM-encoded file. The PEM-encoded file is called a web administration certificate file (*webadmincert_name*.pem).

Step 2 Move the *webadmincert_name*.pem file to the default directory on your TFTP server.

Step 3 To view the current download settings, enter this command and answer **n** to the prompt:

transfer download start

Information similar to the following appears:

```
Mode..................................... TFTP
Data Type................................ Admin Cert
TFTP Server IP........................... xxx.xxx.xxx.xxx
```

```
TFTP Path..................................... <directory path>
TFTP Filename.................................
Are you sure you want to start? (y/n) n
Transfer Canceled
```

Step 4 Use these commands to change the download settings:

transfer download mode tftp

transfer download datatype webauthcert

transfer download serverip *TFTP_server IP_address*

transfer download path *absolute_TFTP_server_path_to_the_update_file*

transfer download filename *webadmincert_name.pem*

Step 5 To set the password for the .PEM file so that the operating system can decrypt the web administration SSL key and certificate, enter this command:

transfer download certpassword *private_key_password*

Step 6 To confirm the current download settings and start the certificate and key download, enter this command and answer **y** to the prompt:

transfer download start

Information similar to the following appears:

```
Mode.......................................... TFTP
Data Type..................................... Site Cert
TFTP Server IP................................ xxx.xxx.xxx.xxx
TFTP Path..................................... directory path
TFTP Filename................................. webadmincert_name
Are you sure you want to start? (y/n) y
TFTP Webadmin cert transfer starting.
Certificate installed.
Please restart the switch (reset system) to use the new certificate.
```

Step 7 To save the SSL certificate, key, and secure web password to NVRAM so that your changes are retained across reboots, enter this command:

save config

Step 8 To reboot the controller, enter this command:

reset system

Using the CLI

A Cisco UWN solution command-line interface (CLI) is built into each controller. The CLI allows you to use a VT-100 terminal emulation program to locally or remotely configure, monitor, and control individual controllers and its associated lightweight access points. The CLI is a simple text-based, tree-structured interface that allows up to five users with Telnet-capable terminal emulation programs to access the controller.

Note See the C*isco Wireless LAN Controller Command Reference* for information on specific commands.

Note If you want to input any strings from the XML configuration into CLI commands, you must enclose the strings in quotation marks.

Logging into the CLI

You access the controller CLI using one of two methods:

- A direct serial connection to the controller console port
- A remote console session over Ethernet through the preconfigured service port or the distribution system ports

Before you log into the CLI, configure your connectivity and environment variables based on the type of connection you use.

Using a Local Serial Connection

You need these items to connect to the serial port:

- A PC that is running a VT-100 terminal emulation program (such as HyperTerminal, ProComm, Minicom, or Tip)
- A null-modem serial cable

To log into the controller CLI through the serial port, follow these steps:

Step 1 Connect one end of a null-modem serial cable to the controller's console port and the other end to your PC's serial port.

Note On Cisco 5500 Series Controllers, you can use either the RJ-45 console port or the USB console port. If you use the USB console port, plug the 5-pin mini Type B connector into the controller's USB console port and the other end of the cable into the PC's USB Type A port. The first time that you connect a Windows PC to the USB console port, you are prompted to install the USB console driver. Follow the installation prompts to install the driver. The USB console driver maps to a COM port on your PC; you then need to map the terminal emulator application to the COM port.

Step 2 Start the PC's VT-100 terminal emulation program.

Step 3 Configure the terminal emulation program for these parameters:

- 9600 baud
- 8 data bits
- 1 stop bit
- No parity
- No hardware flow control

Note The controller serial port is set for a 9600 baud rate and a short timeout. If you would like to change either of these values, enter **config serial baudrate** *baudrate* and **config serial timeout** *timeout* to make your changes. If you enter **config serial timeout 0**, serial sessions never time out.

Step 4 When prompted, enter a valid username and password to log into the controller. The administrative username and password that you created in the configuration wizard are case sensitive.

Note The default username is *admin*, and the default password is *admin*.

The CLI displays the root level system prompt:

```
#(system prompt)>
```

Note The system prompt can be any alphanumeric string up to 31 characters. You can change it by entering the **config prompt** command.

Using a Remote Ethernet Connection

You need these items to connect to a controller remotely:

- A PC with access to the controller over the Ethernet network
- The IP address of the controller
- A VT-100 terminal emulation program or a DOS shell for the Telnet session

Note By default, controllers block Telnet sessions. You must use a local connection to the serial port to enable Telnet sessions. See the "Configuring Telnet and SSH Sessions" section on page 2-34 for information on enabling Telnet sessions.

To log into the controller CLI through a remote Ethernet connection, follow these steps:

Step 1 Verify that your VT-100 terminal emulation program or DOS shell interface is configured with these parameters:

- Ethernet address
- Port 23

Step 2 Use the controller IP address to Telnet to the CLI.

Step 3 When prompted, enter a valid username and password to log into the controller. The administrative username and password that you created in the configuration wizard are case sensitive.

Note The default username is *admin*, and the default password is *admin*.

The CLI displays the root level system prompt:

```
#(system prompt)>
```

Note The system prompt can be any alphanumeric string up to 31 characters. You can change it by entering the **config prompt** command.

Logging Out of the CLI

When you finish using the CLI, navigate to the root level and enter **logout**. The system prompts you to save any changes you made to the volatile RAM.

Note The CLI automatically logs you out without saving any changes after 5 minutes of inactivity. You can set the automatic logout from 0 (never log out) to 160 minutes using the **config serial timeout** command.

Navigating the CLI

The CLI is organized around five levels:

Root Level

Level 2

Level 3

Level 4

Level 5

When you log into the CLI, you are at the root level. From the root level, you can enter any full command without first navigating to the correct command level. Table 2-1 lists commands you use to navigate the CLI and to perform common tasks.

Table 2-1 Commands for CLI Navigation and Common Tasks

Command	Action
help	At the root level, view system wide navigation commands
?	View commands available at the current level
command **?**	View parameters for a specific command
exit	Move down one level
Ctrl-Z	Return from any level to the root level
save config	At the root level, save configuration changes from active working RAM to nonvolatile RAM (NVRAM) so they are retained after reboot
reset system	At the root level, reset the controller without logging out

Using the AutoInstall Feature for Controllers Without a Configuration

When you boot up a controller that does not have a configuration, the AutoInstall feature can download a configuration file from a TFTP server and then load the configuration onto the controller automatically.

Note The Cisco WiSM controllers do not support the AutoInstall feature.

Overview of AutoInstall

If you create a configuration file on a controller that is already on the network (or through a WCS filter), place that configuration file on a TFTP server, and configure a DHCP server so that a new controller can get an IP address and TFTP server information, the AutoInstall feature can obtain the configuration file for the new controller automatically.

When the controller boots, the AutoInstall process starts. The controller does not take any action until AutoInstall is notified that the configuration wizard has started. If the wizard has not started, the controller has a valid configuration.

If AutoInstall is notified that the configuration wizard has started (which means that the controller does not have a configuration), AutoInstall waits for an additional 30 seconds. This time period gives you an opportunity to respond to the first prompt from the configuration wizard:

```
Would you like to terminate autoinstall? [yes]:
```

When the 30-second abort timeout expires, AutoInstall starts the DHCP client. You can abort the AutoInstall task even after this 30-second timeout if you enter **Yes** at the prompt. However, AutoInstall cannot be aborted if the TFTP task has locked the flash and is in the process of downloading and installing a valid configuration file.

Obtaining an IP Address Through DHCP and Downloading a Configuration File from a TFTP Server

AutoInstall uses the following interfaces:

- Cisco 5500 and 4400 Series Controllers
  - eth0—Service port (untagged)
  - dtl0—Gigabit port 1 through the NPU (untagged)
- Cisco 2100 Series Controller
  - dtl0—FastEthernet port 1 (untagged)

AutoInstall attempts to obtain an IP address from the DHCP server until the DHCP process is successful or until you abort the AutoInstall process. The first interface to successfully obtain an IP address from the DHCP server registers with the AutoInstall task. The registration of this interface causes AutoInstall to begin the process of obtaining TFTP server information and downloading the configuration file.

Following the acquisition of the DHCP IP address for an interface, AutoInstall begins a short sequence of events to determine the host name of the controller and the IP address of the TFTP server. Each phase of this sequence gives preference to explicitly configured information over default or implied information and to explicit host names over explicit IP addresses.

The process is as follows:

- If at least one Domain Name System (DNS) server IP address is learned through DHCP, AutoInstall creates a /etc/resolv.conf file. This file includes the domain name and the list of DNS servers that have been received. The Domain Name Server option provides the list of DNS servers, and the Domain Name option provides the domain name.
- If the domain servers are not on the same subnet as the controller, static route entries are installed for each domain server. These static routes point to the gateway that is learned through the DHCP Router option.
- The host name of the controller is determined in this order by one of the following:
  - If the DHCP Host Name option was received, this information (truncated at the first period [.]) is used as the host name for the controller.
  - A reverse DNS lookup is performed on the controller IP address. If DNS returns a hostname, this name (truncated at the first period [.]) is used as the hostname for the controller.
- The IP address of the TFTP server is determined in this order by one of the following:
  - If AutoInstall received the DHCP TFTP Server Name option, AutoInstall performs a DNS lookup on this server name. If the DNS lookup is successful, the returned IP address is used as the IP address of the TFTP server.
  - If the DHCP Server Host Name (sname) text box is valid, AutoInstall performs a DNS lookup on this name. If the DNS lookup is successful, the IP address that is returned is used as the IP address of the TFTP server.
  - If AutoInstall received the DHCP TFTP Server Address option, this address is used as the IP address of the TFTP server.
  - AutoInstall performs a DNS lookup on the default TFTP server name (cisco-wlc-tftp). If the DNS lookup is successful, the IP address that is received is used as the IP address of the TFTP server.
  - If the DHCP server IP address (siaddr) text box is nonzero, this address is used as the IP address of the TFTP server.
  - The limited broadcast address (255.255.255.255) is used as the IP address of the TFTP server.
- If the TFTP server is not on the same subnet as the controller, a static route (/32) is installed for the IP address of the TFTP server. This static route points to the gateway that is learned through the DHCP Router option.

Note For more information on configuring DHCP on a controller, See the "Configuring DHCP" section on page 7-10.

Note For more information on configuring a TFTP server on a controller, see Chapter 10, "Managing Controller Software and Configurations."

Note For more information on configuring DHCP and TFTP servers through WCS, see Chapter 10 of the *Cisco Wireless Control System Configuration Guide, Release 7.0.172.0.*

Selecting a Configuration File

After the hostname and TFTP server have been determined, AutoInstall attempts to download a configuration file. AutoInstall performs three full download iterations on each interface that obtains a DHCP IP address. For example, if a Cisco 4400 Series Controller obtains DHCP IP addresses on both eth0 and dtl0, each interface tries to download a configuration. If the interface cannot download a configuration file successfully after three attempts, the interface does not attempt further.

The first configuration file that is downloaded and installed successfully triggers a reboot of the controller. After the reboot, the controller runs the newly downloaded configuration.

AutoInstall searches for configuration files in the order in which the names are listed:

- The filename that is provided by the DHCP Boot File Name option
- The filename that is provided by the DHCP File text box
- *host name*-confg
- *host name*.cfg
- *base MAC address*-confg (for example, 0011.2233.4455-confg)
- *serial number*-confg
- ciscowlc-confg
- ciscowlc.cfg

AutoInstall runs through this list until it finds a configuration file. It stops running if it does not find a configuration file after it cycles through this list three times on each registered interface.

Note The downloaded configuration file can be a complete configuration, or it can be a minimal configuration that provides enough information for the controller to be managed by WCS. Full configuration can then be deployed directly from WCS.

Note For information about creating and uploading a configuration file that AutoInstall can obtain from a TFTP server, see Chapter 10, “Managing Controller Software and Configurations.”

Note WCS release 5.0 and later releases provide AutoInstall capabilities for controllers. A WCS administrator can create a filter that includes the host name, the MAC address, or the serial number of the controller and associate a group of templates (a configuration group) to this filter rule. WCS pushes the initial configuration to the controller when the controller boots up initially. After the controller is discovered, WCS pushes the templates that are defined in the configuration group. For more information about the AutoInstall feature and WCS, see Chapter 15 of the *Cisco Wireless Control System Configuration Guide, Release 7.0.172.0*.

Example of AutoInstall Operation

The following is an example of an AutoInstall process from start to finish:

```
Welcome to the Cisco Wizard Configuration Tool
Use the '-' character to backup
Would you like to terminate autoinstall? [yes]:
AUTO-INSTALL: starting now...
AUTO-INSTALL: interface 'service-port' - setting DHCP TFTP Filename ==> 'abcd-confg'
AUTO-INSTALL: interface 'service-port' - setting DHCP TFTP Server IP ==> 1.100.108.2
AUTO-INSTALL: interface 'service-port' - setting DHCP siaddr ==> 1.100.108.2
AUTO-INSTALL: interface 'service-port' - setting DHCP Domain Server[0] ==> 1.100.108.2
AUTO-INSTALL: interface 'service-port' - setting DHCP Domain Name ==> 'engtest.com'
AUTO-INSTALL: interface 'service-port' - setting DHCP yiaddr ==> 172.19.29.253
AUTO-INSTALL: interface 'service-port' - setting DHCP Netmask ==> 255.255.255.0
AUTO-INSTALL: interface 'service-port' - setting DHCP Gateway ==> 172.19.29.1
AUTO-INSTALL: interface 'service-port' registered
AUTO-INSTALL: interation 1 -- interface 'service-port'
AUTO-INSTALL: DNS reverse lookup 172.19.29.253 ===> 'wlc-1'
AUTO-INSTALL: hostname 'wlc-1'
AUTO-INSTALL: TFTP server 1.100.108.2 (from DHCP Option 150)
AUTO-INSTALL: attempting download of 'abcd-confg'
AUTO-INSTALL: TFTP status - 'TFTP Config transfer starting.' (2)
AUTO-INSTALL: interface 'management' - setting DHCP file ==> 'bootfile1'
AUTO-INSTALL: interface 'management' - setting DHCP TFTP Filename ==> 'bootfile2-confg'
AUTO-INSTALL: interface 'management' - setting DHCP siaddr ==> 1.100.108.2
AUTO-INSTALL: interface 'management' - setting DHCP Domain Server[0] ==> 1.100.108.2
AUTO-INSTALL: interface 'management' - setting DHCP Domain Server[1] ==> 1.100.108.3
AUTO-INSTALL: interface 'management' - setting DHCP Domain Server[2] ==> 1.100.108.4
AUTO-INSTALL: interface 'management' - setting DHCP Domain Name ==> 'engtest.com'
AUTO-INSTALL: interface 'management' - setting DHCP yiaddr ==> 1.100.108.238
AUTO-INSTALL: interface 'management' - setting DHCP Netmask ==> 255.255.254.0
AUTO-INSTALL: interface 'management' - setting DHCP Gateway ==> 1.100.108.1
AUTO-INSTALL: interface 'management' registered
AUTO-INSTALL: TFTP status - 'Config file transfer failed - Error from server: File not
found' (3)
AUTO-INSTALL: attempting download of 'wlc-1-confg'
AUTO-INSTALL: TFTP status - 'TFTP Config transfer starting.' (2)
AUTO-INSTALL: TFTP status - 'TFTP receive complete... updating configuration.' (2)
AUTO-INSTALL: TFTP status - 'TFTP receive complete... storing in flash.' (2)
AUTO-INSTALL: TFTP status - 'System being reset.' (2)
Resetting system
```

Managing the System Date and Time

If you did not configure the system date and time through the configuration wizard or if you want to change your configuration, you can follow the instructions in this section to configure the controller to obtain the date and time from a Network Time Protocol (NTP) server or to configure the date and time manually. Greenwich Mean Time (GMT) is used as the standard for setting the time zone on the controller.

Note If you are configuring wIPS, you must set the controller time zone to UTC.

Note Cisco Aironet lightweight access points might not connect to the controller if the date and time are not set properly. Set the current date and time on the controller before allowing the access points to connect to it.

Configuring an NTP Server to Obtain the Date and Time

Each NTP server IP address is added to the controller database. Each controller searches for an NTP server and obtains the current time upon reboot and at each user-defined polling interval (daily to weekly).

Use these commands to configure an NTP server to obtain the date and time:

- To specify the NTP server for the controller, enter this command:

  config time ntp server *index ip_address*

- To specify the polling interval (in seconds), enter this command:

  config time ntp *interval*

Configuring NTP Authentication

Starting in the 7.0.116.0 release, you can configure an authentication channel between the controller and the NTP server.

Using the GUI to Configure NTP Authentication

To configure NTP authentication using the controller GUI, perform these steps:

Step 1 Choose **Controller > NTP > Servers** to open the NTP Servers page.

Step 2 Click **New** to add an NTP server.

The NTP Servers > New page appears

Step 3 Select a server priority from the Server Index (Priority) from the drop-down list.

Step 4 Enter the NTP server IP Address in the Server IP Address text box.

Step 5 Enable NTP server authentication by selecting the **NTP Server Authentication** check box.

Step 6 Click **Apply**.

Step 7 Choose **Controller > NTP > Keys**

Step 8 Click **New** to create a key.

Step 9 Enter the key index in the Key Index text box.

Step 10 Select the key format from the Key Format drop-down list.

Step 11 Enter the Key in the Key text box.

Step 12 Click **Apply**.

Using the CLI to Configure NTP Authentication

To configure NTP authentication using the CLI, use the following commands:

- To enable or disable NTP authentication, use the following command:

Note By default MD5 is used.

  - **config time ntp auth enable** <*server-index*> <*key-index*>
  - **config time ntp auth disable** <*server-index*>
  - **config time ntp key-auth add** <*key-index*> **md5** <*key-format*> <*key*>
- To delete an authentication key, use the following command:

  config time ntp key-auth delete <key-index>
- To view the list of NTP key Indices, use the following command:

  show ntp-keys

Configuring the Date and Time Manually

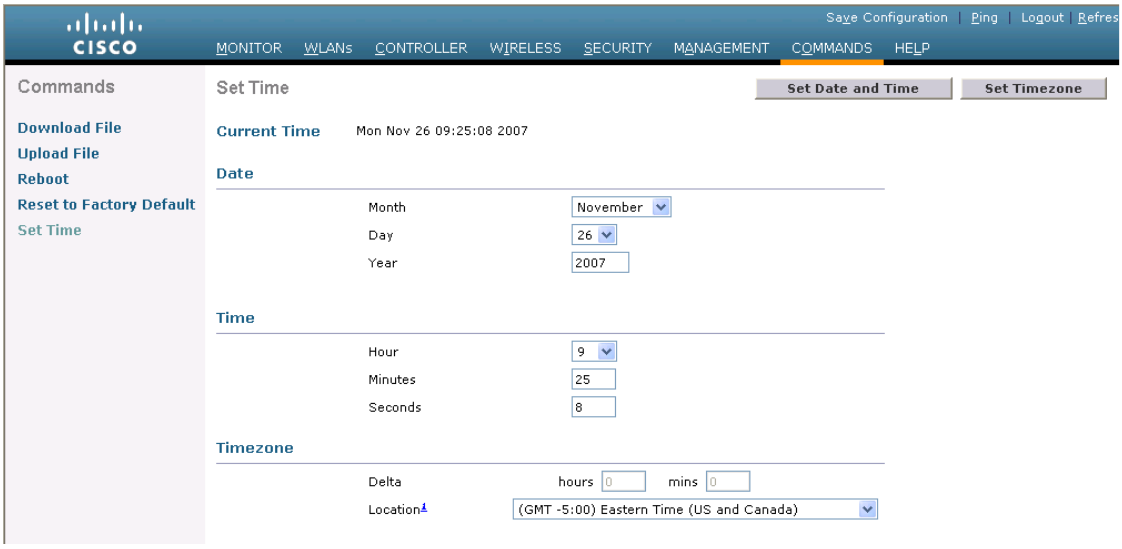
This section describes how to configure the date and time manually using the controller GUI or CLI.

Using the GUI to Configure the Date and Time

To configure the local date and time using the controller GUI, follow these steps:

Step 1 Choose **Commands > Set Time** to open the Set Time page (see Figure 2-15).

Figure 2-15 Set Time Page



The current date and time appear at the top of the page.

Step 2 In the Timezone area, choose your local time zone from the Location drop-down list.

Note When you choose a time zone that uses Daylight Saving Time (DST), the controller automatically sets its system clock to reflect the time change when DST occurs. In the United States, DST starts on the second Sunday in March and ends on the first Sunday in November.

Note You cannot set the time zone delta on the controller GUI. However, if you do so on the controller CLI, the change is reflected in the Delta Hours and Mins text boxes on the controller GUI.

Step 3 Click **Set Timezone** to apply your changes.

Step 4 In the Date area, choose the current local month and day from the Month and Day drop-down lists, and enter the year in the Year text box.

Step 5 In the Time area, choose the current local hour from the Hour drop-down list, and enter the minutes and seconds in the Minutes and Seconds text boxes.

Note If you change the time zone location after setting the date and time, the values in the Time area are updated to reflect the time in the new time zone location. For example, if the controller is currently configured for noon Eastern time and you change the time zone to Pacific time, the time automatically changes to 9:00 a.m.

Step 6 Click **Set Date and Time** to apply your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure the Date and Time

To configure the local date and time using the controller CLI, follow these steps:

Step 1 To configure the current local date and time in GMT on the controller, enter this command:

config time manual *mm/dd/yy hh:mm:ss*

Note When setting the time, the current local time is entered in terms of GMT and as a value between 00:00 and 24:00. For example, if it is 8:00 a.m. Pacific time in the United States, you would enter 16:00 because the Pacific time zone is 8 hours behind GMT.

Step 2 Perform one of the following to set the time zone for the controller:

- To set the time zone location in order to have Daylight Saving Time (DST) set automatically when it occurs, enter this command:

  config time timezone location *location_index*

  where *location_index* is a number representing one of the following time zone locations:

  1. (GMT-12:00) International Date Line West

  2. (GMT-11:00) Samoa

3. (GMT-10:00) Hawaii
4. (GMT-9:00) Alaska
5. (GMT-8:00) Pacific Time (US and Canada)
6. (GMT-7:00) Mountain Time (US and Canada)
7. (GMT-6:00) Central Time (US and Canada)
8. (GMT-5:00) Eastern Time (US and Canada)
9. (GMT-4:00) Atlantic Time (Canada)
10. (GMT-3:00) Buenos Aires (Argentina)
11. (GMT-2:00) Mid-Atlantic
12. (GMT-1:00) Azores
13. (GMT) London, Lisbon, Dublin, Edinburgh (default value)
14. (GMT +1:00) Amsterdam, Berlin, Rome, Vienna
15. (GMT +2:00) Jerusalem
16. (GMT +3:00) Baghdad
17. (GMT +4:00) Muscat, Abu Dhabi
18. (GMT +4:30) Kabul
19. (GMT +5:00) Karachi, Islamabad, Tashkent
20. (GMT +5:30) Colombo, Kolkata, Mumbai, New Delhi
21. (GMT +5:45) Katmandu
22. (GMT +6:00) Almaty, Novosibirsk
23. (GMT +6:30) Rangoon
24. (GMT +7:00) Saigon, Hanoi, Bangkok, Jakarta
25. (GMT +8:00) Hong Kong, Beijing, Chongqing
26. (GMT +9:00) Tokyo, Osaka, Sapporo
27. (GMT +9:30) Darwin
28. (GMT+10:00) Sydney, Melbourne, Canberra
29. (GMT+11:00) Magadan, Solomon Is., New Caledonia
30. (GMT+12:00) Kamchatka, Marshall Is., Fiji
31. (GMT+12:00) Auckland (New Zealand)

Note If you enter this command, the controller automatically sets its system clock to reflect DST when it occurs. In the United States, DST starts on the second Sunday in March and ends on the first Sunday in November.

- To manually set the time zone so that DST is not set automatically, enter this command:

  config time timezone *delta_hours delta_mins*

  where *delta_hours* is the local hour difference from GMT, and *delta_mins* is the local minute difference from GMT.

When manually setting the time zone, enter the time difference of the local current time zone with respect to GMT (+/–). For example, Pacific time in the United States is 8 hours behind GMT. Therefore, it is entered as –8.

Note You can manually set the time zone and prevent DST from being set only on the controller CLI.

Step 3 To save your changes, enter this command:

save config

Step 4 To verify that the controller shows the current local time with respect to the local time zone, enter this command:

show time

Information similar to the following appears:

```
Time..................................... Thu Apr  7 13:56:37 2011
Timezone delta........................... 0:0
Timezone location....................... (GMT +5:30) Colombo, New Delhi, Chennai, Kolkata

NTP Servers
    NTP Polling Interval.........................     3600

     Index     NTP Key Index     NTP Server      NTP Msg Auth Status
    -------  ------------------------------------------------------------
       1              1           209.165.200.225  AUTH SUCCESS
```

Note If you configured the time zone location, the Timezone Delta value is set to "0:0." If you manually configured the time zone using the time zone delta, the Timezone Location is blank.

Configuring Telnet and SSH Sessions

Telnet is a network protocol used to provide access to the controller's CLI. Secure Shell (SSH) is a more secure version of Telnet that uses data encryption and a secure channel for data transfer. You can use the controller GUI or CLI to configure Telnet and SSH sessions.

Note Only the FIPS approved algorithm aes128-cbc is supported when using SSH to control WLANs.

Note See the "Troubleshooting" section on page D-1 for instructions on using Telnet or SSH to troubleshoot lightweight access points.

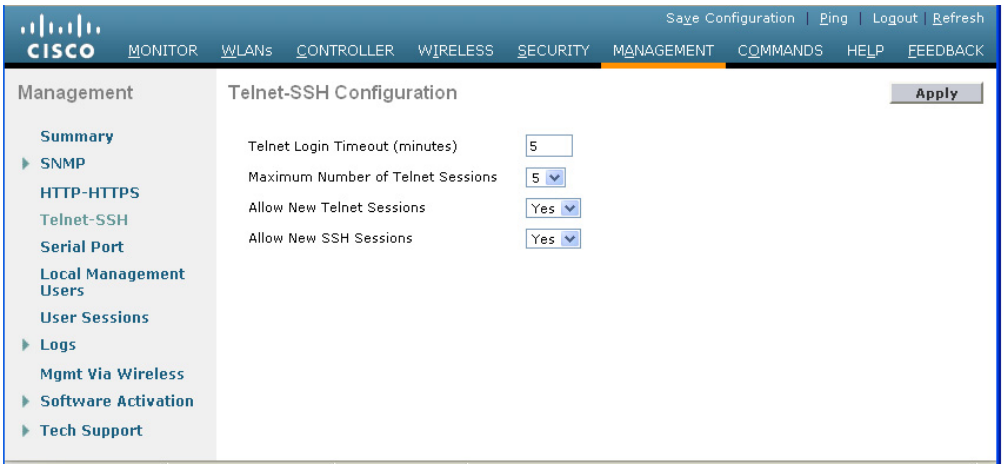
Note The controller does not support raw Telnet mode.

Using the GUI to Configure Telnet and SSH Sessions

To configure Telnet and SSH using the controller GUI, follow these steps:

Step 1 Choose **Management** > **Telnet-SSH** to open the Telnet-SSH Configuration page (see Figure 2-16).

Figure 2-16 Telnet-SSH Configuration Page



Step 2 In the Telnet Login Timeout text box, enter the number of minutes that a Telnet session is allowed to remain inactive before being terminated. The valid range is 0 to 160 minutes (inclusive), and the default value is 5 minutes. A value of 0 indicates no timeout.

Step 3 From the Maximum Number of Sessions drop-down list, choose the number of simultaneous Telnet or SSH sessions allowed. The valid range is 0 to 5 sessions (inclusive), and the default value is 5 sessions. A value of zero indicates that Telnet/SSH sessions are disallowed.

Step 4 From the Allow New Telnet Sessions drop-down list, choose **Yes** or **No** to allow or disallow new Telnet sessions on the controller. The default value is No.

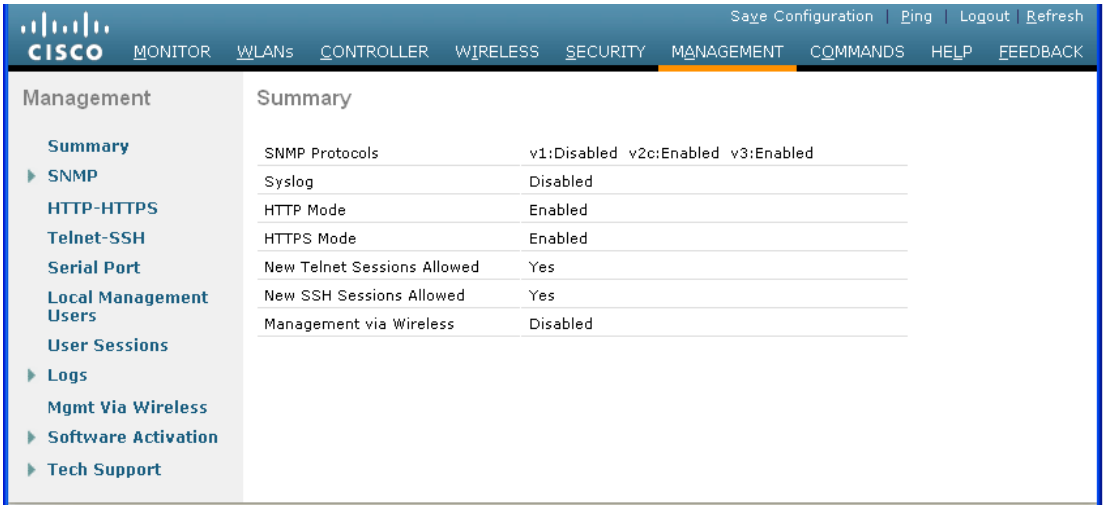
Step 5 From the Allow New SSH Sessions drop-down list, choose **Yes** or **No** to allow or disallow new SSH sessions on the controller. The default value is Yes.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Step 8 To see a summary of the Telnet configuration settings, choose **Management** > **Summary**. The Summary page appears (see Figure 2-17).

Figure 2-17 Summary Page



This page shows whether additional Telnet and SSH sessions are permitted.

Using the CLI to Configure Telnet and SSH Sessions

To configure Telnet and SSH sessions using the controller CLI, follow these steps:

Step 1 To allow or disallow new Telnet sessions on the controller, enter this command:

config network telnet {**enable** | **disable**}

The default value is disabled.

Step 2 To allow or disallow new SSH sessions on the controller, enter this command:

config network ssh {**enable** | **disable**}

The default value is enabled.

Step 3 To specify the number of minutes that a Telnet session is allowed to remain inactive before being terminated, enter this command:

config sessions timeout *timeout*

where *timeout* is a value between 0 and 160 minutes (inclusive). The default value is 5 minutes. A value of 0 indicates no timeout.

Step 4 To specify the number of simultaneous Telnet or SSH sessions allowed, enter this command:

config sessions maxsessions *session_num*

where *session_num* is a value between 0 and 5 (inclusive). The default value is 5 sessions. A value of zero indicates that Telnet/SSH sessions are disallowed.

Step 5 To save your changes, enter this command:

save config

Step 6 To see the Telnet and SSH configuration settings, enter this command:

show network summary

Information similar to the following appears:

```
RF-Network Name.............................. TestNetwork1
Web Mode..................................... Enable
Secure Web Mode.............................. Enable
Secure Web Mode Cipher-Option High.......... Disable
Secure Web Mode Cipher-Option SSLv2......... Enable
Secure Shell (ssh)........................... Enable
Telnet....................................... Disable
...
```

Step 7 To see the Telnet session configuration settings, enter this command:

show sessions

Information similar to the following appears:

```
CLI Login Timeout (minutes)............ 5
Maximum Number of CLI Sessions....... 5
```

Step 8 To see all active Telnet sessions, enter this command:

show loginsession

Information similar to the following appears:

```
ID    User Name     Connection From   Idle Time    Session Time
-- ---------------  ---------------  ------------  ------------
00      admin          EIA-232     00:00:00      00:19:04
```

Step 9 If you ever want to close all active Telnet sessions or a specific Telnet session, enter this command:

config loginsession close {**all** | *session_id*}

Enabling Wireless Connections to the GUI and CLI

You can monitor and configure controllers using a wireless client. This feature is supported for all management tasks except uploads from and downloads to the controller.

Before you can open the GUI or the CLI from a wireless client device, you must configure the controller to allow the connection.

To enable wireless connections to the GUI or CLI, follow these steps:

Step 1 Log into the CLI.

Step 2 Enter **config network mgmt-via-wireless enable**.

Step 3 Use a wireless client to associate to a lightweight access point connected to the controller.

Step 4 On the wireless client, open a Telnet session to the controller, or browse to the controller GUI.

Tip To use the controller GUI to enable wireless connections, choose **Management > Mgmt Via Wireless** page and select the **Enable Controller Management to be accessible from Wireless Clients** check box.

CHAPTER 3

Configuring Ports and Interfaces

This chapter describes the controller's physical ports and interfaces and provides instructions for configuring them. It contains these sections:

Overview of Ports and Interfaces

Three concepts are key to understanding how controllers connect to a wireless network: ports, interfaces, and WLANs.

Ports

A port is a physical entity that is used for connections on the controller platform. Controllers have two types of ports: distribution system ports and a service port. Figure 3-1 through Figure 3-4 show the ports available on each controller.

Note The controller in a Cisco Integrated Services Router and the controllers on the Cisco WiSM do not have external physical ports. They connect to the network through ports on the router or switch.

Figure 3-1 Ports on the Cisco 2100 Series Wireless LAN Controllers

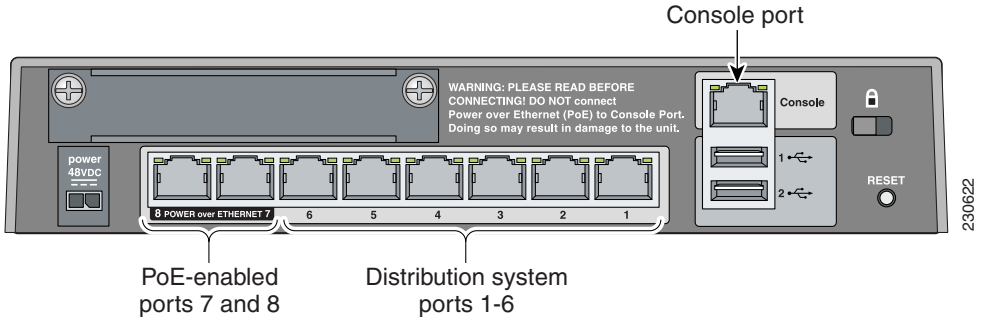
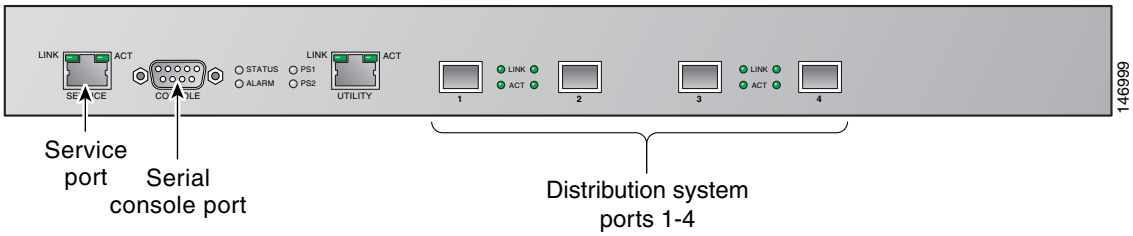
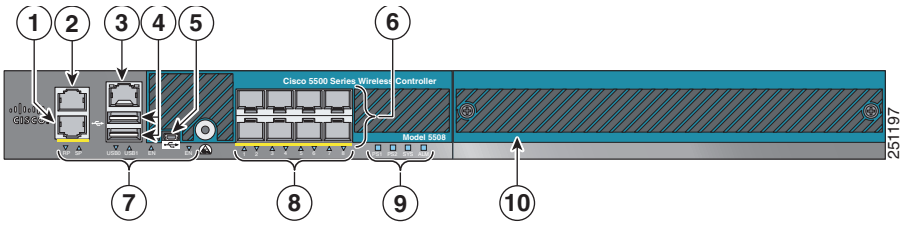


Figure 3-2 Ports on the Cisco 4400 Series Wireless LAN Controllers



Note Figure 3-2 shows a Cisco 4404 Controller. The Cisco 4402 Controller is similar but has only two distribution system ports. The utility port, which is the unlabeled port in Figure 3-2, is currently not operational.

Figure 3-3 Ports on the Cisco 5500 Series Wireless LAN Controllers



1	Redundant port for future use (RJ-45)	**6**	SFP distribution system ports 1–8
2	Service port (RJ-45)	**7**	Management port LEDs
3	Console port (RJ-45)[1]	**8**	SFP distribution port Link and Activity LEDs
4	USB ports 0 and 1 (Type A)	**9**	Power supply (PS1 and PS2), System (SYS), and Alarm (ALM) LEDs
5	Console port (Mini USB Type B)[1]	**10**	Expansion module slot

1. You can use only one console port (either RJ-45 or mini USB). When you connect to one console port, the other is disabled.

Figure 3-4 Ports on the Catalyst 3750G Integrated Wireless LAN Controller Switch

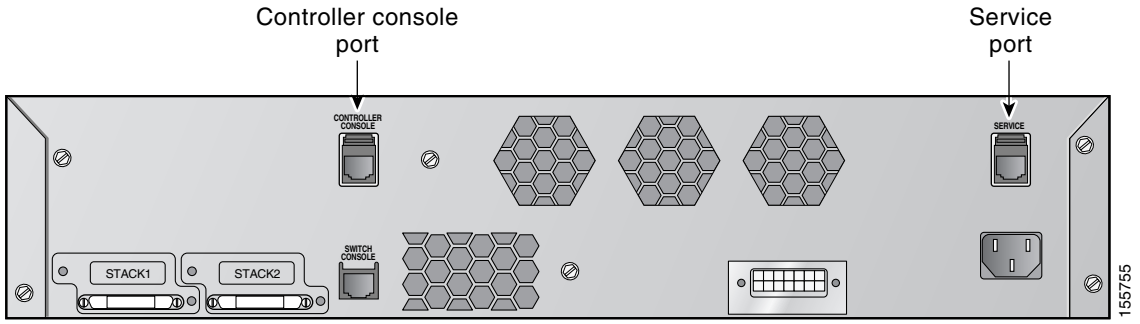


Table 3-1 provides a list of ports per controller.

Table 3-1 Controller Ports

Controller	Service Ports	Distribution System Ethernet Ports	Serial Console Port
2100 series	None	8 (6 + 2 PoE ports)	1
4402	1	2	1
4404	1	4	1
5508	1	8 (ports 1–8)	1
Cisco WiSM	2 (ports 9 and 10)	8 (ports 1–8)	2
Controller Network Module within the Cisco 28/37/38xx Series Integrated Services Routers	None	1	1[1]
Catalyst 3750G Integrated Wireless LAN Controller Switch	1	2 (ports 27 and 28)	1

1. The baud rate for the Gigabit Ethernet version of the controller network module is limited to 9600 bps while the baud rate for the Fast Ethernet version supports up to 57600 bps.

Note Appendix E provides logical connectivity diagrams and related software commands for the integrated controllers.

Distribution System Ports

A distribution system port connects the controller to a neighbor switch and serves as the data path between these two devices.

- Cisco 2100 Series Controllers have eight 10/100 copper Ethernet distribution system ports through which the controller can support up to 6, 12, or 25 access points. Two of these ports (7 and 8) are power-over-Ethernet (PoE) enabled and can be used to provide power directly to access points that are connected to these ports.

Note All client connections to the Cisco 2100 Series Controller are limited to the 10/100 Ethernet uplink port connection between the switch and the controller, even though their connection speeds might be higher. The exception is for access points running in local hybrid-REAP mode because this traffic is switched at the access point level and not forwarded back to the controller.

- Cisco 4402 Controllers have two Gigabit Ethernet distribution system ports, each of which is capable of managing up to 48 access points. However, we recommend no more than 25 access points per port due to bandwidth constraints. The 4402-25 and 4402-50 models allow a total of 25 or 50 access points to join the controller.
- Cisco 4404 Controllers have four Gigabit Ethernet distribution system ports, each of which is capable of managing up to 48 access points. However, we recommend no more than 25 access points per port due to bandwidth constraints. The 4404-25, 4404-50, and 4404-100 models allow a total of 25, 50, or 100 access points to join the controller.

Note The Gigabit Ethernet ports on the Cisco 4402 and 4404 Controllers accept these SX/LC/T small form-factor plug-in (SFP) modules:
- 1000BASE-SX SFP modules, which provide a 1000-Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector
- 1000BASE-LX SFP modules, which provide a 1000-Mbps wired connection to a network through a 1300nM (LX/LH) fiber-optic link using an LC physical connector
- 1000BASE-T SFP modules, which provide a 1000-Mbps wired connection to a network through a copper link using an RJ-45 physical connector

- Cisco 5508 Controllers have eight Gigabit Ethernet distribution system ports, through which the Controller can manage multiple access points. The 5508-12, 5508-25, 5508-50, 5508-100, and 5508-250 models allow a total of 12, 25, 50, 100, or 250 access points to join the controller. Cisco 5508 controllers have no restrictions on the number of access points per port. However, we recommend using link aggregation (LAG) or configuring dynamic AP-manager interfaces on each Gigabit Ethernet port to automatically balance the load. If more than 100 access points are connected to the Cisco 5500 Series Controller, make sure that more than one Gigabit Ethernet interface is connected to the upstream switch.

Note The Gigabit Ethernet ports on the Cisco 5508 Controllers accept these SX/LC/T small form-factor plug-in (SFP) modules:
- 1000BASE-SX SFP modules, which provide a 1000-Mbps wired connection to a network through an 850nM (SX) fiber-optic link using an LC physical connector
- 1000BASE-LX SFP modules, which provide a 1000-Mbps wired connection to a network through a 1300nM (LX/LH) fiber-optic link using an LC physical connector
- 1000BASE-T SFP modules, which provide a 1000-Mbps wired connection to a network through a copper link using an RJ-45 physical connector

- The Catalyst 6500 series switch Wireless Services Module (WiSM) and the Cisco 7600 series router Wireless Services Module (WiSM) have eight internal Gigabit Ethernet distribution system ports (ports 1 through 8) that connect the switch or router and the integrated controller. These internal ports are located on the backplane of the switch or router and are not visible on the front panel. Through these ports, the controller can support up to 300 access points.

- The controller network module within the Cisco 28/37/38xx Series Integrated Services Router can support up to 6, 8, 12, or 25 access points (and up to 256, 256, 350, or 350 clients, respectively), depending on the version of the network module. The network module supports these access points through a Fast Ethernet distribution system port (on the NM-AIR-WLC6-K9 6-access-point version) or a Gigabit Ethernet distribution system port (on the 8-, 12-, and 25-access-point versions and on the NME-AIR-WLC6-K9 6-access-point version) that connects the router and the integrated controller. This port is located on the router backplane and is not visible on the front panel. The Fast Ethernet port operates at speeds up to 100 Mbps, and the Gigabit Ethernet port operates at speeds up to 1 Gbps.
- The Catalyst 3750G Integrated Wireless LAN Controller Switch has two internal Gigabit Ethernet distribution system ports (ports 27 and 28) that connect the switch and the integrated controller. These internal ports are located on the switch backplane and are not visible on the front panel. Each port is capable of managing up to 48 access points. However, we recommend no more than 25 access points per port due to bandwidth constraints. The -S25 and -S50 models allow a total of 25 or 50 access points to join the controller.

Note See the "Choosing Between Link Aggregation and Multiple AP-Manager Interfaces" section on page 3-36 if you want to configure your Cisco 4400 Series Controller to support more than 48 access points.

Each distribution system port is, by default, an 802.1Q VLAN trunk port. The VLAN trunking characteristics of the port are not configurable.

Note Some controllers support link aggregation (LAG), which bundles all of the controller's distribution system ports into a single 802.3ad port channel. Cisco 4400 Series Controllers support LAG in software release 3.2 or later releases, Cisco 5500 Series Controllers support LAG in software release 6.0 or later releases, and LAG is enabled automatically on the controllers within the Cisco WiSM and the Catalyst 3750G Integrated Wireless LAN Controller Switch. See the "Enabling Link Aggregation" section on page 3-36 for more information.

Service Port

Cisco 4400 and Cisco 5500 Series Controllers also have a 10/100/1000 copper Ethernet service port. The service port is controlled by the service-port interface and is reserved for out-of-band management of the controller and system recovery and maintenance in the event of a network failure. It is also the only port that is active when the controller is in boot mode. The service port is not capable of carrying 802.1Q tags, so it must be connected to an access port on the neighbor switch. Use of the service port is optional.

Note The Cisco WiSM's controllers use the service port for internal protocol communication between the controllers and the Supervisor 720.

Note The Cisco 2100 Series Controller and the controller in the Cisco Integrated Services Router do not have a service port.

Note The service port is not autosensing. You must use the correct straight-through or crossover Ethernet cable to communicate with the service port.

Caution Do not configure wired clients in the same VLAN or subnet of the service port on the network. If you configure wired clients on the same subnet or VLAN as the service port, you will not be able to access the management interface.

Interfaces

An interface is a logical entity on the controller. An interface has multiple parameters associated with it, including an IP address, default gateway (for the IP subnet), primary physical port, secondary physical port, VLAN identifier, and DHCP server.

These five types of interfaces are available on the controller. Four of these are static and are configured at setup time:

- Management interface (static and configured at setup time; mandatory)
- AP-manager interface (static and configured at setup time; mandatory)

  Note You are not required to configure an AP-manager interface on Cisco 5500 Series Controllers.

- Virtual interface (static and configured at setup time; mandatory)
- Service-port interface (static and configured at setup time; optional)
- Dynamic interface (user-defined)

Each interface is mapped to at least one primary port, and some interfaces (management and dynamic) can be mapped to an optional secondary (or backup) port. If the primary port for an interface fails, the interface automatically moves to the backup port. In addition, multiple interfaces can be mapped to a single controller port.

Note For Cisco 5500 Series Controllers in a non-link-aggregation (non-LAG) configuration, the management interface must be on a different VLAN than any dynamic AP-manager interface. Otherwise, the management interface cannot fail over to the port that the AP-manager is on.

Note Cisco 5500 Series Controllers do not support fragmented pings on any interface. Similarly, Cisco 4400 Series Controllers, the Cisco WiSM, and the Catalyst 3750G Integrated Wireless LAN Controller Switch do not support fragmented pings on the AP-manager interface.

Note See the "Enabling Link Aggregation" section on page 3-36 if you want to configure the controller to dynamically map the interfaces to a single port channel rather than having to configure primary and secondary ports for each interface.

Management Interface

The management interface is the default interface for in-band management of the controller and connectivity to enterprise services such as AAA servers. It is also used for communications between the controller and access points. The management interface has the only consistently "pingable" in-band interface IP address on the controller. You can access the controller's GUI by entering the controller's management interface IP address in Internet Explorer's or Mozilla Firefox's address field.

For CAPWAP, the controller requires one management interface to control all inter-controller communications and one AP-manager interface to control all controller-to-access point communications, regardless of the number of ports.

Note If the service port is in use, the management interface must be on a different supernet from the service-port interface.

Caution Do not map a guest WLAN to the management interface. If the EoIP tunnel breaks, the client could obtain an IP and be placed on the management subnet.

Caution Do not configure wired clients in the same VLAN or subnet of the service port on the network. If you configure wired clients on the same subnet or VLAN as the service port, you will not be able to access the management interface.

AP-Manager Interface

A controller has one or more AP-manager interfaces, which are used for all Layer 3 communications between the controller and lightweight access points after the access points have joined the controller. The AP-manager IP address is used as the tunnel source for CAPWAP packets from the controller to the access point and as the destination for CAPWAP packets from the access point to the controller.

Note For Cisco 5500 Series Controllers, you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default, and the access points can join on this interface.

Note The Controller does not support transmitting the jumbo frames. To avoid having the controller transmit CAPWAP packets to the AP that will necessitate fragmentation and reassembly, reduce MTU/MSS on the client side.

Note With the 7.0.116.0 release onwards, the MAC address of the management interface and the AP-manager interface is the same as the base LAG MAC address.

The AP-manager interface communicates through any distribution system port by listening across the Layer 3 network for access point CAPWAP or LWAPP join messages to associate and communicate with as many lightweight access points as possible.

For Cisco 4404 and WiSM Controllers, configure the AP-manager interface on all distribution system ports (1, 2, 3, and 4). For Cisco 4402 Controllers, configure the AP-manager interface on distribution system ports 1 and 2. In both cases, the static (or permanent) AP-manager interface is always assigned to distribution system port 1 and given a unique IP address. Configuring the AP-manager interface on the same VLAN or IP subnet as the management interface results in optimum access point association.

Note If only one distribution system port can be used, you should use distribution system port 1.

If link aggregation (LAG) is enabled, there can be only one AP-manager interface. But when LAG is disabled, one or more AP-manager interfaces can be created, generally one per physical port.

Note The Cisco 2100 Series Controllers do not support LAG.

Note Port redundancy for the AP-manager interface is not supported. You cannot map the AP-manager interface to a backup port.

Note See the "Configuring Multiple AP-Manager Interfaces" section on page 3-42 for information on creating and using multiple AP-manager interfaces.

Virtual Interface

The virtual interface is used to support mobility management, Dynamic Host Configuration Protocol (DHCP) relay, and embedded Layer 3 security such as guest web authentication and VPN termination. It also maintains the DNS gateway host name used by Layer 3 security and mobility managers to verify the source of certificates when Layer 3 web authorization is enabled.

Specifically, the virtual interface plays these two primary roles:

- Acts as the DHCP server placeholder for wireless clients that obtain their IP address from a DHCP server.
- Serves as the redirect address for the web authentication login page.

Note See Chapter 6, "Configuring Security Solutions," for additional information on web authentication.

The virtual interface IP address is used only in communications between the controller and wireless clients. It never appears as the source or destination address of a packet that goes out a distribution system port and onto the switched network. For the system to operate correctly, the virtual interface IP address must be set (it cannot be 0.0.0.0), and no other device on the network can have the same address as the virtual interface. Therefore, the virtual interface must be configured with an unassigned and unused gateway IP address. The virtual interface IP address is not pingable and should not exist in any routing table in your network. In addition, the virtual interface cannot be mapped to a backup port.

Note All controllers within a mobility group must be configured with the same virtual interface IP address. Otherwise, inter-controller roaming may appear to work, but the handoff does not complete, and the client loses connectivity for a period of time.

Service-Port Interface

The service-port interface controls communications through and is statically mapped by the system to the service port. The service port can obtain an IP address using DHCP, or it can be assigned a static IP address, but a default gateway cannot be assigned to the service-port interface. Static routes can be defined through the controller for remote network access to the service port.

Note Only Cisco 4400 and Cisco 5500 Series Controllers have a service-port interface.

Note You must configure an IP address on the service-port interface of both Cisco WiSM controllers. Otherwise, the neighbor switch is unable to check the status of each controller.

Dynamic Interface

Dynamic interfaces, also known as VLAN interfaces, are created by users and designed to be analogous to VLANs for wireless LAN clients. A controller can support up to 512 dynamic interfaces (VLANs). Each dynamic interface is individually configured and allows separate communication streams to exist on any or all of a controller's distribution system ports. Each dynamic interface controls VLANs and other communications between controllers and all other network devices, and each acts as a DHCP relay for wireless clients associated to WLANs mapped to the interface. You can assign dynamic interfaces to distribution system ports, WLANs, the Layer 2 management interface, and the Layer 3 AP-manager interface, and you can map the dynamic interface to a backup port.

You can configure zero, one, or multiple dynamic interfaces on a distribution system port. However, all dynamic interfaces must be on a different VLAN or IP subnet from all other interfaces configured on the port. If the port is untagged, all dynamic interfaces must be on a different IP subnet from any other interface configured on the port.

Note A controller's WLAN dynamic interface and all wireless clients in the WLAN that are local to the controller must have IP addresses in the same subnet.

Note We recommend using tagged VLANs for dynamic interfaces.

Dynamic AP Management

A dynamic interface is created as a WLAN interface by default. However, any dynamic interface can be configured as an AP-manager interface, with one AP-manager interface allowed per physical port. A dynamic interface with the Dynamic AP Management option enabled is used as the tunnel source for packets from the controller to the access point and as the destination for CAPWAP packets from the access point to the controller. The dynamic interfaces for AP management must have a unique IP address and are usually configured on the same subnet as the management interface.

Note If link aggregation (LAG) is enabled, there can be only one AP-manager interface.

We recommend having a separate dynamic AP-manager interface per controller port. See the "Configuring Multiple AP-Manager Interfaces" section on page 3-42 for instructions on configuring multiple dynamic AP-manager interfaces.

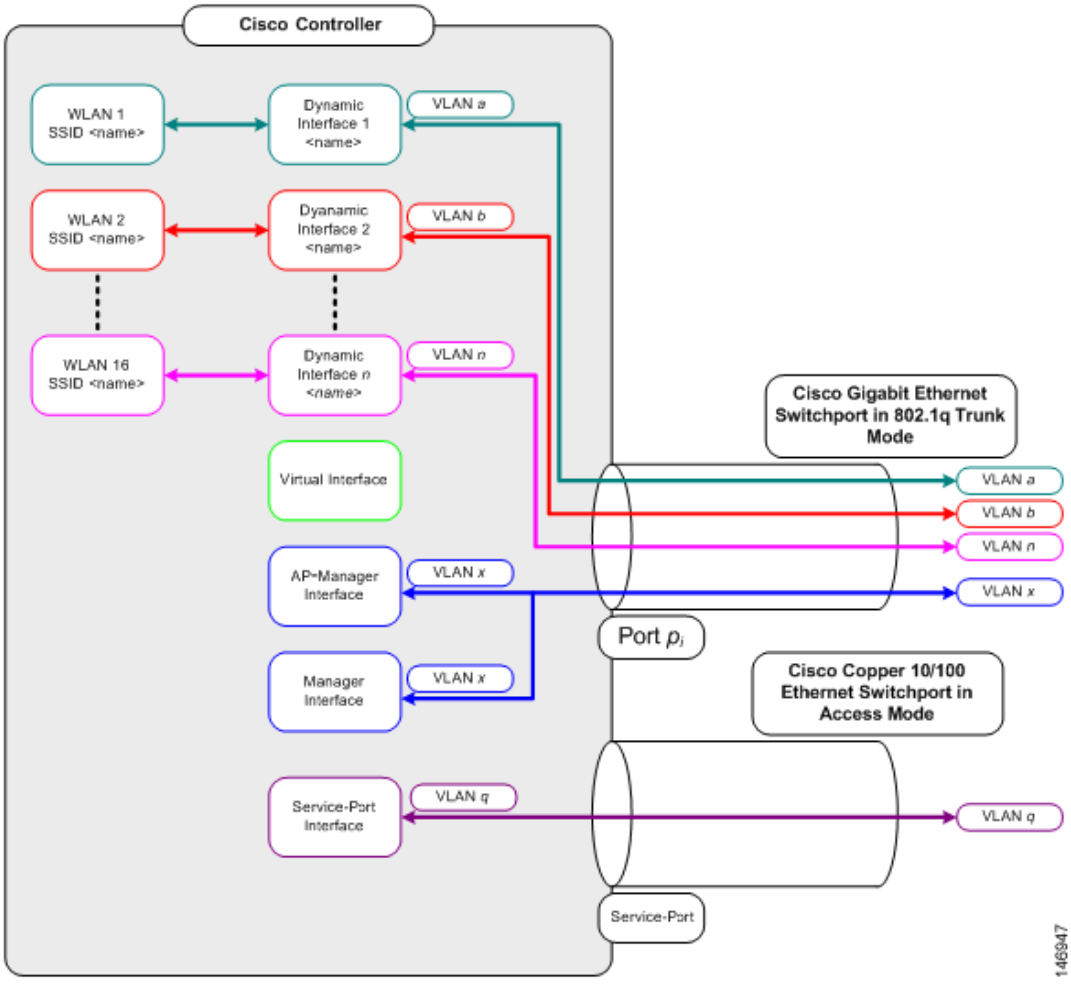
WLANs

A WLAN associates a service set identifier (SSID) to an interface. It is configured with security, quality of service (QoS), radio policies, and other wireless network parameters. Up to 512 access point WLANs can be configured per controller.

Note Chapter 7, "Configuring WLANs," provides instructions for configuring WLANs.

Figure 3-5 shows the relationship between ports, interfaces, and WLANs.

Figure 3-5 Ports, Interfaces, and WLANs



As shown in Figure 3-5, each controller port connection is an 802.1Q trunk and should be configured as such on the neighbor switch. On Cisco switches, the native VLAN of an 802.1Q trunk is an untagged VLAN. If you configure an interface to use the native VLAN on a neighboring Cisco switch, make sure you configure the interface on the controller to be untagged.

Note A zero value for the VLAN identifier (on the Controller > Interfaces page) means that the interface is untagged.

The default (untagged) native VLAN on Cisco switches is VLAN 1. When controller interfaces are configured as tagged (meaning that the VLAN identifier is set to a nonzero value), the VLAN must be allowed on the 802.1Q trunk configuration on the neighbor switch and not be the native untagged VLAN.

We recommend that tagged VLANs be used on the controller. You should also allow only relevant VLANs on the neighbor switch's 802.1Q trunk connections to controller ports. All other VLANs should be disallowed or pruned in the switch port trunk configuration. This practice is extremely important for optimal performance of the controller.

Note We recommend that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that controllers properly route VLAN traffic.

Configuring the Management, AP-Manager, Virtual, and Service-Port Interfaces

Typically, you define the management, AP-manager, virtual, and service-port interface parameters using the Startup Wizard. However, you can display and configure interface parameters through either the GUI or CLI after the controller is running.

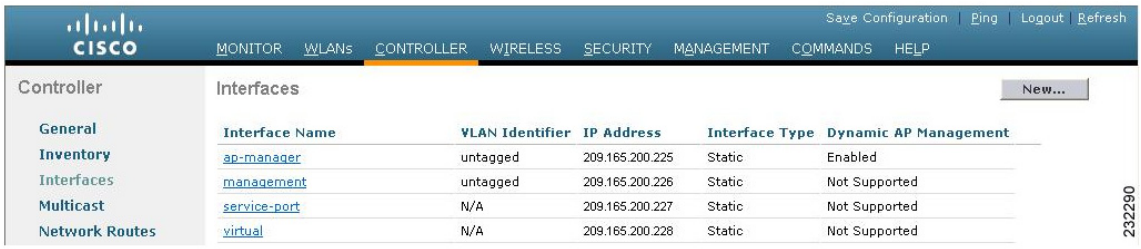
Note When assigning a WLAN to a DHCP server, both should be on the same subnet. Otherwise, you need to use a router to route traffic between the WLAN and the DHCP server.

Using the GUI to Configure the Management, AP-Manager, Virtual, and Service-Port Interfaces

To display and configure the management, AP-manager, virtual, and service-port interface parameters using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Interfaces** to open the Interfaces page (see Figure 3-6).

Figure 3-6 Interfaces Page



This page shows the current controller interface settings.

Step 2 If you want to modify the settings of a particular interface, click the name of the interface. The Interfaces > Edit page for that interface appears.

Step 3 Configure the following parameters for each interface type:

Management Interface

Note The management interface uses the controller's factory-set distribution system MAC address.

- Quarantine and quarantine VLAN ID, if applicable

Note Select the **Quarantine** check box if you want to configure this VLAN as unhealthy or you want to configure network access control (NAC) out-of-band integration. Doing so causes the data traffic of any client that is assigned to this VLAN to pass through the controller. See Chapter 7, "Configuring WLANs," for more information about NAC out-of-band integration.

- NAT address (only for Cisco 5500 Series Controllers configured for dynamic AP management)

Note Select the **Enable NAT Address** check box and enter the external NAT IP address if you want to be able to deploy your Cisco 5500 Series Controller behind a router or other gateway device that is using one-to-one mapping network address translation (NAT). NAT allows a device, such as a router, to act as an agent between the Internet (public) and a local network (private). In this case, it maps the controller's intranet IP addresses to a corresponding external address. The controller's dynamic AP-manager interface must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

Note The NAT parameters are supported for use only with one-to-one-mapping NAT, where each private client has a direct and fixed mapping to a global address. The NAT parameters do not support one-to-many NAT, which uses source port mapping to enable a group of clients to be represented by a single IP address.

Note If a Cisco 5500 Series Controller is configured with an external NAT IP address under the management interface, the APs in local mode cannot associate with the controller. The workaround is to either ensure that the management interface has a globally valid IP address or ensure that external NAT IP address is valid internally for the local APs.

- VLAN identifier

Note Enter **0** for an untagged VLAN or a nonzero value for a tagged VLAN. We recommend using tagged VLANs for the management interface.

- Fixed IP address, IP netmask, and default gateway
- Dynamic AP management (for Cisco 5500 Series Controllers only)

Note For Cisco 5500 Series Controllers, the management interface acts like an AP-manager interface by default. If desired, you can disable the management interface as an AP-manager interface and create another dynamic interface as an AP manager.

- Physical port assignment (for all controllers except the Cisco 5500 Series Controller)
- Primary and secondary DHCP servers
- Access control list (ACL) setting, if required

Note To create ACLs, follow the instructions in Chapter 6, "Configuring Security Solutions."

AP-Manager Interface

Note For Cisco 5500 Series Controllers, you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default.

- Physical port assignment
- VLAN identifier

Note Enter **0** for an untagged VLAN or a nonzero value for a tagged VLAN. We recommend using tagged VLANs for the AP-manager interface.

- Fixed IP address, IP netmask, and default gateway

Note The AP-manager interface's IP address must be different from the management interface's IP address and may or may not be on the same subnet as the management interface. However, we recommend that both interfaces be on the same subnet for optimum access point association.

- Primary and secondary DHCP servers
- Access control list (ACL) name, if required

Note To create ACLs, follow the instructions in Chapter 6, "Configuring Security Solutions."

Virtual Interface

- Any fictitious, unassigned, and unused gateway IP address
- DNS gateway hostname

Note To ensure connectivity and web authentication, the DNS server should always point to the virtual interface. If a DNS hostname is configured for the virtual interface, then the same DNS host name must be configured on the DNS server(s) used by the client.

Service-Port Interface

Note The service-port interface uses the controller's factory-set service-port MAC address.

- DHCP protocol (enabled)
- DHCP protocol (disabled) and IP address and IP netmask

Step 4 Click **Save Configuration** to save your changes.

Step 5 If you made any changes to the management or virtual interface, reboot the controller so that your changes take effect.

Using the CLI to Configure the Management, AP-Manager, Virtual, and Service-Port Interfaces

This section provides instructions for displaying and configuring the management, AP-manager, virtual, and service-port interfaces using the CLI.

Using the CLI to Configure the Management Interface

To display and configure the management interface parameters using the CLI, follow these steps:

Step 1 Enter the **show interface detailed management** command to view the current management interface settings.

Note The management interface uses the controller's factory-set distribution system MAC address.

Step 2 Enter the **config wlan disable** *wlan-number* command to disable each WLAN that uses the management interface for distribution system communication.

Step 3 Enter these commands to define the management interface:

- **config interface address management** *ip-addr ip-netmask gateway*
- **config interface quarantine vlan management** *vlan_id*

Note Use the **config interface quarantine vlan management** *vlan_id* command to configure a quarantine VLAN on the management interface.

- **config interface vlan management** {*vlan-id* | **0**}

Note Enter **0** for an untagged VLAN or a nonzero value for a tagged VLAN. We recommend using tagged VLANs for the management interface.

- **config interface ap-manager management** {**enable** | **disable**} (for Cisco 5500 Series Controllers only)

Note Use the **config interface ap-manager management** {**enable** | **disable**} command to enable or disable dynamic AP management for the management interface. For Cisco 5500 Series Controllers, the management interface acts like an AP-manager interface by default. If desired, you can disable the management interface as an AP-manager interface and create another dynamic interface as an AP manager.

- **config interface port management** *physical-ds-port-number* (for all controllers except the 5500 series)
- **config interface dhcp management** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- **config interface acl management** *access-control-list-name*

Note See Chapter 6, "Configuring Security Solutions," for more information on ACLs.

Step 4 Enter these commands if you want to be able to deploy your Cisco 5500 Series Controller behind a router or other gateway device that is using one-to-one mapping network address translation (NAT):

- **config interface nat-address management** {**enable** | **disable**}
- **config interface nat-address management set** *public_IP_address*

NAT allows a device, such as a router, to act as an agent between the Internet (public) and a local network (private). In this case, it maps the controller's intranet IP addresses to a corresponding external address. The controller's dynamic AP-manager interface must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

Note These NAT commands can be used only on Cisco 5500 Series Controllers and only if the management interface is configured for dynamic AP management.

Note These commands are supported for use only with one-to-one-mapping NAT, where each private client has a direct and fixed mapping to a global address. These commands do not support one-to-many NAT, which uses source port mapping to enable a group of clients to be represented by a single IP address.

Step 5 Enter the **save config** command to save your changes.

Step 6 Enter the **show interface detailed management** command to verify that your changes have been saved.

Step 7 If you made any changes to the management interface, enter the **reset system** command to reboot the controller in order for the changes to take effect.

Using the CLI to Configure the AP-Manager Interface

To display and configure the AP-manager interface parameters using the CLI, follow these steps:

Note For Cisco 5500 Series Controllers, you are not required to configure an AP-manager interface. The management interface acts like an AP-manager interface by default.

Step 1 Enter the **show interface summary** command to view the current interfaces.

Note If the system is operating in Layer 2 mode, the AP-manager interface is not listed.

Step 2 Enter the **show interface detailed ap-manager** command to view the current AP-manager interface settings.

Step 3 Enter the **config wlan disable** *wlan-number* command to disable each WLAN that uses the AP-manager interface for distribution system communication.

Step 4 Enter these commands to define the AP-manager interface:

- **config interface address ap-manager** *ip-addr ip-netmask gateway*
- **config interface vlan ap-manager** {*vlan-id* | **0**}

  Note Enter **0** for an untagged VLAN or a nonzero value for a tagged VLAN. We recommend using tagged VLANs for the AP-manager interface.

- **config interface port ap-manager** *physical-ds-port-number*
- **config interface dhcp ap-manager** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- **config interface acl ap-manager** *access-control-list-name*

  Note See Chapter 6, "Configuring Security Solutions," for more information on ACLs.

Step 5 Enter the **save config** command to save your changes.

Step 6 Enter the **show interface detailed ap-manager** command to verify that your changes have been saved.

Using the CLI to Configure the Virtual Interface

To display and configure the virtual interface parameters using the CLI, follow these steps:

Step 1 Enter the **show interface detailed virtual** command to view the current virtual interface settings.

Step 2 Enter the **config wlan disable** *wlan-number* command to disable each WLAN that uses the virtual interface for distribution system communication.

Step 3 Enter these commands to define the virtual interface:

- **config interface address virtual** *ip-address*

  Note For *ip-address*, enter any fictitious, unassigned, and unused gateway IP address.

- **config interface hostname virtual** *dns-host-name*

Step 4 Enter the **reset system** command. At the confirmation prompt, enter **Y** to save your configuration changes to NVRAM. The controller reboots.

Step 5 Enter the **show interface detailed virtual** command to verify that your changes have been saved.

Using the CLI to Configure the Service-Port Interface

To display and configure the service-port interface parameters using the CLI, follow these steps:

Step 1 Enter the **show interface detailed service-port** command to view the current service-port interface settings.

Note The service-port interface uses the controller's factory-set service-port MAC address.

Step 2 Enter these commands to define the service-port interface:

- To configure the DHCP server: **config interface dhcp service-port** *ip-address-of-primary-dhcp-server* [*ip-address-of-secondary-dhcp-server*]
- To disable the DHCP server: **config interface dhcp service-port none**
- To configure the IP address: **config interface address service-port** *ip-addr ip-netmask*

Step 3 The service port is used for out-of-band management of the controller. If the management workstation is in a remote subnet, you may need to add a route on the controller in order to manage the controller from that remote workstation. To do so, enter this command:

config route add *network-ip-addr ip-netmask gateway*

Step 4 Enter the **save config** command to save your changes.

Step 5 Enter the **show interface detailed service-port** command to verify that your changes have been saved.

Configuring Dynamic Interfaces

This section provides instructions for configuring dynamic interfaces using either the GUI or CLI.

Using the GUI to Configure Dynamic Interfaces

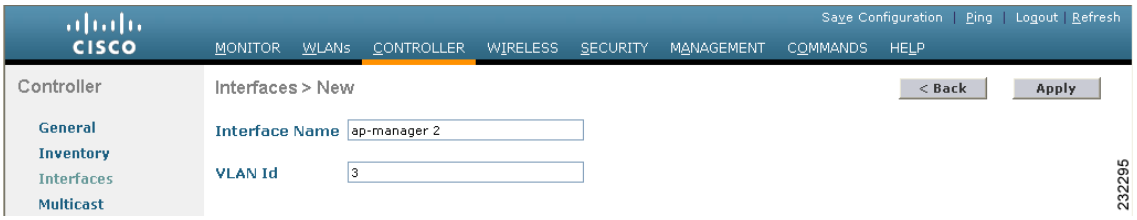
To create new or edit existing dynamic interfaces using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Interfaces** to open the Interfaces page (see Figure 3-6).

Step 2 Perform one of the following:

- To create a new dynamic interface, click **New**. The Interfaces > New page appears (see Figure 3-7). Go to Step 3.
- To modify the settings of an existing dynamic interface, click the name of the interface. The Interfaces > Edit page for that interface appears (see Figure 3-8). Go to Step 5.
- To delete an existing dynamic interface, hover your cursor over the blue drop-down arrow for the desired interface and choose **Remove**.

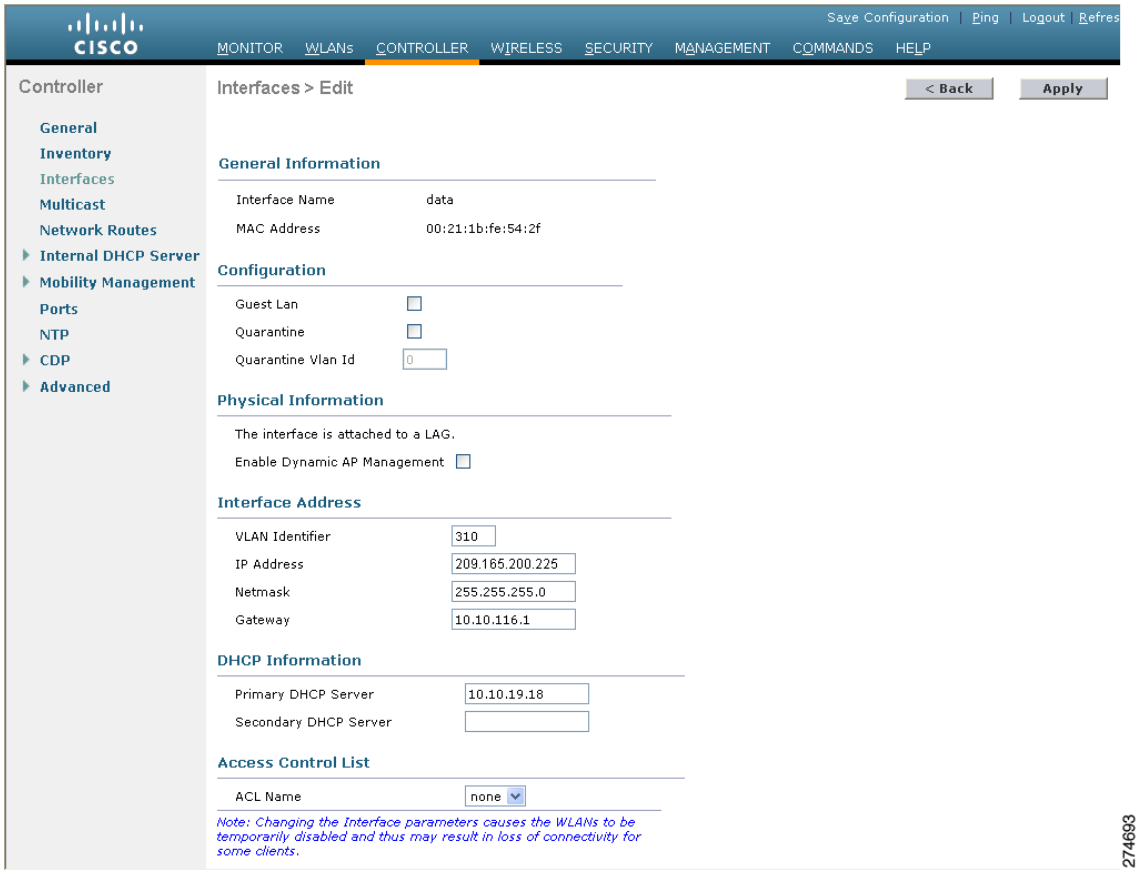
Figure 3-7 Interfaces > New Page



Step 3 Enter an interface name and a VLAN identifier, as shown in Figure 3-7.

Step 4 Click **Apply** to commit your changes. The Interfaces > Edit page appears (see Figure 3-8).

Figure 3-8 Interfaces > Edit Page



Step 5 Configure the following parameters:

- Guest LAN, if applicable
- Quarantine and quarantine VLAN ID, if applicable

Note Select the **Quarantine** check box if you want to configure this VLAN as unhealthy or you want to configure network access control (NAC) out-of-band integration. Doing so causes the data traffic of any client that is assigned to this VLAN to pass through the controller. See Chapter 7, "Configuring WLANs," for more information about NAC out-of-band integration.

- Physical port assignment (for all controllers except the 5500 series)
- NAT address (only for Cisco 5500 Series Controllers configured for dynamic AP management)

Note Select the **Enable NAT Address** check box and enter the external NAT IP address if you want to be able to deploy your Cisco 5500 Series Controller behind a router or other gateway device that is using one-to-one mapping network address translation (NAT). NAT allows a device, such as a router, to act as an agent between the Internet (public) and a local network (private). In this case, it maps the controller's intranet IP addresses to a corresponding external address. The controller's dynamic AP-manager interface must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

Note The NAT parameters are supported for use only with one-to-one-mapping NAT, where each private client has a direct and fixed mapping to a global address. The NAT parameters do not support one-to-many NAT, which uses source port mapping to enable a group of clients to be represented by a single IP address.

- Dynamic AP management

Note When you enable this feature, this dynamic interface is configured as an AP-manager interface (only one AP-manager interface is allowed per physical port). A dynamic interface that is marked as an AP-manager interface cannot be used as a WLAN interface.

Note Set the APs in a VLAN that is different than the dynamic interface configured on the controller. If the APs are in the same VLAN as the dynamic interface, the APs are not registered on the controller and the "LWAPP discovery rejected" and "Layer 3 discovery request not received on management VLAN" errors are logged on the controller.

- VLAN identifier
- Fixed IP address, IP netmask, and default gateway
- Primary and secondary DHCP servers
- Access control list (ACL) name, if required

Note See Chapter 6, "Configuring Security Solutions," for more information on ACLs.

Note To ensure proper operation, you must set the Port Number and Primary DHCP Server parameters.

Step 6 Click **Save Configuration** to save your changes.

Step 7 Repeat this procedure for each dynamic interface that you want to create or edit.

Note When you apply a flow policer or an aggregate policer on the ingress of a Dynamic Interface VLAN for the Upstream (wireless to wired) traffic, it is not possible to police because the vLAN based policy has no effect and thus no policing occurs. When the traffic comes out of the WiSM LAG (L2) and hits the Switch Virtual Interface (SVI) (L3), the QoS policy applied is a VLAN based policy that has no effect on the policing.

To enable ingress L3 VLAN based policy on the SVI, you must enable VLAN based QoS equivalent to mls qos vlan-based command on the WiSM LAG. All the previous 12.2(33)SXI releases, which support Auto LAG for WiSM only, that is 12.2(33)SXI, 12.2(33)SXI1, 12.2(33)SXI2a, 12.2(33)SXI3, and so on, do not have this WiSM CLI. Therefore, the VLAN based QoS policy applied ingress on the SVI for wireless to wired traffic never polices any traffic coming out of the WiSM LAG and hitting the SVI. The commands equivalent to the mls qos vlan-based command are as follows:

Standalone: **wism module *module_no* controller *controller_no* qos-vlan-based**

Virtual Switching System: **wism switch *switch_no* module *module_no* controller *controller_no* qos-vlan-based**

Using the CLI to Configure Dynamic Interfaces

To configure dynamic interfaces using the CLI, follow these steps:

Step 1 Enter the **show interface summary** command to view the current dynamic interfaces.

Step 2 View the details of a specific dynamic interface by entering this command:

show interface detailed *operator_defined_interface_name*.

Step 3 Enter the **config wlan disable** *wlan_id* command to disable each WLAN that uses the dynamic interface for distribution system communication.

Step 4 Enter these commands to configure dynamic interfaces:

- **config interface create** *operator_defined_interface_name* {*vlan_id* | ***x***}
- **config interface address** *operator_defined_interface_name ip_addr ip_netmask* [*gateway*]
- **config interface vlan** *operator_defined_interface_name* {*vlan_id* | **0**}
- **config interface port** *operator_defined_interface_name physical_ds_port_number*
- **config interface ap-manager** *operator_defined_interface_name* {**enable** | **disable**}

  Note Use the **config interface ap-manager** *operator_defined_interface_name* {**enable** | **disable**} command to enable or disable dynamic AP management. When you enable this feature, this dynamic interface is configured as an AP-manager interface (only one AP-manager interface is allowed per physical port). A dynamic interface that is marked as an AP-manager interface cannot be used as a WLAN interface.

- **config interface dhcp** *operator_defined_interface_name ip_address_of_primary_dhcp_server* [*ip_address_of_secondary_dhcp_server*]
- **config interface quarantine vlan** *interface_name vlan_id*

Note Use the **config interface quarantine vlan** *interface_name vlan_id* command to configure a quarantine VLAN on any interface.

- **config interface acl** *operator_defined_interface_name access_control_list_name*

Note See Chapter 6, "Configuring Security Solutions," for more information on ACLs.

Step 5 Enter these commands if you want to be able to deploy your Cisco 5500 Series Controller behind a router or other gateway device that is using one-to-one mapping network address translation (NAT):

- **config interface nat-address dynamic-interface** *operator_defined_interface_name* {**enable** | **disable**}
- **config interface nat-address dynamic-interface** *operator_defined_interface_name* **set** *public_IP_address*

NAT allows a device, such as a router, to act as an agent between the Internet (public) and a local network (private). In this case, it maps the controller's intranet IP addresses to a corresponding external address. The controller's dynamic AP-manager interface must be configured with the external NAT IP address so that the controller can send the correct IP address in the Discovery Response.

Note These NAT commands can be used only on Cisco 5500 Series Controllers and only if the dynamic interface is configured for dynamic AP management.

Note These commands are supported for use only with one-to-one-mapping NAT, whereby each private client has a direct and fixed mapping to a global address. These commands do not support one-to-many NAT, which uses source port mapping to enable a group of clients to be represented by a single IP address.

Step 6 Enter the **config wlan enable** *wlan_id* command to reenable each WLAN that uses the dynamic interface for distribution system communication.

Step 7 Enter the **save config** command to save your changes.

Step 8 Enter the **show interface detailed** *operator_defined_interface_name* command and **show interface summary** command to verify that your changes have been saved.

Note If desired, you can enter the **config interface delete** *operator_defined_interface_name* command to delete a dynamic interface.

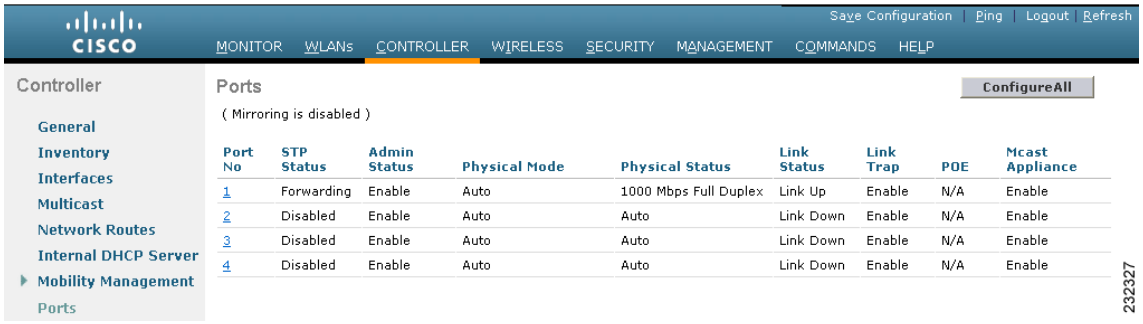
Configuring Ports

The controller's ports are preconfigured with factory-default settings designed to make the controllers' ports operational without additional configuration. However, you can view the status of the controller's ports and edit their configuration parameters at any time.

To use the GUI to view the status of the controller's ports and make any configuration changes if necessary, follow these steps:

Step 1 Choose **Controller** > **Ports** to open the Ports page (see Figure 3-9).

Figure 3-9 Ports Page



This page shows the current configuration for each of the controller's ports.

If you want to change the settings of any port, click the number for that specific port. The Port > Configure page appears (see Figure 3-10).

Note If the management and AP-manager interfaces are mapped to the same port and are members of the same VLAN, you must disable the WLAN before making a port-mapping change to either interface. If the management and AP-manager interfaces are assigned to different VLANs, you do not need to disable the WLAN.

Note The number of parameters available on the Port > Configure page depends on your controller type. For instance, Cisco 2100 Series Controller and the controller in a Cisco Integrated Services Router have fewer configurable parameters than a Cisco 4400 Series Controller, which is shown in Figure 3-10.

Figure 3-10 Port > Configure Page

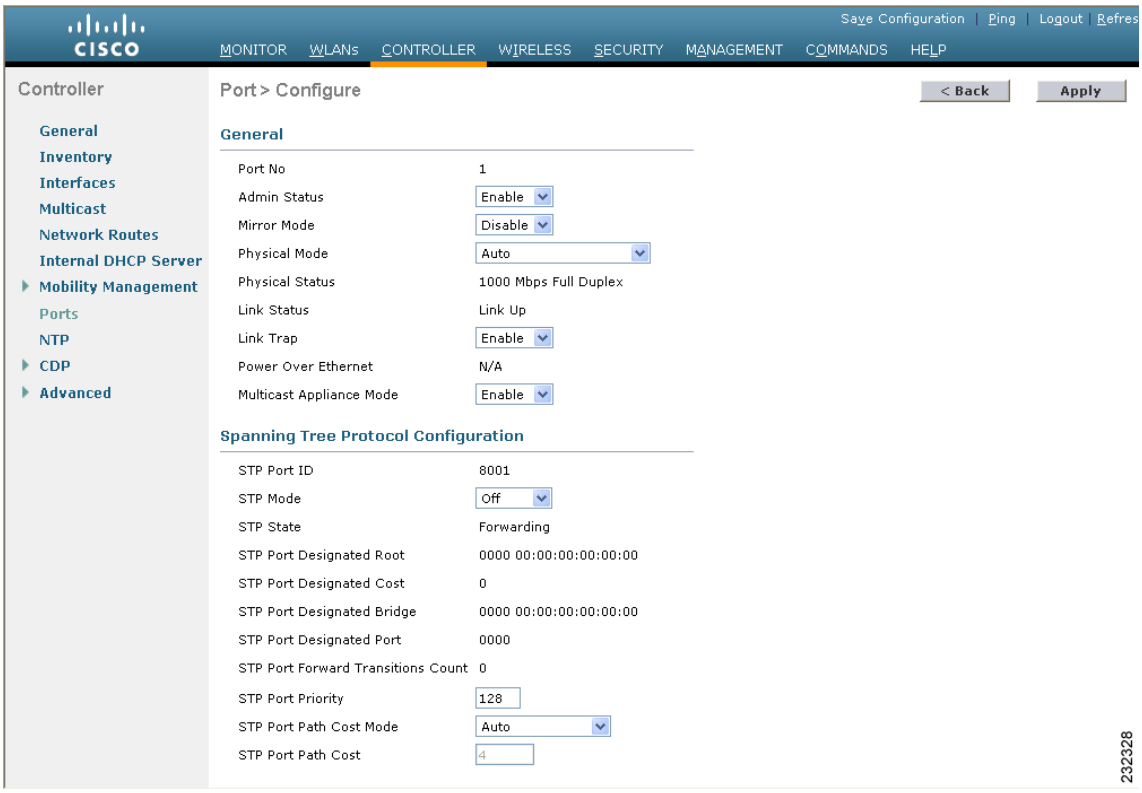


Table 3-2 shows the current status of the port.

Table 3-2 Port Status

Parameter	Description
Port Number	Number of the current port.
Admin Status	Current state of the port. **Values:** Enable or Disable
Physical Mode	Configuration of the port physical interface. The mode varies by the controller type. **Values:** Auto, 100 Mbps Full Duplex, 100 Mbps Half Duplex, 10 Mbps Full Duplex, or 10 Mbps Half Duplex **Note** In Cisco NM-AIR-WLC6-K9, 5500 series, and 7500 series controllers, the physical mode is always set to Auto.
Physical Status	The data rate being used by the port. The available data rates vary based on controller type.

Controller	Available Data Rates
5500 series	1000 Mbps full duplex
4400 series	1000 Mbps full duplex
2100 series	10 or 100 Mbps, half or full duplex
WiSM	1000 Mbps full duplex
Controller network module	100 Mbps full duplex
Catalyst 3750G Integrated Wireless LAN Controller Switch	1000 Mbps full duplex

Link Status	Port's link status. **Values:** Link Up or Link Down
Link Trap	Whether the port is set to send a trap when the link status changes. **Values:** Enable or Disable
Power over Ethernet (PoE)	If the connecting device is equipped to receive power through the Ethernet cable and if so, provides –48 VDC. **Values:** Enable or Disable **Note** Some older Cisco access points do not draw PoE even if it is enabled on the controller port. In such cases, contact the Cisco Technical Assistance Center (TAC). **Note** The controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch supports PoE on all ports.

Step 2 Table 3-3 lists and describes the port's configurable parameters. Follow the instructions in the table to make any desired changes.

Table 3-3 Port Parameters

<table>
<tr><th>Parameter</th><th>Description</th></tr>
<tr><td>Admin Status</td><td>Enables or disables the flow of traffic through the port.
Options: Enable or Disable
Default: Enable
Note Administratively disabling the port on a controller does not affect the port's link status. The link can be brought down only by other Cisco devices. On other Cisco products, however, administratively disabling a port brings the link down.</td></tr>
<tr><td>Physical Mode</td><td>Determines whether the port's data rate is set automatically or specified by the user. The supported data rates vary based on the controller type.
Default: Auto
<table><tr><th>Controller</th><th>Supported Data Rates</th></tr><tr><td>5500 series</td><td>Fixed 1000 Mbps full duplex</td></tr><tr><td>4400 series</td><td>Auto or 1000 Mbps full duplex</td></tr><tr><td>2100 series</td><td>Auto or 10 or 100 Mbps, half or full duplex</td></tr><tr><td>WiSM</td><td>Auto or 1000 Mbps full duplex</td></tr><tr><td>Controller network module</td><td>Auto or 100 Mbps full duplex</td></tr><tr><td>Catalyst 3750G Integrated Wireless LAN Controller Switch</td><td>Auto or 1000 Mbps full duplex</td></tr></table>Note Make sure that a duplex mismatch does not exist between a Cisco 2100 series Controller and the Catalyst switch. A duplex mismatch is a situation where the switch operates at full duplex and the connected device operates at half duplex or vice versa. The results of a duplex mismatch are extremely slow performance, intermittent connectivity, and loss of connection. Other possible causes of data link errors at full duplex are bad cables, faulty switch ports, or client software or hardware issues.</td></tr>
<tr><td>Link Trap</td><td>Causes the port to send a trap when the port's link status changes.
Options: Enable or Disable
Default: Enable</td></tr>
<tr><td>Multicast Appliance Mode</td><td>Enables or disables the multicast appliance service for this port.
Options: Enable or Disable
Default: Enable</td></tr>
</table>

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 Click **Back** to return to the Ports page and review your changes.

Step 6 Repeat this procedure for each additional port that you want to configure.

Step 7 Go to the following sections if you want to configure the controller's ports for these advanced features:

- For port mirroring, see the "Configuring Port Mirroring" section on page 3-27
- For the Spanning Tree Protocol (STP), see the "Configuring Spanning Tree Protocol" section on page 3-28.

Note Users will be prompted with a warning message when the following events occur:

1. When the traffic rate from the data ports exceeds 300 Mbps.

2. When the traffic rate from the data ports exceeds 250 Mbps constantly for one minute.

3. When the traffic rate from the data ports falls back to normal from one of the above state for 1 minute.

Configuring Port Mirroring

Mirror mode enables you to duplicate to another port all of the traffic originating from or terminating at a single client device or access point. It is useful in diagnosing specific network problems. Mirror mode should be enabled only on an unused port as any connections to this port become unresponsive.

Note The Cisco 5500 Series Controllers, Cisco 2100 Series Controller, controller network modules, and Cisco WiSM controllers do not support mirror mode. Also, a controller's service port cannot be used as a mirrored port.

Note Port mirroring is not supported when link aggregation (LAG) is enabled on the controller.

Note We recommend that you do not mirror traffic from one controller port to another as this setup could cause network problems.

To enable port mirroring, follow these steps:

Step 1 Choose **Controller** > **Ports** to open the Ports page (see Figure 3-9).

Step 2 Click the number of the unused port for which you want to enable mirror mode. The Port > Configure page appears (see Figure 3-10).

Step 3 Set the Mirror Mode parameter to **Enable**.

Step 4 Click **Apply** to commit your changes.

Step 5 Perform one of the following:

- Follow these steps if you want to choose a specific client device that will mirror its traffic to the port you selected on the controller:
  a. Choose **Wireless > Clients** to open the Clients page.
  b. Click the MAC address of the client for which you want to enable mirror mode. The Clients > Detail page appears.
  c. Under Client Details, set the Mirror Mode parameter to **Enable**.
- Follow these steps if you want to choose an access point that will mirror its traffic to the port you selected on the controller:
  a. Choose **Wireless > Access Points > All APs** to open the All APs page.
  b. Click the name of the access point for which you want to enable mirror mode. The All APs > Details page appears.
  c. Choose the **Advanced** tab.
  d. Set the Mirror Mode parameter to **Enable**.

Step 6 Click **Save Configuration** to save your changes.

Configuring Spanning Tree Protocol

Spanning Tree Protocol (STP) is a Layer 2 link management protocol that provides path redundancy while preventing loops in the network. For a Layer 2 Ethernet network to function properly, only one active path can exist between any two network devices. STP allows only one active path at a time between network devices but establishes redundant links as a backup if the initial link should fail.

The spanning-tree algorithm calculates the best loop-free path throughout a Layer 2 network. Infrastructure devices such as controllers and switches send and receive spanning-tree frames, called bridge protocol data units (BPDUs), at regular intervals. The devices do not forward these frames but use them to construct a loop-free path.

Multiple active paths among end stations cause loops in the network. If a loop exists in the network, end stations might receive duplicate messages. Infrastructure devices might also learn end-station MAC addresses on multiple Layer 2 interfaces. These conditions result in an unstable network.

STP defines a tree with a root bridge and a loop-free path from the root to all infrastructure devices in the Layer 2 network.

Note STP discussions use the term *root* to describe two concepts: the controller on the network that serves as a central point in the spanning tree is called the *root bridge*, and the port on each controller that provides the most efficient path to the root bridge is called the *root port*. The root bridge in the spanning tree is called the *spanning-tree root*.

STP forces redundant data paths into a standby (blocked) state. If a network segment in the spanning tree fails and a redundant path exists, the spanning-tree algorithm recalculates the spanning-tree topology and activates the standby path.

When two ports on a controller are part of a loop, the spanning-tree port priority and path cost settings determine which port is put in the forwarding state and which is put in the blocking state. The port priority value represents the location of a port in the network topology and how well it is located to pass traffic. The path cost value represents the media speed.

The controller maintains a separate spanning-tree instance for each active VLAN configured on it. A bridge ID, consisting of the bridge priority and the controller's MAC address, is associated with each instance. For each VLAN, the controller with the lowest controller ID becomes the spanning-tree root for that VLAN.

STP is disabled for the controller's distribution system ports by default. The following sections provide instructions for configuring STP for your controller using either the GUI or CLI.

Note STP cannot be configured for Cisco 2100 Series Controllers, Cisco 5500 Series Controllers, and the controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch.

Using the GUI to Configure Spanning Tree Protocol

To configure STP using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Ports** to open the Ports page (see Figure 3-9).

Step 2 Click the number of the port for which you want to configure STP. The Port > Configure page appears (see Figure 3-10). This page shows the STP status of the port and enables you to configure STP parameters.

Table 3-4 interprets the current STP status of the port.

Table 3-4 Port Spanning Tree Status

Parameter	Description	
STP Port ID	Number of the port for which STP is enabled or disabled.	
STP State	Port's current STP state. It controls the action that a port takes upon receiving a frame. **Values:** Disabled, Blocking, Listening, Learning, Forwarding, and Broken	
	STP State	**Description**
	Disabled	Port that does not participate in spanning tree because the port is shut down, the link is down, or STP is not enabled for this port.
	Blocking	Port that does not participate in frame forwarding.
	Listening	First transitional state after the blocking state when STP determines that the port should participate in frame forwarding.
	Learning	Port that prepares to participate in frame forwarding.
	Forwarding	Port that forwards frames.
	Broken	Port that is malfunctioning.
STP Port Designated Root	Unique identifier of the root bridge in the configuration BPDUs.	
STP Port Designated Cost	Path cost of the designated port.	
STP Port Designated Bridge	Identifier of the bridge that the port considers to be the designated bridge for this port.	

Table 3-4 Port Spanning Tree Status (continued)

Parameter	Description
STP Port Designated Port	Port identifier on the designated bridge for this port.
STP Port Forward Transitions Count	Number of times that the port has transitioned from the learning state to the forwarding state.

Step 3 Table 3-5 lists and describes the port's configurable STP parameters. Follow the instructions in the table to make any desired changes.

Table 3-5 Port Spanning Tree Parameters

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td>STP Mode</td><td colspan="2">STP administrative mode associated with this port.
Options: Off, 802.1D, or Fast
Default: Off</td></tr>
<tr><td></td><td>STP Mode</td><td>Description</td></tr>
<tr><td></td><td>Off</td><td>Disables STP for this port.</td></tr>
<tr><td></td><td>802.1D</td><td>Enables this port to participate in the spanning tree and go through all of the spanning tree states when the link state transitions from down to up.</td></tr>
<tr><td></td><td>Fast</td><td>Enables this port to participate in the spanning tree and puts it in the forwarding state when the link state transitions from down to up more quickly than when the STP mode is set to 802.1D.
Note In this state, the forwarding delay timer is ignored on link up.</td></tr>
<tr><td>STP Port Priority</td><td colspan="2">Location of the port in the network topology and how well the port is located to pass traffic.
Range: 0 to 255
Default: 128</td></tr>
<tr><td>STP Port Path Cost Mode</td><td colspan="2">Whether the STP port path cost is set automatically or specified by the user. If you choose User Configured, you also need to set a value for the STP Port Path Cost parameter.
Range: Auto or User Configured
Default: Auto</td></tr>
</table>

Table 3-5 Port Spanning Tree Parameters (continued)

Parameter	Description
STP Port Path Cost	Speed at which traffic is passed through the port. This parameter must be set if the STP Port Path Cost Mode parameter is set to User Configured. **Options:** 0 to 65535 **Default:** 0, which causes the cost to be adjusted for the speed of the port when the link comes up. **Note** Typically, a value of 100 is used for 10-Mbps ports and 19 for 100-Mbps ports.

Step 4 Click **Apply** to commit your changes.

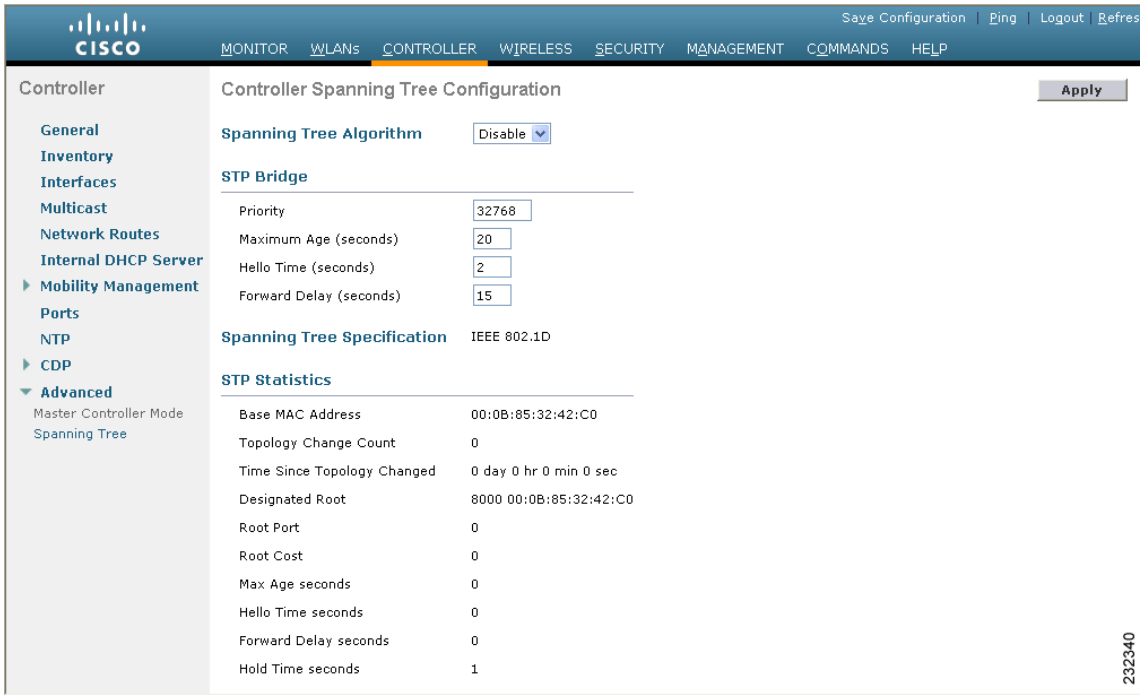
Step 5 Click **Save Configuration** to save your changes.

Step 6 Click **Back** to return to the Ports page.

Step 7 Repeat Step 2 through Step 6 for each port for which you want to enable STP.

Step 8 Choose **Controller > Advanced > Spanning Tree** to open the Controller Spanning Tree Configuration page (see Figure 3-11).

Figure 3-11 Controller Spanning Tree Configuration Page



This page allows you to enable or disable the spanning tree algorithm for the controller, modify its characteristics, and view the STP status. Table 3-6 interprets the current STP status for the controller.

Table 3-6 Controller Spanning Tree Status

Parameter	Description
Spanning Tree Specification	STP version being used by the controller. Currently, only an IEEE 802.1D implementation is available.
Base MAC Address	MAC address used by this bridge when it must be referred to in a unique fashion. When it is concatenated with dot1dStpPriority, a unique bridge identifier is formed that is used in STP.
Topology Change Count	Total number of topology changes detected by this bridge since the management entity was last reset or initialized.
Time Since Topology Changed	Time (in days, hours, minutes, and seconds) since a topology change was detected by the bridge.
Designated Root	Bridge identifier of the spanning tree root. This value is used as the Root Identifier parameter in all configuration BPDUs originated by this node.
Root Port	Number of the port that offers the lowest cost path from this bridge to the root bridge.
Root Cost	Cost of the path to the root as seen from this bridge.
Max Age (seconds)	Maximum age of STP information learned from the network on any port before it is discarded.
Hello Time (seconds)	Amount of time between the transmission of configuration BPDUs by this node on any port when it is the root of the spanning tree or trying to become so. This is the actual value that this bridge is currently using.
Forward Delay (seconds)	Value that controls how fast a port changes its spanning tree state when moving toward the forwarding state. It determines how long the port stays in each of the listening and learning states that precede the forwarding state. This value is also used, when a topology change has been detected and is underway, to age all dynamic entries in the forwarding database. **Note** This value is the actual value that this bridge is currently using, in contrast to *Stp Bridge Forward Delay*, which is the value that this bridge and all others would start using if this bridge were to become the root.
Hold Time (seconds)	Minimum time period to elapse between the transmission of configuration BPDUs through a given LAN port. **Note** Only one configuration BPDU can be transmitted in any hold time period.

Step 9 See Table 3-7 for the controller's configurable STP parameters. Follow the instructions in the table to make any desired changes.

Table 3-7 Controller Spanning Tree Parameters

Parameter	Description
Spanning Tree Algorithm	Algorithm that you use to enable or disable STP for the controller. **Options:** Enable or Disable **Default:** Disable
Priority	Location of the controller in the network topology and how well the controller is located to pass traffic. **Range:** 0 to 65535 **Default:** 32768
Maximum Age (seconds)	Length of time that the controller stores protocol information received on a port. **Range:** 6 to 40 seconds **Default:** 20 seconds
Hello Time (seconds)	Length of time that the controller broadcasts hello messages to other controllers. **Options:** 1 to 10 seconds **Default:** 2 seconds
Forward Delay (seconds)	Length of time that each of the listening and learning states lasts before the port begins forwarding. **Options:** 4 to 30 seconds **Default:** 15 seconds

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Configure Spanning Tree Protocol

To configure STP using the CLI, follow these steps:

Step 1 Enter the **show spanningtree port** command and the **show spanningtree switch** command to view the current STP status.

Step 2 If STP is enabled, you must disable it before you can change STP settings. Enter the **config spanningtree switch mode disable** command to disable STP on all ports.

Step 3 Enter one of these commands to configure the STP port administrative mode:

- **config spanningtree port mode 802.1d** {*port-number* | **all**}
- **config spanningtree port mode fast** {*port-number* | **all**}
- **config spanningtree port mode off** {*port-number* | **all**}

Step 4 Enter one of these commands to configure the STP port path cost on the STP ports:

- **config spanningtree port pathcost** *1-65535* {*port-number* | **all**}—Specifies a path cost from 1 to 65535 to the port.
- **config spanningtree port mode pathcost auto** {*port-number* | **all**}—Enables the STP algorithm to automatically assign the path cost. This is the default setting.

Step 5 Enter the **config spanningtree port priority** command *0-255 port-number* to configure the port priority on STP ports. The default priority is 128.

Step 6 If necessary, enter the **config spanningtree switch bridgepriority** command *0-65535* to configure the controller's STP bridge priority. The default bridge priority is 32768.

Step 7 If necessary, enter the **config spanningtree switch forwarddelay** command *4-30* to configure the controller's STP forward delay in seconds. The default forward delay is 15 seconds.

Step 8 If necessary, enter the **config spanningtree switch hellotime** command *1-10* to configure the controller's STP hello time in seconds. The default hello time is 2 seconds.

Step 9 If necessary, enter the **config spanningtree switch maxage** command *6-40* to configure the controller's STP maximum age. The default maximum age is 20 seconds.

Step 10 After you configure STP settings for the ports, enter the **config spanningtree switch mode enable** command to enable STP for the controller. The controller automatically detects logical network loops, places redundant ports on standby, and builds a network with the most efficient pathways.

Step 11 Enter the **save config** command to save your settings.

Step 12 Enter the **show spanningtree port** command and the **show spanningtree switch** command to verify that your changes have been saved.

Using the Cisco 5500 Series Controller USB Console Port

The USB console port on the Cisco 5500 Series Controllers connects directly to the USB connector of a PC using a USB Type A-to-5-pin mini Type B cable.

Note The 4-pin mini Type B connector is easily confused with the 5-pin mini Type B connector. They are not compatible. Only the 5-pin mini Type B connector can be used.

For operation with Microsoft Windows, the Cisco Windows USB console driver must be installed on any PC connected to the console port. With this driver, you can plug and unplug the USB cable into and from the console port without affecting Windows HyperTerminal operations.

Note Only one console port can be active at a time. When a cable is plugged into the USB console port, the RJ-45 port becomes inactive. Conversely, when the USB cable is removed from the USB port, the RJ-45 port becomes active.

USB Console OS Compatibility

These operating systems are compatible with the USB console:

- Microsoft Windows 2000, XP, Vista (Cisco Windows USB console driver required)
- Apple Mac OS X 10.5.2 (no driver required)

- Linux (no driver required)

To install the Cisco Windows USB console driver, follow these steps:

Step 1 Download the USB_Console.inf driver file as follows:

a. Click this URL to go to the Software Center:
http://tools.cisco.com/support/downloads/go/Redirect.x?mdfid=278875243

b. Click **Wireless LAN Controllers**.

c. Click **Standalone Controllers**.

d. Click **Cisco 5500 Series Wireless LAN Controllers**.

e. Click **Cisco 5508 Wireless LAN Controller**.

f. Choose the USB driver file.

g. Save the file to your hard drive.

Step 2 Connect the Type A connector to a USB port on your PC.

Step 3 Connect the mini Type B connector to the USB console port on the controller.

Step 4 When prompted for a driver, browse to the USB_Console.inf file on your PC. Follow the prompts to install the USB driver.

Note Some systems might also require an additional system file. You can download the Usbser.sys file from this URL:
http://support.microsoft.com/kb/918365

The USB driver is mapped to COM port 6. Some terminal emulation programs do not recognize a port higher than COM 4. If necessary, change the Cisco USB systems management console COM port to an unused port of COM 4 or lower. To do so, follow these steps:

Step 1 From your Windows desktop, right-click **My Computer** and choose **Manage**.

Step 2 From the list on the left side, choose **Device Manager**.

Step 3 From the device list on the right side, double-click **Ports (COM & LPT)**.

Step 4 Right-click **Cisco USB System Management Console 0108** and choose **Properties**.

Step 5 Click the **Port Settings** tab and click the **Advanced** button.

Step 6 From the COM Port Number drop-down list, choose an unused COM port of 4 or lower.

Step 7 Click **OK** to save and then close the **Advanced Settings** dialog box.

Step 8 Click **OK** to save and then close the **Communications Port Properties** dialog box.

Choosing Between Link Aggregation and Multiple AP-Manager Interfaces

Cisco 4400 Series Controllers can support up to 48 access points per port. However, you can configure your Cisco 4400 Series Controller to support more access points by using link aggregation (LAG) or configuring dynamic AP-managers on each Gigabit Ethernet port. Cisco 5500 Series Controllers have no restrictions on the number of access points per port, but we recommend using LAG or multiple AP-manager interfaces on each Gigabit Ethernet port to automatically balance the load.

The following factors should help you decide which method to use if your controller is set for Layer 3 operation:

- With LAG, all of the controller ports need to connect to the same neighbor switch. If the neighbor switch goes down, the controller loses connectivity.
- With multiple AP-manager interfaces, you can connect your ports to different neighbor devices. If one of the neighbor switches goes down, the controller still has connectivity. However, using multiple AP-manager interfaces presents certain challenges (as discussed in the "Configuring Multiple AP-Manager Interfaces" section) when port redundancy is a concern.

Follow the instructions on the page indicated for the method you want to use:

- Link aggregation, page 3-36
- Multiple AP-manager interfaces, page 3-42

Enabling Link Aggregation

Link aggregation (LAG) is a partial implementation of the 802.3ad port aggregation standard. It bundles all of the controller's distribution system ports into a single 802.3ad port channel, thereby reducing the number of IP addresses needed to configure the ports on your controller. When LAG is enabled, the system dynamically manages port redundancy and load balances access points transparently to the user.

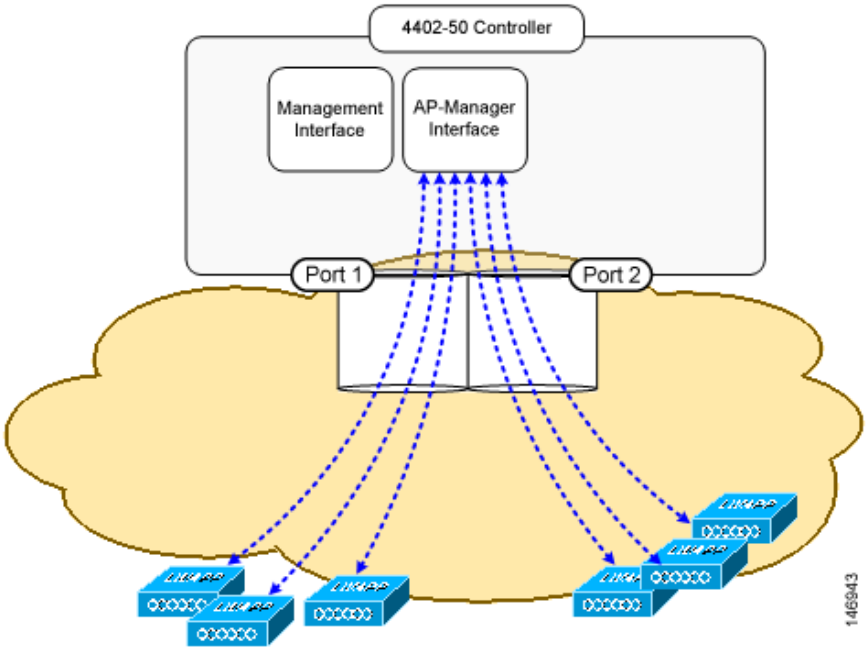
Note The Cisco 2100 Series Controller do not support LAG.

Note You can bundle all four ports on a Cisco 4404 Controller (or two on a 4402 controller) or all eight ports on a Cisco 5508 Controller into a single link.

Cisco 5500 Series Controllers support LAG in software release 6.0 or later releases, Cisco 4400 Series Controllers support LAG in software release 3.2 or later releases, and LAG is enabled automatically on the controllers within the Cisco WiSM and the Catalyst 3750G Integrated Wireless LAN Controller Switch. Without LAG, each distribution system port on a Cisco 4400 Series Controller supports up to 48 access points. With LAG enabled, a Cisco 4402 Controller's logical port supports up to 50 access points, a Cisco 4404 Controller's logical port supports up to 100 access points, and the logical port on the Catalyst 3750G Integrated Wireless LAN Controller Switch and on each Cisco WiSM controller supports up to 150 access points.

Figure 3-12 shows LAG.

Figure 3-12 Link Aggregation



LAG simplifies controller configuration because you no longer need to configure primary and secondary ports for each interface. If any of the controller ports fail, traffic is automatically migrated to one of the other ports. As long as at least one controller port is functioning, the system continues to operate, access points remain connected to the network, and wireless clients continue to send and receive data.

Note LAG is supported across switches.

Terminating on two different modules within a single Catalyst 6500 series switch provides redundancy and ensures that connectivity between the switch and the controller is maintained when one module fails. Figure 3-13 shows this use of redundant modules. A Cisco 4402-50 Controller is connected to two different Gigabit modules (slots 2 and 3) within the Catalyst 6500 Series Switch. The controller's port 1 is connected to Gigabit interface 3/1, and the controller's port 2 is connected to Gigabit interface 2/1 on the Catalyst 6500 series switch. Both switch ports are assigned to the same channel group.

When a Cisco 5500 Series Controller, Cisco 4404 Controller, or WiSM controller module LAG port is connected to a Catalyst 3750G or a 6500 or 7600 channel group employing load balancing, note the following:

- LAG requires the EtherChannel to be configured for the on mode on both the controller and the Catalyst switch.
- Once the EtherChannel is configured as on at both ends of the link, it does not matter if the Catalyst switch is configured for either Link Aggregation Control Protocol (LACP) or Cisco proprietary Port Aggregation Protocol (PAgP) because no channel negotiation is done between the controller and the switch. Additionally, LACP and PAgP are not supported on the controller.
- The load-balancing method configured on the Catalyst switch must be a load-balancing method that terminates all IP datagram fragments on a single controller port. Not following this recommendation may result in problems with access point association.

- The recommended load-balancing method for Catalyst switches is **src-dst-ip** (enter the **port-channel load-balance** *src-dst-ip* command).
- The Catalyst 6500 series switches running in PFC3 or PFC3CXL mode implement enhanced EtherChannel load balancing. The enhanced EtherChannel load balancing adds the VLAN number to the hash function, which is incompatible with LAG. From Release 12.2(33)SXH and later releases, Catalyst 6500 IOS software offers the **exclude vlan** keyword to the **port-channel load-balance** command to implement **src-dst-ip** load distribution. See the *Cisco IOS Interface and Hardware Component Command Reference* for more information.
- Enter the **show platform hardware pfc mode** command on the Catalyst 6500 switch to confirm the PFC operating mode.

  The following example shows a Catalyst 6500 series switch in PFC3B mode when you enter the global configuration **port-channel load-balance src-dst-ip** command for proper LAG functionality:

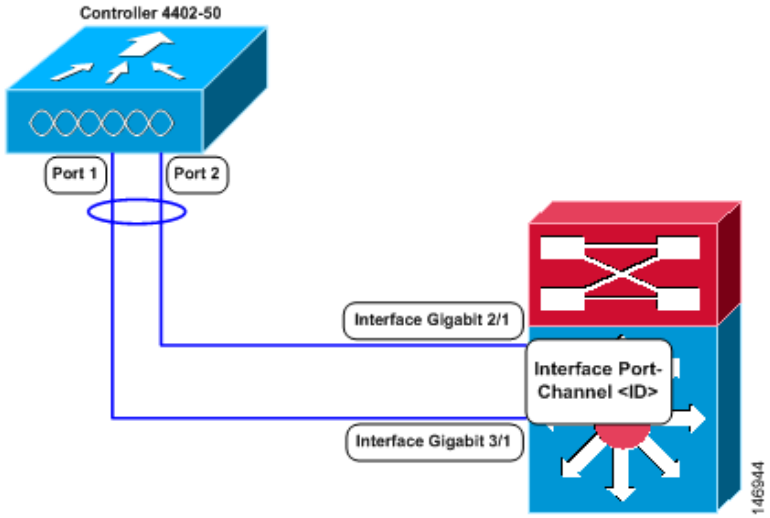
```
# show platform hardware pfc mode PFC operating mode
PFC operating mode : PFC3B
# show EtherChannel load-balance
EtherChannel Load-Balancing Configuration:
src-dst-ip
```

  The following example shows Catalyst 6500 series switch in PFC3C mode when you enter the **exclude vlan** keyword in the **port-channel load- balance src-dst-ip exclude vlan** command:

```
# show platform hardware pfc mode
PFC operating mode : PFC3C
# show EtherChannel load-balance
EtherChannel Load-Balancing Configuration:
src-ip enhanced
# mpls label-ip
```

- If the recommended load-balancing method cannot be configured on the Catalyst switch, then configure the LAG connection as a single member link or disable LAG on the controller.

Figure 3-13 Link Aggregation with the Catalyst 6500 Series Neighbor Switch



Link Aggregation Guidelines

Follow these guidelines when using LAG:

- You cannot configure the controller's ports into separate LAG groups. Only one LAG group is supported per controller. Therefore, you can connect a controller in LAG mode to only one neighbor device.

  Note The two internal Gigabit ports on the controller within the Catalyst 3750G Integrated Wireless LAN Controller Switch are always assigned to the same LAG group.

- When you enable LAG or make any changes to the LAG configuration, you must immediately reboot the controller.
- When you enable LAG, you can configure only one AP-manager interface because only one logical port is needed. LAG removes the requirement for supporting multiple AP-manager interfaces.
- When you enable LAG, all dynamic AP-manager interfaces and untagged interfaces are deleted, and all WLANs are disabled and mapped to the management interface. Also, the management, static AP-manager, and VLAN-tagged dynamic interfaces are moved to the LAG port.
- Multiple untagged interfaces to the same port are not allowed.
- When you enable LAG, you cannot create interfaces with a primary port other than 29.
- When you enable LAG, all ports participate in LAG by default. You must configure LAG for all of the connected ports in the neighbor switch.
- When you enable LAG on the Cisco WiSM, you must enable port-channeling/EtherChanneling for all of the controller's ports on the switch.
- When you enable LAG, port mirroring is not supported.
- When you enable LAG, if any single link goes down, traffic migrates to the other links.
- When you enable LAG, only one functional physical port is needed for the controller to pass client traffic.

- When you enable LAG, access points remain connected to the switch, and data service for users continues uninterrupted.
- When you enable LAG, you eliminate the need to configure primary and secondary ports for each interface.
- When you enable LAG, the controller sends packets out on the same port on which it received them. If a CAPWAP packet from an access point enters the controller on physical port 1, the controller removes the CAPWAP wrapper, processes the packet, and forwards it to the network on physical port 1. This may not be the case if you disable LAG.
- When you disable LAG, the management, static AP-manager, and dynamic interfaces are moved to port 1.
- When you disable LAG, you must configure primary and secondary ports for all interfaces.
- When you disable LAG, you must assign an AP-manager interface to each port on the controller. Otherwise, access points are unable to join.
- Cisco 5500 and 4400 Series Controllers support a single static link aggregation bundle.
- LAG is typically configured using the Startup Wizard, but you can enable or disable it at any time through either the GUI or CLI.

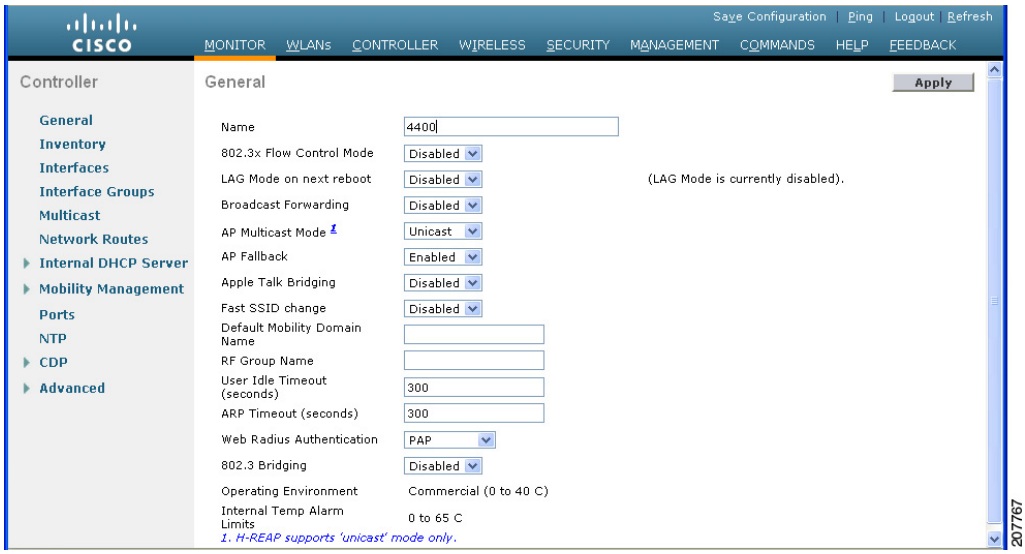
Note LAG is enabled by default and is the only option on the WiSM controller and the controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch.

Using the GUI to Enable Link Aggregation

To enable LAG on your controller using the controller GUI, follow these steps:

Step 1 Choose **Controller > General** to open the General page (see Figure 3-14).

Figure 3-14 General Page



Step 2 Set the LAG Mode on Next Reboot parameter to **Enabled**.

Note Choose **Disabled** if you want to disable LAG. LAG is disabled by default on the Cisco 5500 and 4400 series controllers but enabled by default on the Cisco WiSM and the controller in the Catalyst 3750G Integrated Wireless LAN Controller Switch.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 Reboot the controller.

Step 6 Assign the WLAN to the appropriate VLAN.

Using the CLI to Enable Link Aggregation

To enable LAG on your controller using the CLI, follow these steps:

Step 1 Enter the **config lag enable** command to enable LAG.

Note Enter the **config lag disable** command if you want to disable LAG.

Step 2 Enter the **save config** command to save your settings.

Step 3 Reboot the controller.

Using the CLI to Verify Link Aggregation Settings

To verify your LAG settings, enter this command:

show lag summary

Information similar to the following appears:

```
LAG Enabled
```

Configuring Neighbor Devices to Support Link Aggregation

The controller's neighbor devices must also be properly configured to support LAG.

- Each neighbor port to which the controller is connected should be configured as follows:

```
interface GigabitEthernet <interface id>
    switchport
    channel-group <id> mode on
    no shutdown
```

- The port channel on the neighbor switch should be configured as follows:

```
interface port-channel <id>
    switchport
    switchport trunk encapsulation dot1q
```

```
switchport trunk native vlan <native vlan id>
switchport trunk allowed vlan <allowed vlans>
switchport mode trunk
no shutdown
```

Configuring Multiple AP-Manager Interfaces

Note Only Cisco 5500 Series Controllers and Cisco 4400 Series Controllers support the use of multiple AP-manager interfaces.

When you create two or more AP-manager interfaces, each one is mapped to a different port (see Figure 3-15). The ports should be configured in sequential order so that AP-manager interface 2 is on port 2, AP-manager interface 3 is on port 3, and AP-manager interface 4 is on port 4.

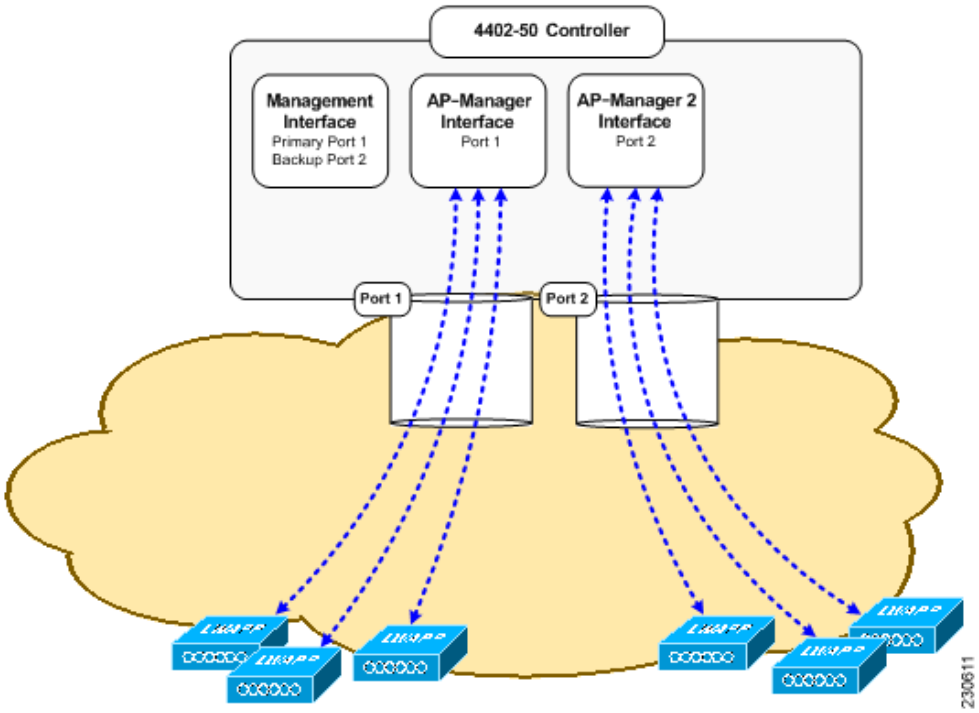
Note AP-manager interfaces do not need to be on the same VLAN or IP subnet, and they may or may not be on the same VLAN or IP subnet as the management interface. However, we recommend that you configure all AP-manager interfaces on the same VLAN or IP subnet.

Note You must assign an AP-manager interface to each port on the controller.

Before an access point joins a controller, it sends out a discovery request. From the discovery response that it receives, the access point can tell the number of AP-manager interfaces on the controller and the number of access points on each AP-manager interface. The access point generally joins the AP-manager with the least number of access points. In this way, the access point load is dynamically distributed across the multiple AP-manager interfaces.

Note Access points may not be distributed completely evenly across all of the AP-manager interfaces, but a certain level of load balancing occurs.

Figure 3-15 Two AP-Manager Interfaces



Before implementing multiple AP-manager interfaces, you should consider how they would impact your controller's port redundancy.

Examples:

1. The Cisco 4402-50 Controller supports a maximum of 50 access points and has two ports. To support the maximum number of access points, you would need to create two AP-manager interfaces (see Figure 3-15) because a Cisco 4400 Series Controller can support only 48 access points on one port.
2. The Cisco 4404-100 Controller supports up to 100 access points and has four ports. To support the maximum number of access points, you would need to create three (or more) AP-manager interfaces (see Figure 3-16). If the port of one of the AP-manager interfaces fails, the controller clears the access points' state, and the access points must reboot to reestablish communication with the controller using the normal controller join process. The controller no longer includes the failed AP-manager interface in the CAPWAP or LWAPP discovery responses. The access points then rejoin the controller and are load balanced among the available AP-manager interfaces.

Figure 3-16 Three AP-Manager Interfaces

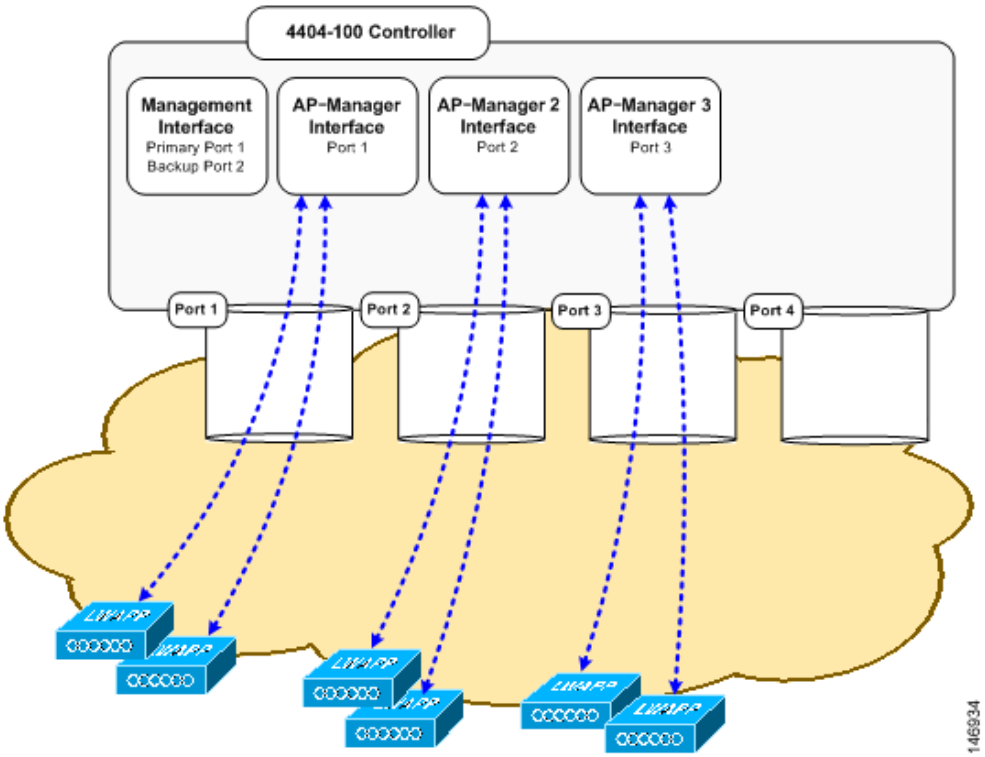
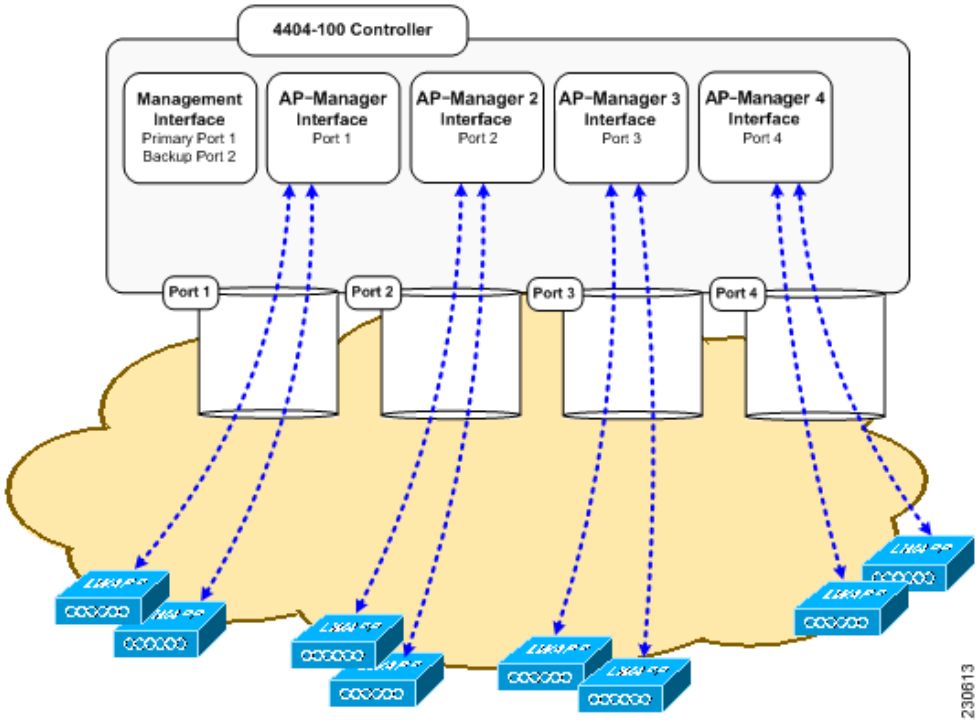


Figure 3-17 shows the use of four AP-manager interfaces to support 100 access points on a Cisco 4400 Series Controller.

Figure 3-17 Four AP-Manager Interfaces



This configuration has the advantage of load balancing all 100 access points evenly across all four AP-manager interfaces. If one of the AP-manager interfaces fails, all of the access points connected to the controller would be evenly distributed among the three available AP-manager interfaces. For example, if AP-manager interface 2 fails, the remaining AP-manager interfaces (1, 3, and 4) would each manage approximately 33 access points.

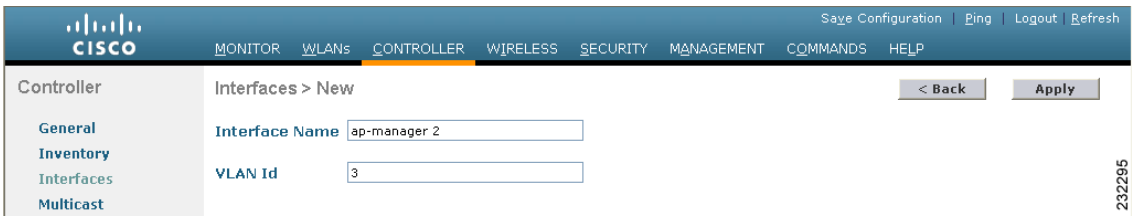
Using the GUI to Create Multiple AP-Manager Interfaces

To create multiple AP-manager interfaces using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Interfaces** to open the Interfaces page.

Step 2 Click **New**. The Interfaces > New page appears (see Figure 3-18).

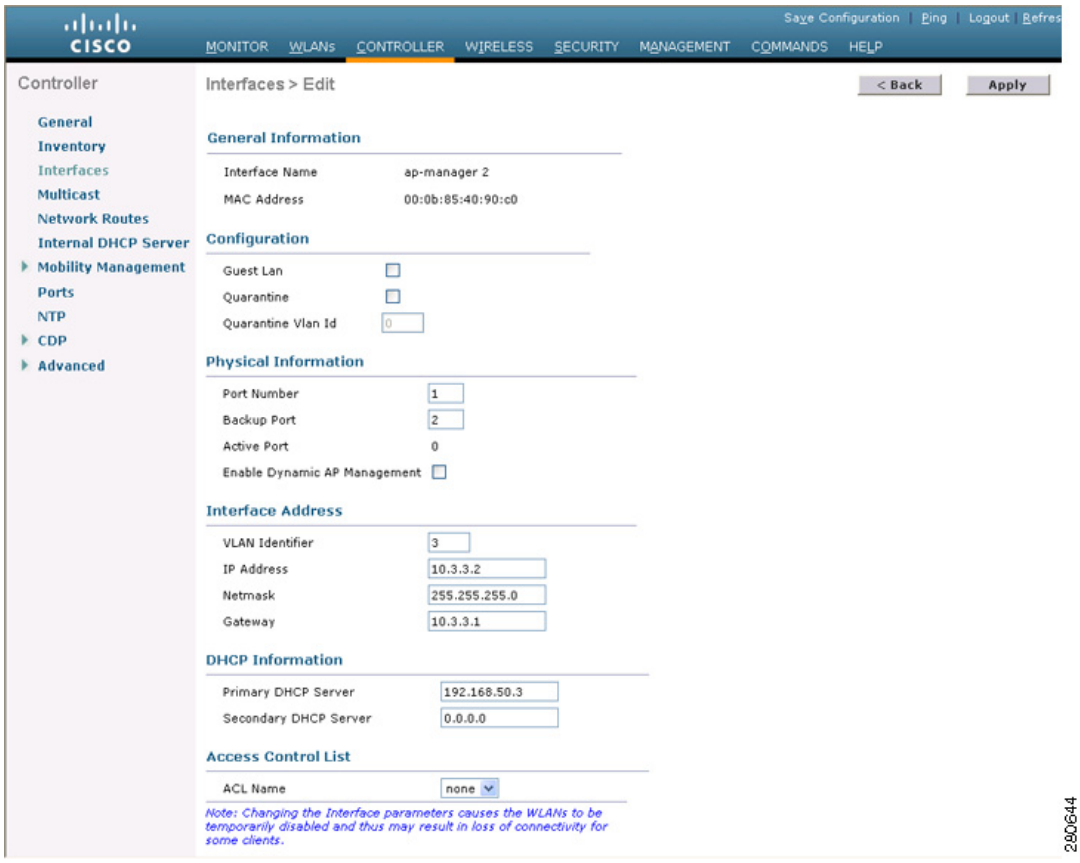
Figure 3-18 Interfaces > New Page



Step 3 Enter an AP-manager interface name and a VLAN identifier.

Step 4 Click **Apply** to commit your changes. The Interfaces > Edit page appears (see Figure 3-19).

Figure 3-19 Interfaces > Edit Page



Step 5 Enter the appropriate interface parameters.

Note Do not define a backup port for an AP-manager interface. Port redundancy is not supported for AP-manager interfaces. If the AP-manager interface fails, all of the access points connected to the controller through that interface are evenly distributed among the other configured AP-manager interfaces.

Step 6 To make this interface an AP-manager interface, select the **Enable Dynamic AP Management** check box.

Note Only one AP-manager interface is allowed per physical port. A dynamic interface that is marked as an AP-manager interface cannot be used as a WLAN interface.

Step 7 Click **Save Configuration** to save your settings.

Step 8 Repeat this procedure for each additional AP-manager interface that you want to create.

Using the CLI to Create Multiple AP-Manager Interfaces

To create multiple AP-manager interfaces using the controller CLI, follow these steps:

Step 1 Enter these commands to create a new interface:

- **config interface create** *operator_defined_interface_name* {*vlan_id* | ***x***}
- **config interface address** *operator_defined_interface_name ip_addr ip_netmask* [*gateway*]
- **config interface vlan** *operator_defined_interface_name* {*vlan_id* | **0**}
- **config interface port** *operator_defined_interface_name physical_ds_port_number*
- **config interface dhcp** *operator_defined_interface_name ip_address_of_primary_dhcp_server* [*ip_address_of_secondary_dhcp_server*]
- **config interface quarantine vlan** *interface_name vlan_id*

  Note Use this command to configure a quarantine VLAN on any interface.

- **config interface acl** *operator_defined_interface_name access_control_list_name*

  Note See Chapter 6, "Configuring Security Solutions," for more information on ACLs.

Step 2 To make this interface an AP-manager interface, enter this command:

config interface ap-manager *operator_defined_interface_name* {**enable** | **disable**}

Note Only one AP-manager interface is allowed per physical port. A dynamic interface that is marked as an AP-manager interface cannot be used as a WLAN interface.

Step 3 To save your changes, enter this command:

save config

Step 4 Repeat this procedure for each additional AP-manager interface that you want to create.

Cisco 5500 Series Controller Example

For a Cisco 5500 Series Controller, we recommend having eight dynamic AP-manager interfaces and associating them to the controller's eight Gigabit ports. If you are using the management interface, which acts like an AP-manager interface by default, you need to create only seven more dynamic AP-manager interfaces and associate them to the remaining seven Gigabit ports. For example, Figure 3-20 shows a dynamic interface that is enabled as a dynamic AP-manager interface and associated to port number 2, and Figure 3-21 shows a Cisco 5500 Series Controller with LAG disabled, the management interface used as one dynamic AP-manager interface, and seven additional dynamic AP-manager interfaces, each mapped to a different Gigabit port.

Figure 3-20 Dynamic Interface Example with Dynamic AP Management

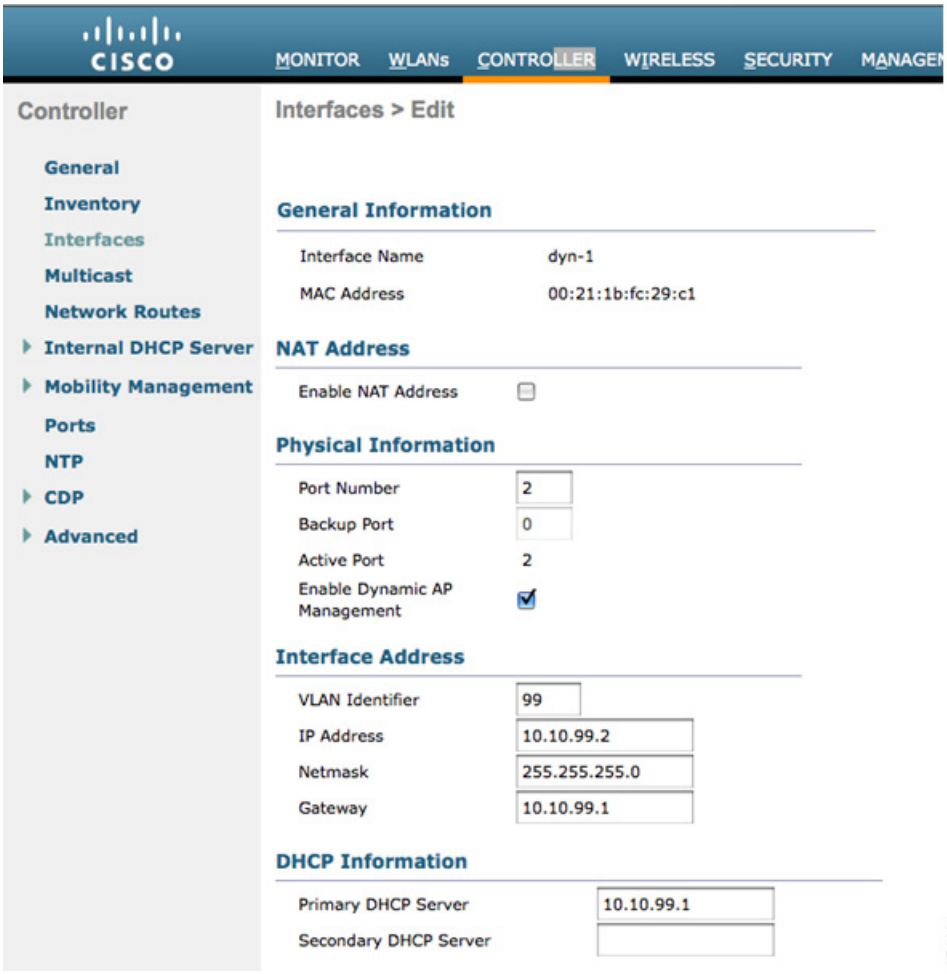
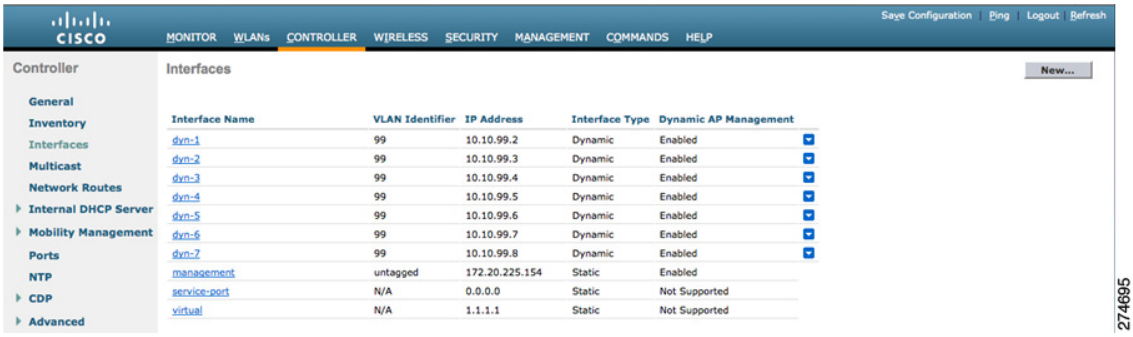


Figure 3-21 Cisco 5500 Series Controller Interface Configuration Example



Configuring VLAN Select

Whenever a wireless client connects to a wireless network (WLAN), the client is placed in a VLAN that is associated with the WLAN. Release 7.0.116.0 and prior releases of the controller software enabled you to associate one VLAN with a WLAN. Each VLAN required a single IP subnet. As a result, a WLAN required a large subnet to accommodate more clients. In a large venue such as an auditorium, a stadium, or a conference where there may be numerous wireless clients, having only a single WLAN to accommodate many clients might be a challenge.

The VLAN select feature enables you to use a single WLAN that can support multiple VLANs. Clients can get assigned to one of the configured VLANs. This feature enables you to map a WLAN to a single or multiple interface VLANs using interface groups. Wireless clients that associate to the WLAN get an IP address from a pool of subnets identified by the interfaces in round-robin fashion. This feature also extends the current AP group architecture where AP groups can override an interface or interface group to which the WLAN is mapped to, with multiple interfaces using the interface groups. This feature also provides the solution to auto anchor restrictions where a wireless guest user on a foreign location can get an IP address from multiple subnets based on their foreign locations or foreign controllers from the same anchor controller.

When a client roams from one controller to another, the foreign controller sends the VLAN information as part of the mobility announce message. Based on the VLAN information received, the anchor decides whether the tunnel should be created between the anchor controller and the foreign controller. If the same VLAN is available on the foreign controller, the client context is completely deleted from the anchor and the foreign controller becomes the new anchor controller for the client.

If an interface (int-1) in a subnet is untagged in one controller (Vlan ID 0) and the interface (int-2) in the same subnet is tagged to another controller (Vlan ID 1), then with the VLAN select, client joining the first controller over this interface may not undergo an L2 roam while it moves to the second controller. Hence, for L2 roaming to happen between two controllers with VLAN select, all the interfaces in the same subnet should be either tagged or untagged.

As part of the VLAN select feature, the mobility announce message carries an additional vendor payload that contains the list of VLAN inte rfaces in an interface group mapped to a foreign controller's WLAN. This VLAN list enables the anchor to differentiate from a local to local or local to foreign handoff.

Note VLAN pooling applies to wireless clients and locally switched WLANs.

This section lists the following topics:

Platform Support

The following lightweight access points are supported:

Cisco Aironet 1120, 1230, 1130, 1040, 1140, 1240, 1250, 1260, 3500, 1522/1524 Access Points, and 800 Series access points.

The following controllers are supported:

Cisco Flex 7500, Cisco 5508, 4402, 4404, WISM, WiSM-2, 2500, 2106, 2112, 2125 Series Controllers.

Using Interface Groups

Interface groups are logical groups of interfaces. Interface groups facilitate user configuration where the same interface group can be configured on multiple WLANs or while overriding a WLAN interface per AP group. An interface group can exclusively contain either quarantine or nonquarantine interfaces. An interface can be part of multiple interface groups.

A WLAN can be associated with an interface or interface group. The interface group name and the interface name cannot be the same.

This feature also enables you to associate a client to specific subnets based on the foreign controller that they are connected to. The anchor controller WLAN can be configured to maintain a mapping between foreign controller MAC and a specific interface or interface group (Foreign maps) as needed. If this mapping is not configured, clients on that foreign controller gets VLANs associated in a round robin fashion from interface group configured on WLAN.

Table 3-8 lists the platform support for interface and interface groups:

Table 3-8 Platform Support for Interface and Interface groups

Platform	Interface Groups	Interfaces per Interface Group
WiSM-2, Cisco 5508 Series Controller, Cisco Flex 7500 Series Controller, Cisco 2500 Series Controller.	64	64
WiSM, Cisco 4400 Series Controller, Cisco 4200 Series Controllers	32	32
Cisco 2100 Series Controller and NM6 series	4	4

This section contains the following topics:

Using the GUI to Create Interface Groups

To create interface groups using the controller GUI, follow these steps:

Step 1 Choose **Controller > Interface Groups** from the left navigation pane.

The Interface Groups page appears with the list of interface groups already created.

Note To remove an interface group, hover your mouse pointer over the blue drop-down icon and choose **Remove**.

Step 2 Click **Add Group** to add a new group.

The Add New Interface Group page appears.

Step 3 Enter the details of the interface group:

- **Interface Group Name**—Specify the name of the interface group.
- **Description**—Add a brief description of the interface group.

Step 4 Click **Add**.

Using the CLI to Create Interface Groups

To create interface groups using the CLI, use the following commands:

- **config interface group {create| delete}** *interface_group_name*—Creates or deletes an interface group
- **config interface group description** *interface_group_name* "description"—Adds a description to the interface group

Using the GUI to Add Interfaces to Interface Groups

To add an interface to an interface group, follow these steps:

Step 1 Choose **Controller > Interface Groups**.

The Interface Groups page appears with a list of all interface groups.

Step 2 Click the name of the interface group to which you want to add interfaces.

The Interface Groups > Edit page appears.

Step 3 Choose the interface name that you want to add to this interface group from the Interface Name drop-down list.

Step 4 Click **Add Interface** to add the interface to the Interface group.

Step 5 Repeat Steps 2 and 3 if you want to add multiple interfaces to this interface group.

Note To remove an interface from the interface group, hover your mouse pointer over the blue drop-down arrow and choose **Remove**.

Using the CLI to Add Interfaces to Interface Groups

To add interfaces to interface groups, use the **config interface group interface add** *interface_group interface_name* command.

Using the GUI to Add an Interface Group to a WLAN

To add an interface group to a WLAN, follow these steps:

Step 1 Choose the **WLAN** tab.

The WLANs page appears listing the available WLANs.

Step 2 Click the WLAN ID of the WLAN to which you want to add the interface group.

Step 3 In the **General** tab, choose the interface group from the Interface/Interface Group (G) drop-down list.

Step 4 Click **Apply**.

Using the CLI to Add an Interface Group to a WLAN

To add an interface group to a WLAN, use the command **config wlan interface** *wlan_id interface_group_name.*

Using Multicast Optimization

Prior to the 7.0.116.0 release, multicast was based on the grouping of the multicast address and the VLAN as one entity, MGID. With VLAN select and VLAN pooling, there is a possibility that you might increase duplicate packets. With the VLAN select feature, every client listens to the multicast stream on a different VLAN. As a result, the controller creates different MGIDs for each multicast address and VLAN. Therefore, the upstream router sends one copy for each VLAN, which results, in the worst case, in as many copies as there are VLANs in the pool. Since the WLAN is still the same for all clients, multiple copies of the multicast packet are sent over the air. To suppress the duplication of a multicast stream on the wireless medium and between the controller and access points, you can use the multicast optimization feature.

Multicast optimization enables you to create a multicast VLAN which you can use for multicast traffic. You can configure one of the VLANs of the WLAN as a multicast VLAN where multicast groups are registered. Clients are allowed to listen to a multicast stream on the multicast VLAN. The MGID is generated using mulicast VLAN and multicast IP addresses. If multiple clients on the VLAN pool of the same WLAN are listening to a single multicast IP address, a single MGID is generated. The controller makes sure that all multicast streams from the clients on this VLAN pool always go out on the multicast VLAN to ensure that the upstream router has one entry for all the VLANs of the VLAN pool. Only one multicast stream hits the VLAN pool even if the clients are on different VLANs. Therefore, the multicast packets that are sent out over the air is just one stream.

Using the GUI to Configure a Multicast VLAN

To configure a multicast VLAN using the controller GUI, follow these steps:

Step 1 Choose the **WLANs** tab.

The WLANs tab appears.

Step 2 Click on the WLAN ID of the WLAN that you want to choose for a multicast VLAN.

The WLANs > Edit page appears

Step 3 Enable the multicast VLAN feature by selecting the **Multicast VLAN feature** check box.

The Multicast Interface drop-down list appears.

Step 4 Choose the VLAN from the Multicast Interface drop-down list.

Step 5 Click **Apply**.

Using the CLI to Configure Multicast VLAN

Use the **config wlan multicast interface** *wlan_id* **enable** *interface_name* command to configure the multicast VLAN feature.

CHAPTER 4

Configuring Controller Settings

This chapter describes how to configure settings on the controller. It contains these sections:

- Resetting the Controller to Default Settings, page 4-124

Installing and Configuring Licenses

You can order Cisco 5500 Series Controllers with support for 12, 25, 50, 100, 250 or 500 access points as the controller's base capacity. You can add additional access point capacity through capacity adder licenses available at 25, 50, 100 and 250 access point capacities. You can add the capacity adder licenses to any base license in any combination to arrive at the maximum capacity of 500 access points. The base and adder licenses are supported through both rehosting and RMAs.

Note These controller platforms do not require licenses: Cisco 2100 and Cisco 4400 Series Controllers, Cisco WiSMs, Controller Network Modules, and Catalyst 3750G Integrated Wireless LAN Controller Switches.

Note All features included in a Wireless LAN Controller Wplus license are now included in the base license; this change is introduced in release 6.0.196.0. There are no changes to WCS BASE and PLUS licensing.

The base license supports the standard base software set and, for releases 6.0196.0 and later, the premium software set is included as part of the base feature set, which includes this functionality:

- Datagram Transport Layer Security (DTLS) data encryption for added security across remote WAN and LAN links. See the "Configuring Data Encryption" section on page 8-2 for more information on data encryption.

Note The Availability of data DTLS for the 7.0.116.0 release is as follows:

Cisco 5500 Series Controller—The Cisco 5500 Series Controller will be available with two licensing options: One with data DTLS capabilities and another image without data DTLS.

2500, WiSM2, WLC2—These platforms by default will not contain DTLS. To turn on data DTLS, you must install a license. These platforms will have a single image with data DTLS turned off. To use data DTLS you will need to have a license.

- Support for OfficeExtend access points, which are used for secure mobile teleworking. See the "OfficeExtend Access Points" section on page 8-69 for more information on OfficeExtend access points.
- Support for the 1130AG and 1240AG series indoor mesh access points, which dynamically establish wireless connections in locations where it might be difficult to connect to the wired network. See Chapter 9, "Controlling Mesh Access Points," for more information on mesh access points.

All features included in a Wireless LAN Controller WPLUS license are now included in the base license; this change is introduced in release 6.0.196.0. There are no changes to WCS BASE and PLUS licensing. These WPlus license features are included in the base license:

- OfficeExtend AP
- Enterprise Mesh
- CAPWAP Data Encryption

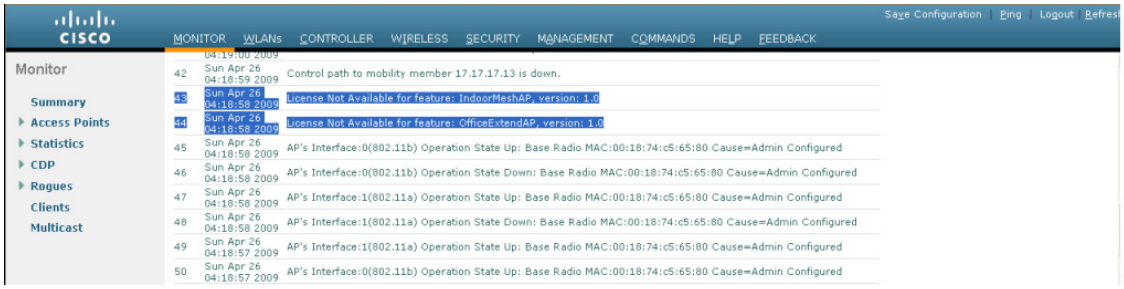
The licensing change can affect features on your wireless LAN when you upgrade or downgrade software releases, so you should be aware of these guidelines:

- If you have a WPlus license and you upgrade from 6.0.x.x to 7.0.98.0, your license file contains both Basic and WPlus license features. You won't see any disruption in feature availability and operation.
- If you have a WPlus license and you downgrade from 7.0.98.0 to 6.0.196.0 or 6.0.188 or 6.0.182, your license file contains only base license, and you will lose all WPlus features.
- If you have a base license and you downgrade from 6.0.196.0 to 6.0.188 or 6.0.182, when you downgrade, you lose all WPlus features.

To view the controller trap log, choose **Monitor** and click **View All** under "Most Recent Traps" on the controller GUI (see Figure 4-1).

Note You can also view traps by using SNMP-based management tools.

Figure 4-1 Trap Logs Page



The ap-count licenses and their corresponding image-based licenses are installed together. The controller keeps track of the licensed access point count and does not allow more than the number of access points to associate to it.

The Cisco 5500 Series Controller is shipped with both permanent and evaluation base and base-ap-count licenses. If desired, you can activate the evaluation licenses, which are designed for temporary use and set to expire after 60 days.

Note See the "Choosing the Licensed Feature Set" section on page 4-14 for instructions on activating an image-based evaluation license and the "Activating an AP-Count Evaluation License" section on page 4-17 for instructions on activating an ap-count evaluation license.

No licensing steps are required after you receive your Cisco 5500 Series Controller because the licenses you ordered are installed at the factory. In addition, licenses and product authorization keys (PAKs) are preregistered to serial numbers. However, as your wireless network evolves, you might want to add support for additional access points or upgrade from the standard software set to the base software set. To do so, you need to obtain and install an upgrade license.

Obtaining an Upgrade or Capacity Adder License

A certificate with a product authorization key (PAK) is required before you can obtain an upgrade license.

You can use the capacity adder licenses to increase the number of access points supported by the controller up to a maximum of 500 access points. The capacity adder licenses are available in access point capacities of 10, 25, 50, 100 and 250 access points. You can add these licenses to any of the base capacity licenses of 12, 25, 50, 100 and 250 access points.

For example, if your controller was initially ordered with support for 100 access points (base license AIR-CT5508-100-K9), you could increase the capacity to 500 access points by purchasing a 250 access point, 100 access point, and a 50 access point additive capacity license (LIC-CT5508-250A, LIC-CT5508-100A, and LIC-CT5508-50A).

You can find more information on ordering capacity adder licenses at this URL: http://www.cisco.com/en/US/products/ps10315/products_data_sheets_list.html

Note If you skip any tiers when upgrading (for example, if you do not install the -25U and -50U licenses along with the -100U), the license registration fails.

For a single controller, you can order different upgrade licenses in one transaction (for example, -25U, -50U, -100U, and -250U), for which you receive one PAK with one license. Then you have only one license (instead of four) to install on your controller.

If you have multiple controllers and want to upgrade all of them, you can order multiple quantities of each upgrade license in one transaction (for example, you can order 10 each of the -25U, -50U, -100U, and -250 upgrade licenses), for which you receive one PAK with one license. You can continue to register the PAK for multiple controllers until it is exhausted.

Base license SKUs for the Cisco 5500 Series Controllers are as follows:

- AIR-CT5508-12-K9
- AIR-CT5508-25-K9
- AIR-CT5508-50-K9
- AIR-CT5508-100-K9
- AIR-CT5508-250-K9
- AIR-CT5508-500-K9

Base license SKUs for the Cisco 2500 Series Controllers are as follows:

- AIR-CT2504-5-K9
- AIR-CT2504-15-K9
- AIR-CT2504-25-K9
- AIR-CT2504-50-K9

Base license SKUs for the Cisco WiSM2 Controllers are as follows:

- WS-SVC-WISM2-1-K9—WiSM2 with 100 AP support.
- WS-SVC-WISM2-3-K9—WiSM2 with 300 AP support
- WS-SVC-WISM2-5-K9—WiSM2 with 500 AP support

Table 4-1 lists the available adder licenses for the 5500 and 2500 Series Controllers:

Table 4-1 Available Capacity Adder Licenses

Type	Part Number	Description
e-mail	L-LIC-CT5508-UPG	Primary upgrade SKU: Pick any number or combination of the following options under this SKU to upgrade one or many controllers under one product authorization key
	L-LIC-CT5508-25A	25 AP Adder License for the 5508 Controller (eDelivery)
	L-LIC-CT5508-50A	50 AP Adder License for the 5508 Controller (eDelivery)
	L-LIC-CT5508-100A	100 AP Adder License for the 5508 Controller (eDelivery)
	L-LIC-CT5508-250A	250 AP Adder License for the 5508 Controller (eDelivery)
	L-LIC-CT2504-UPG	Primary upgrade SKU: Pick any number or combination of the following options under this SKU to upgrade one or many controllers under one product authorization key
	L-LIC-CT2504-5A	5 AP Adder License for Cisco 2504 Wireless Controller (e-Delivery)
	L-LIC-CT2504-25A	25 AP Adder License for Cisco 2504 Wireless Controller (e-Delivery)
paper	LIC-CT5508-UPG	Primary upgrade SKU: Pick any number or combination of the following options under this SKU, to upgrade one or many controllers under one product authorization key
	LIC-CT5508-25A	25 AP Adder License for the 5508 Controller
	LIC-CT5508-50A	50 AP Adder License for the 5508 Controller
	LIC-CT5508-100A	100 AP Adder License for the 5508 Controller
	LIC-CT5508-250A	250 AP Adder License for the 5508 Controller
	LIC-CT2504-UPG	Primary upgrade SKU: Pick any number or combination of the following options under this SKU to upgrade one or many controllers under one product authorization key
	LIC-CT2504-5A	5 AP Adder License for Cisco 2504 Controller (Paper Certificate - US Mail)
	LIC-CT2504-25A	25 AP Adder License for Cisco 2504 Controller (Paper Certificate - US Mail)

To obtain and register a PAK certificate, follow these steps:

Step 1 Order the PAK certificate for an upgrade license through your Cisco channel partner or your Cisco sales representative, or order it online at this URL:

http://www.cisco.com/go/ordering

Step 2 If you are ordering online, begin by choosing the primary upgrade SKU **L-LIC-CT5508-UPG or LIC CT5508-UPG**. Then, choose any number of the following options to upgrade one or more controllers under one PAK. Table 4-1 lists the capacity adder licenses available through e-mail or on paper:After you receive the certificate, use one of two methods to register the PAK:

- Cisco License Manager (CLM)—This method automates the process of obtaining licenses and deploying them on Cisco devices. For deployments with more than five controllers, we recommend using CLM to register PAKs and install licenses. You can also use CLM to rehost or RMA a license.

Note You cannot use CLM to change the licensed feature set or activate an ap-count evaluation license. To perform these operations, you must follow the instructions in the "Choosing the Licensed Feature Set" section on page 4-14 and the "Activating an AP-Count Evaluation License" section on page 4-17. Because you can use CLM to perform all other license operations, you can disregard the remaining licensing information in this chapter except these two sections and the "Configuring the License Agent" section on page 4-26 if you want your controller to use HTTP to communicate with CLM.

Note You can download the CLM software and access user documentation at this URL:

http://www.cisco.com/go/clm

- Licensing portal—This alternative method enables you to manually obtain and install licenses on your controller. If you want to use the licensing portal to register the PAK, follow the instructions in Step 3.

Step 3 Use the licensing portal to register the PAK as follows:

a. Go to http://tools.cisco.com/SWIFT/Licensing/PrivateRegistrationServlet

b. On the main Product License Registration page, enter the PAK mailed with the certificate in the Product Authorization Key (PAK) text box and click **Submit**.

c. On the Validate Features page, enter the number of licenses that you want to register in the Qty text box and click **Update**.

d. To determine the controller's product ID and serial number, choose **Controller > Inventory** on the controller GUI or enter the **show license udi** command on the controller CLI.

Information similar to the following appears on the controller CLI:

```
Device# PID                   SN                    UDI
------- -------------------- ---------------------- --------------------------------
*0      AIR-CT5508-K9         FCW1308L030            AIR-CT5508-K9:FCW1308L030
```

e. On the Designate Licensee page, enter the product ID and serial number of the controller on which you plan to install the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the text boxes on this page, and click **Submit**.

f. On the Finish and Submit page, verify that all information is correct and click **Submit**.

g. When a message appears indicating that the registration is complete, click **Download License**. The license is e-mailed within 1 hour to the address that you specified.

h. When the e-mail arrives, follow the instructions provided.

i. Copy the license file to your TFTP server.

j. Follow the instructions in the "Installing a License" section below to install the license on your controller.

Installing a License

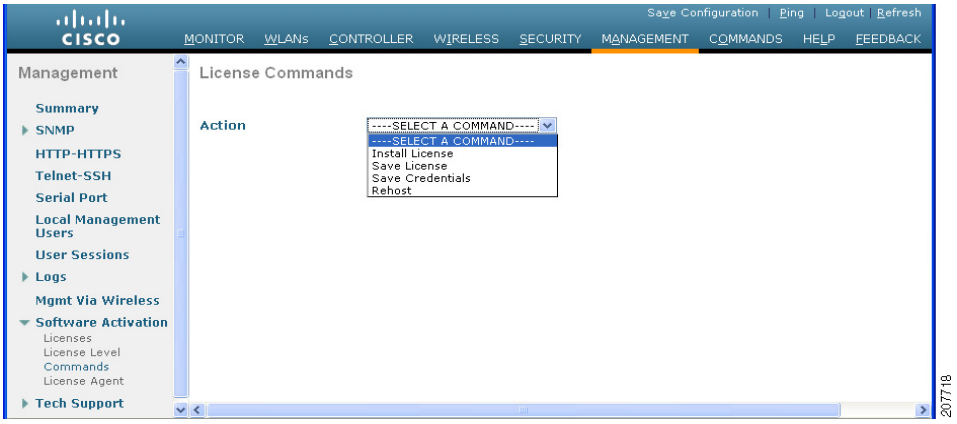
You can use the controller GUI or CLI to install a license on a Cisco 5500 Series Controller.

Using the GUI to Install a License

To install a license on the controller using the controller GUI, follow these steps:

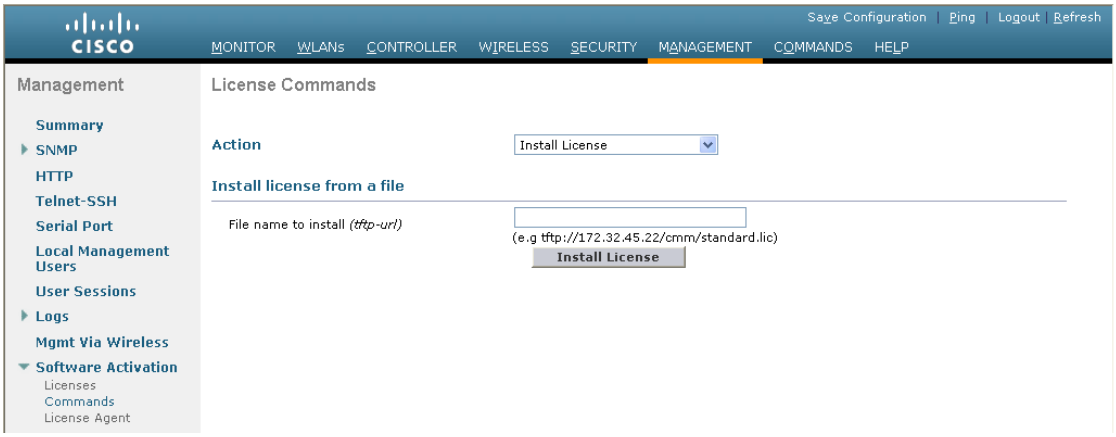
Step 1 Choose **Management > Software Activation > Commands** to open the License Commands page (see Figure 4-2).

Figure 4-2 License Commands Page



Step 2 From the Action drop-down list, choose **Install License**. The Install License from a File section appears (see Figure 4-3).

Figure 4-3 License Commands (Install License) Page



Step 3 In the File Name to Install text box, enter the path to the license (*.lic) on the TFTP server.

Step 4 Click **Install License**. A message appears to show whether the license was installed successfully. If the installation fails, the message provides the reason for the failure, such as the license is an existing license, the path was not found, the license does not belong to this device, you do not have correct permissions for the license, and so on.

Step 5 If the end-user license agreement (EULA) acceptance dialog box appears, read the agreement and click **Accept** to accept the terms of the agreement.

Note Typically, you are prompted to accept the EULA for evaluation, extension, and rehost licenses. The EULA is also required for permanent licenses, but it is accepted during license generation.

Step 6 Save a backup copy of all installed licenses as follows:

a. From the Action drop-down list, choose **Save License**.

b. In the File Name to Save text box, enter the path on the TFTP server where you want the licenses to be saved.

Note You cannot save evaluation licenses.

c. Click **Save Licenses**.

Step 7 Reboot the controller.

Step 8 Follow the instructions in the "Viewing Licenses" section on page 4-9 to see the status of the license that you installed.

Step 9 If the desired license is not being used by the controller, follow the instructions in the "Choosing the Licensed Feature Set" section on page 4-14 or the "Activating an AP-Count Evaluation License" section on page 4-17 to change the license that is used by the controller.

Using the CLI to Install a License

To install a license on the controller using the controller CLI, follow these steps:

Step 1 Install a license on the controller by entering this command:

license install *url*

where *url* is tftp://*server_ip*/*path*/*filename*.

Note To remove a license from the controller, enter the **license clear** *license_name* command. For example, you might want to delete an expired evaluation license or any unused license. You cannot delete unexpired evaluation licenses, the permanent base image license, or licenses that are in use by the controller.

Step 2 If you are prompted to accept the end-user license agreement (EULA), read and accept the terms of the agreement.

Note Typically, you are prompted to accept the EULA for evaluation, extension, and rehost licenses. The EULA is also required for permanent licenses, but it is accepted during license generation.

Step 3 Add comments to a license or delete comments from a license by entering this command:

license comment {**add** | **delete**} *license_name comment_string*

Step 4 Save a backup copy of all installed licenses by entering this command:

license save *url*

where *url* is tftp://*server_ip*/*path*/*filename*.

Step 5 Reboot the controller by entering this command:

reset system

Step 6 Follow the instructions in the "Viewing Licenses" section on page 4-9 to see the status of the license you installed.

Step 7 If the desired license is not being used by the controller, follow the instructions in the "Choosing the Licensed Feature Set" section on page 4-14 or the "Activating an AP-Count Evaluation License" section on page 4-17 to change the license that is used by the controller.

Viewing Licenses

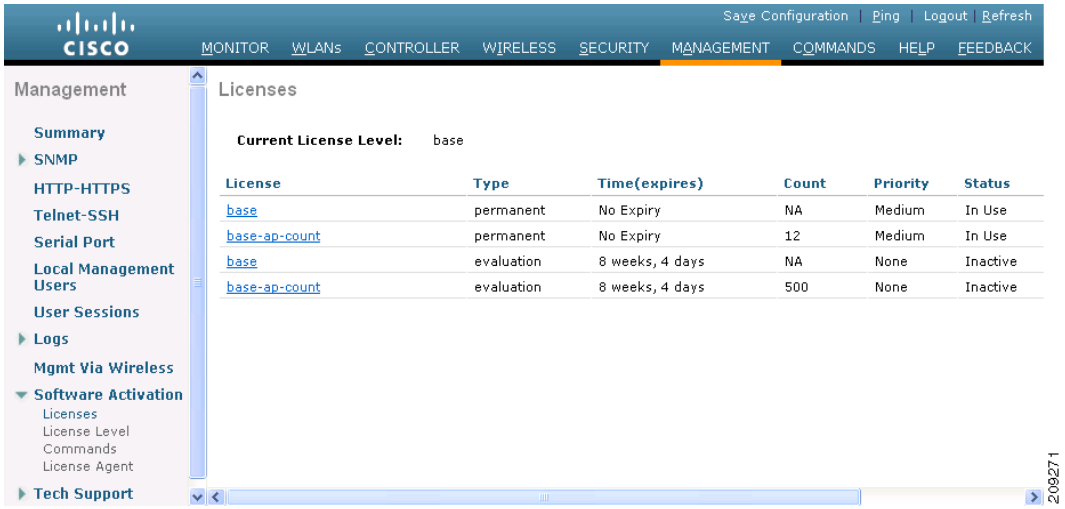
This section describes how to view the licenses on the controller.

Using the GUI to View Licenses

To view licenses on the controller using the controller GUI, follow these steps:

Step 1 Choose **Management** > **Software Activation** > **Licenses** to open the Licenses page (see Figure 4-4).

Figure 4-4 Licenses Page



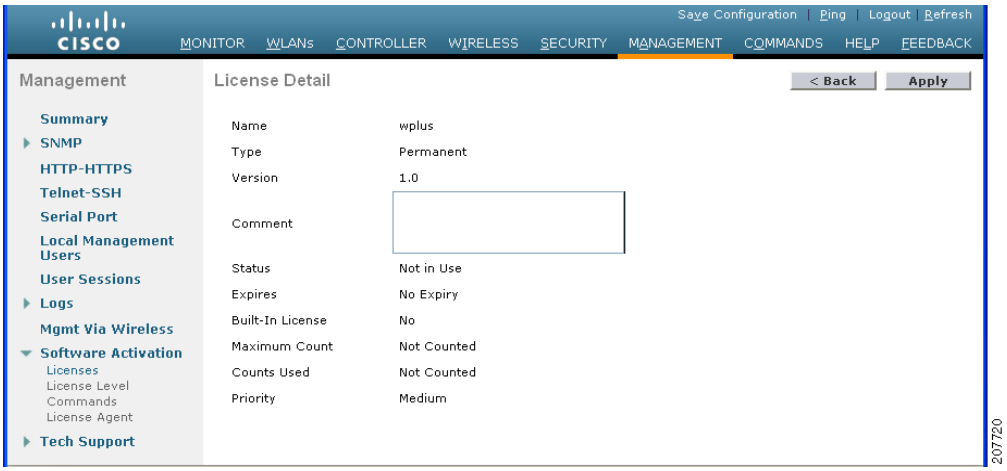
This page lists all of the licenses installed on the controller. For each license, it shows the license type, expiration, count (the maximum number of access points allowed for this license), priority (low, medium, or high), and status (in use, not in use, inactive, or EULA not accepted).

Note Controller platforms do not support the status of "grace period" or "extension" as a license type. The license status will always show "evaluation" even if a grace period or an extension evaluation license is installed.

Note If you ever want to remove a license from the controller, hover your cursor over the blue drop-down arrow for the license and click **Remove**. For example, you might want to delete an expired evaluation license or any unused license. You cannot delete unexpired evaluation licenses, the permanent base image license, or licenses that are in use by the controller.

Step 2 Click the link for the desired license to view more details for a particular license. The License Detail page appears (see Figure 4-5).

Figure 4-5 License Detail Page



This page shows the following additional information for the license:

- The license type (permanent, evaluation, or extension)
- The license version
- The status of the license (in use, not in use, inactive, or EULA not accepted)
- The length of time before the license expires

Note Permanent licenses never expire.

- Whether the license is a built-in license
- The maximum number of access points allowed for this license
- The number of access points currently using this license

Step 3 If you want to enter a comment for this license, type it in the Comment text box and click **Apply**.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to View Licenses

To view licenses on the controller, use these commands:

- See the license level, license type, and number of access points licensed on the controller by entering this command:

  show sysinfo

  Information similar to the following appears:

```
Manufacturer's Name.............................. Cisco Systems Inc.
Product Name..................................... Cisco Controller
Product Version.................................. 7.0
RTOS Version..................................... 7.0
Bootloader Version............................... 5.2
Emergency Image Version.......................... N/A
Build Type....................................... DATA + WPS
System Name...................................... Cisco 69
```

```
System Location................................. na
System Contact.................................. abc@cisco.com
System ObjectID................................. 1.3.6.1.4.1.14179.1.1.4.3
IP Address...................................... 10.10.10.10
System Up Time.................................. 3 days 1 hrs 12 mins 42 secs
System Timezone Location.......................
CurrentBoot License Level.......................base
CurrentBoot License Type........................Permanent
NextBoot License Level..........................base
NextBoot License Type...........................Permanent
Operating Environment........................... Commercial (0 to 40 C)
Internal Temp Alarm Limits...................... 0 to 65 C
Internal Temperature............................ +40 C
State of 802.11b Network........................ Enabled
State of 802.11a Network........................ Enabled
Number of WLANs................................. 4
Number of Active Clients........................ 0
Burned-in MAC Address........................... 00:1A:6D:DD:1E:40
Crypto Accelerator 1............................ Absent
Crypto Accelerator 2............................ Absent
Power Supply 1.................................. Absent
Power Supply 2.................................. Present, OK
Maximum number of APs supported................. 12
```

- See a brief summary of all active licenses installed on the controller by entering this command:

  show license summary

  Information similar to the following appears:

```
Index 1 Feature: wplus
        Period left: 0 minute 0 second
Index 2 Feature: wplus-ap-count
       Period left: 0 minute 0 second
Index3  Feature: base
       Period left: Life time
       License Type: Permanent
       License State: Active, In Use
       License Count: Non-Counted
       License Priority: Medium
Index 4 Feature: base-ap-count
       Period left: 6 weeks, 4 days
       License Type: Evaluation
       License State: Active, In Use
       License Count: 250/250/0
       License Priority: High
```

- See all of the licenses installed on the controller by entering this command:

  show license all

  Information similar to the following appears:

```
License Store: Primary License Storage
StoreIndex:  1  Feature: base   Version: 1.0
        License Type: Permanent
        License State: Active, Not in Use
        License Count: Non-Counted
        License Priority: Medium

StoreIndex:  3  Feature: base-ap-count   Version: 1.0
        License Type: Evaluation
        License State: Active, In Use
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  3 days
```

```
        License Count: 250/0/0
        License Priority: High
```

- See the details for a particular license by entering this command:

  show license detail *license_name*

  Information similar to the following appears:

```
Index:  1       Feature: base-ap-count   Version: 1.0
        License Type: Permanent
        License State: Active, Not in Use
        License Count: 12/0/0
        License Priority: Medium
        Store Index: 0
        Store Name: Primary License Storage

Index:  2       Feature: base-ap-count   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  4 days
        License Count: 250/0/0
        License Priority: Low
        Store Index: 3
       Store Name: Evaluation License Storage
```

- See all expiring, evaluation, permanent, or in-use licenses by entering this command:

  show license {**expiring** | **evaluation** | **permanent** | **in-use**}

  Information similar to the following appears for the **show license in-use** command:

```
StoreIndex:  2  Feature: base-ap-count   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: 12/12/0
        License Priority: Medium
StoreIndex:  3  Feature: base Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: Non-Counted License Priority: Medium
```

Note Controller platforms do not support the status of “grace period” or “extension” as a license type. The license status will always show “evaluation” even if a grace period or an extension evaluation license is installed.

- See the maximum number of access points allowed for this license on the controller, the number of access points currently joined to the controller, and the number of access points that can still join the controller by entering this command:

  show license capacity

  Information similar to the following appears:

```
Licensed Feature    Max Count         Current Count     Remaining Count
----------------- --------------- ------------------- --------------------
AP Count            250               4                 246
```

- See statistics for all licenses on the controller by entering this command:

  show license statistics

  Information similar to the following appears:

```
Administrative statistics
        Install success count:       2
        Install failure count:       0
        Install duplicate count:     0
        Comment add count:           0
        Comment delete count:     0
        Clear count:              0
        Save count:               2
        Save cred count:          0
Client status
        Request success count     2
        Request failure count     0
        Release count             0
        Global Notify count       6
```

- See a summary of license-enabled features by entering this command:

  show license feature

  Information similar to the following appears:

```
Feature name    Enforcement  Evaluation  Clear Allowed  Enabled
 base             yes          yes           yes         yes
base-ap-count     yes          yes           yes         no
```

Choosing the Licensed Feature Set

You can configure the controller to specify which feature set it uses (base or wplus). Only the base or wplus license can be active at a time. The currently active license determines the feature set and number of access points supported on the controller.

Using the GUI to Choose the Licensed Feature Set

To specify the feature set for the controller using the controller GUI, follow these steps:

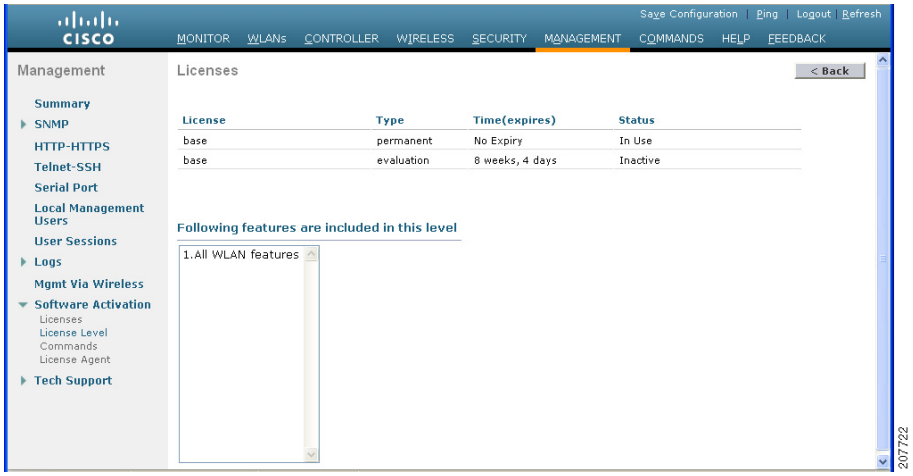
Step 1 Choose **Management > Software Activation > License Level** to open the License Level page (see Figure 4-6).

Figure 4-6 License Level Page

This page shows the current license level and the level to be used after the next controller reboot. It also shows the maximum number of access points allowed by the license on the controller, the number of access points currently joined to the controller, and the number of access points that can still join the controller.

Step 2 Click the **base** license level link to open the Licenses page (see Figure 4-7) to learn more about the available license levels.

Figure 4-7 Licenses Page



This page shows the licenses applicable to this level and the list of features supported.

Step 3 Click **Back** to return to the License Level page.

Step 4 If you want to change the license level, follow these steps:

a. Choose the license level to be used on the next reboot: **base**, **wplus**, or **auto**. If you choose **auto**, the licensing software automatically chooses the license level to use on the next reboot. It chooses permanent licenses over evaluation licenses.

Note To prevent disruptions in operation, the controller does not switch licenses when an evaluation license expires. You must reboot the controller in order to return to a permanent license. Following a reboot, the controller defaults to the same feature set level as the expired evaluation license. If no permanent license at the same feature set level is installed, the controller uses a permanent license at another level or an unexpired evaluation license. If no valid licenses are installed, the controller can always operate in base level.

b. Click **Activate**.

c. Click **OK** when prompted to confirm your decision to change the license level on the next reboot.

d. If you are prompted to accept the end-user license agreement (EULA), read and accept the terms of the agreement and then click **Accept**. The Next Boot Level text box now shows the license level that you specified as the level to be used after the next controller reboot.

e. Reboot the controller so that the specified license level takes effect.

Using the CLI to Choose the Licensed Feature Set

To specify the feature set for the controller using the controller CLI, follow these steps:

Step 1 See the current license level and the level to be used after the next controller reboot by entering this command:

show sysinfo

Information similar to the following appears:

```
Product Name..................................... Cisco Controller
Product Version.................................. 6.0.118.0
...
Current Boot License Level....................... wplus
Current Boot License Type........................ Permanent
Next Boot License Level.......................... wplus
Next Boot License Type........................... Permanent
...
```

Step 2 Specify the license level to be used on the next reboot by entering this command:

config license boot {**base** | **wplus** | **auto**}

If you choose **auto**, the licensing software automatically chooses the license level to use on the next reboot. It chooses permanent licenses over evaluation licenses.

Note To prevent disruptions in operation, the controller does not switch licenses when an evaluation license expires. You must reboot the controller in order to return to a permanent license. Following a reboot, the controller defaults to the same feature set level as the expired evaluation license. If no permanent license at the same feature set level is installed, the controller uses a permanent license at another level or an unexpired evaluation license.

Step 3 If you are prompted to accept the end-user license agreement (EULA), read and accept the terms of the agreement. The EULA appears if no permanent licenses are installed at the specified boot level and the evaluation license has not yet been activated. In this case, the **config license boot** command changes the license level and activates the evaluation license following a reboot.

Step 4 See the license level to be used after the next controller reboot by entering this command:

show sysinfo

Step 5 Reboot the controller in order to have your changes take effect by entering this command:

reset system

Activating an AP-Count Evaluation License

If you are considering upgrading to a license with a higher access point count, you can try an evaluation license before upgrading to a permanent version of the license. For example, if you are using a permanent license with a 50-access-point count and want to try an evaluation license with a 100-access-point count, you can try out the evaluation license for 60 days.

AP-count evaluation licenses are set to low priority by default so that the controller uses the ap-count permanent license. If you want to try an evaluation license with an increased access point count, you must change its priority to high. If you no longer want to have this higher capacity, you can lower the priority of the ap-count evaluation license, which forces the controller to use the permanent license.

Note To prevent disruptions in operation, the controller does not switch licenses when an evaluation license expires. You must reboot the controller in order to return to a permanent license. Following a reboot, the controller defaults to the same feature set level as the expired evaluation license. If no permanent license at the same feature set level is installed, the controller uses a permanent license at another level or an unexpired evaluation license.

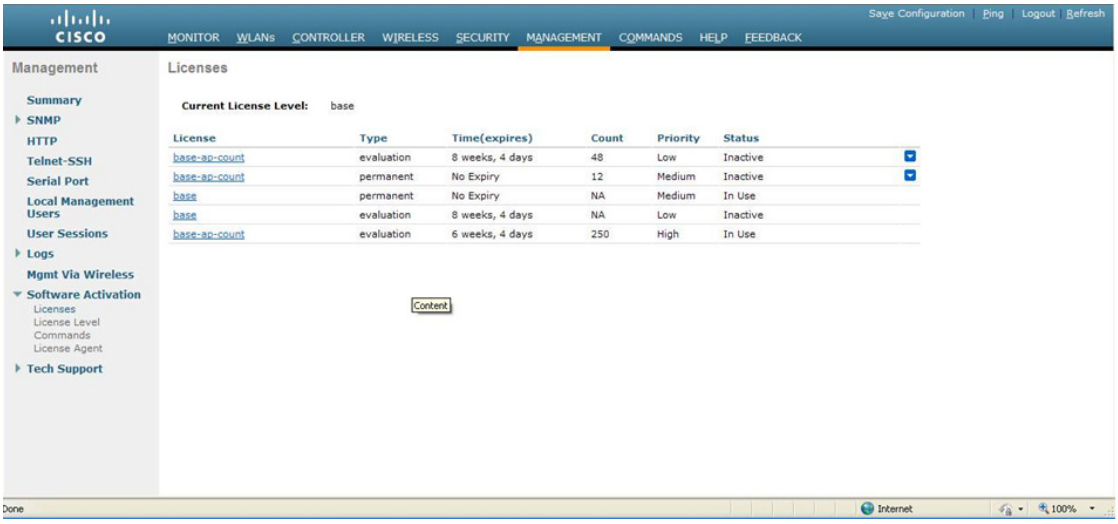
You can activate ap-count evaluation licenses using the controller GUI or CLI.

Using the GUI to Activate an AP-Count Evaluation License

To activate an ap-count evaluation license using the controller GUI, follow these steps:

Step 1 Choose **Management > Software Activation > Licenses** to open the Licenses page (see Figure 4-8).

Figure 4-8 Licenses Page

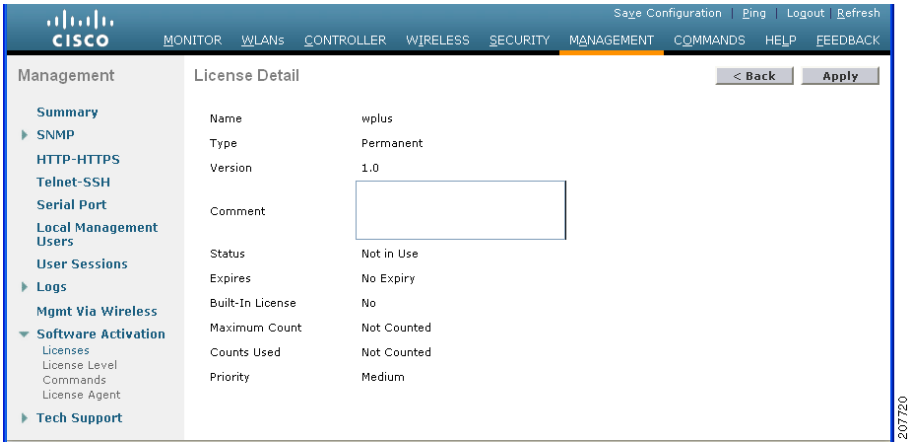


The Status column shows which licenses are currently in use, and the Priority column shows the current priority of each license.

Step 2 Activate an ap-count evaluation license as follows:

a. Click the link for the ap-count evaluation license that you want to activate. The License Detail page appears (see Figure 4-9).

Figure 4-9 License Detail Page



b. Choose **High** from the Priority drop-down list and click **Set Priority**.

Note You can set the priority only for ap-count evaluation licenses. AP-count permanent licenses always have a medium priority, which cannot be configured.

c. Click **OK** when prompted to confirm your decision about changing the priority of the license.

d. When the EULA appears, read the terms of the agreement and then click **Accept**.

e. When prompted to reboot the controller, click **OK**.

f. Reboot the controller in order for the priority change to take effect.

g. Click **Licenses** to open the Licenses page and verify that the ap-count evaluation license now has a high priority and is in use. You can use the evaluation license until it expires.

Step 3 If you decide to stop using the ap-count evaluation license and want to revert to using an ap-count permanent license, follow these steps:

a. On the Licenses page, click the link for the ap-count evaluation license that is in use.

b. Choose **Low** from the Priority drop-down list and click **Set Priority**.

Note You can set the priority only for ap-count evaluation licenses. AP-count permanent licenses always have a medium priority, which cannot be configured.

c. Click **OK** when prompted to confirm your decision about changing the priority of the license.

d. When the EULA appears, read the terms of the agreement and then click **Accept**.

e. When prompted to reboot the controller, click **OK**.

f. Reboot the controller in order for the priority change to take effect.

g. Click **Licenses** to open the Licenses page and verify that the ap-count evaluation license now has a low priority and is not in use. Instead, the ap-count permanent license should be in use.

Using the CLI to Activate an AP-Count Evaluation License

To activate an ap-count evaluation license using the controller CLI, follow these steps:

Step 1 See the current status of all the licenses on your controller by entering this command:

show license all

Information similar to the following appears:

```
License Store: Primary License Storage
StoreIndex:  0  Feature: base-ap-count   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: 12/0/0
        License Priority: Medium
StoreIndex:  1  Feature: base   Version: 1.0
        License Type: Permanent
        License State: Active, In Use
        License Count: Non-Counted
        License Priority: Medium
StoreIndex:  2  Feature: base   Version: 1.0
        License Type: Evaluation
        License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  4 days
        License Count: Non-Counted
        License Priority: Low
StoreIndex:  3  Feature: base-ap-count   Version: 1.0
        License Type: Evaluation
       License State: Inactive
            Evaluation total period:  8 weeks  4 days
            Evaluation period left:  8 weeks  4 days
        License Count: 250/0/0
```

```
License Priority: Low
```

The License State text box shows the licenses that are in use, and the License Priority text box shows the current priority of each license.

Step 2 Activate an ap-count evaluation license as follows:

a. To raise the priority of the base-ap-count evaluation license, enter this command:

license modify priority *license_name* **high**

Note You can set the priority only for ap-count evaluation licenses. AP-count permanent licenses always have a medium priority, which cannot be configured.

b. To reboot the controller in order for the priority change to take effect, enter this command:

reset system

c. To verify that the ap-count evaluation license now has a high priority and is in use, enter this command:

show license all

You can use the evaluation license until it expires.

Step 3 If you decide to stop using the ap-count evaluation license and want to revert to using an ap-count permanent license, follow these steps:

a. To lower the priority of the ap-count evaluation license, enter this command:

license modify priority *license_name* **low**

b. To reboot the controller in order for the priority change to take effect, enter this command:

reset system

c. To verify that the ap-count evaluation license now has a low priority and is not in use, enter this command:

show license all

Instead, the ap-count permanent license should be in use.

Rehosting a License

Revoking a license from one controller and installing it on another is called *rehosting*. You might want to rehost a license in order to change the purpose of a controller. For example, if you want to move your OfficeExtend or indoor mesh access points to a different controller, you could transfer the base license from one controller to another.

In order to rehost a license, you must generate credential information from the controller and use it to obtain a permission ticket to revoke the license from the Cisco licensing site. Next, you must obtain a rehost ticket and use it to obtain a license installation file for the controller on which you want to install the license.

Evaluation licenses and the permanent base image license cannot be rehosted.

Note A revoked license cannot be reinstalled on the same controller.

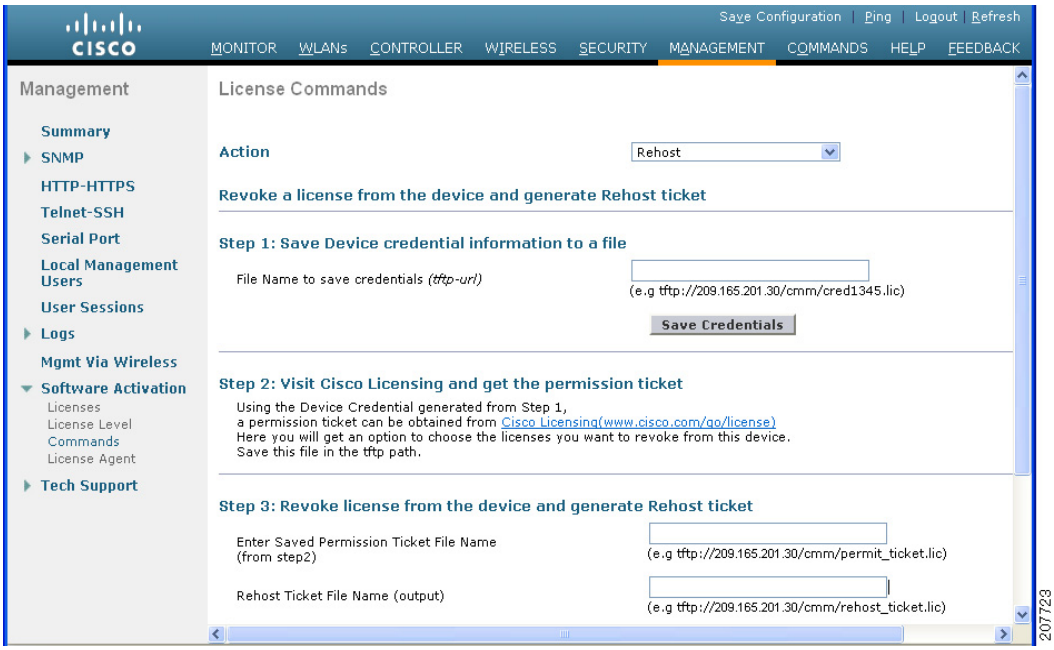
Using the GUI to Rehost a License

To rehost a license using the controller GUI, follow these steps:

Step 1 Choose **Management > Software Activation > Commands** to open the License Commands page.

Step 2 From the Action drop-down list, choose **Rehost**. The Revoke a License from the Device and Generate Rehost Ticket area appears (see Figure 4-10).

Figure 4-10 License Commands (Rehost) Page

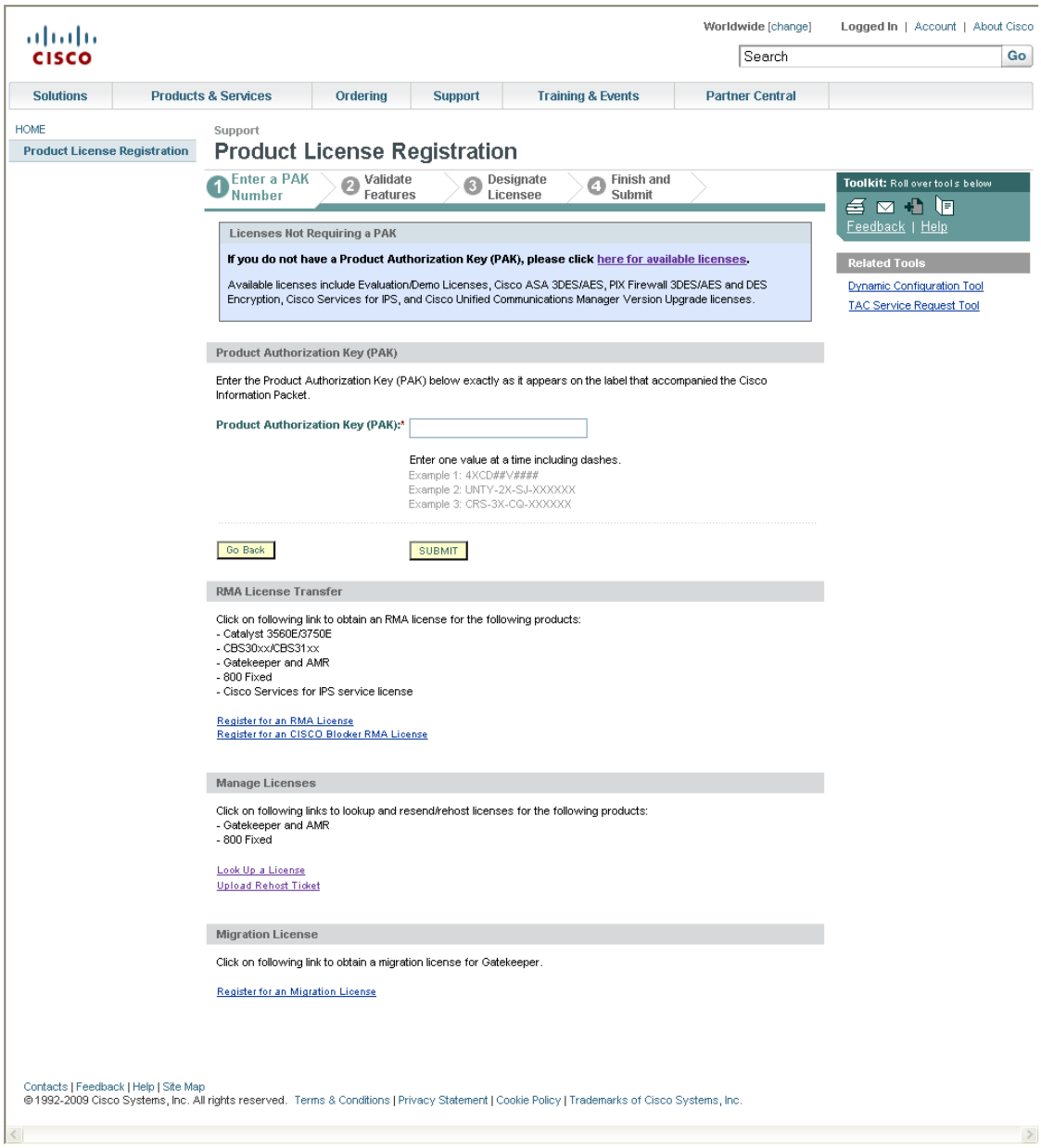


Step 3 In the File Name to Save Credentials text box, enter the path on the TFTP server where you want the device credentials to be saved and click **Save Credentials**.

Step 4 To obtain a permission ticket to revoke the license, follow these steps:

a. Click **Cisco Licensing** (https://tools.cisco.com/SWIFT/Licensing/PrivateRegistrationServlet). The Product License Registration page appears (see Figure 4-11).

Figure 4-11 Product License Registration Page



b. Under Manage Licenses, click **Look Up a License**.

c. Enter the product ID and serial number for your controller.

Note To find the controller's product ID and serial number, choose **Controller > Inventory** on the controller GUI.

d. Open the device credential information file that you saved in Step 3 and copy and paste the contents of the file into the Device Credentials text box.

e. Enter the security code in the blank box and click **Continue**.

f. Choose the licenses that you want to revoke from this controller and click **Start License Transfer**.

g. On the Rehost Quantities page, enter the number of licenses that you want to revoke in the To Rehost text box and click **Continue**.

h. On the Designate Licensee page, enter the product ID and serial number of the controller for which you plan to revoke the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the text boxes on this page, and click **Continue**.

i. On the Review and Submit page, verify that all information is correct and click **Submit**.

j. When a message appears indicating that the registration is complete, click **Download Permission Ticket**. The rehost permission ticket is e-mailed within 1 hour to the address that you specified.

k. After the e-mail arrives, copy the rehost permission ticket to your TFTP server.

Step 5 Use the rehost permission ticket to revoke the license from this controller and generate a rehost ticket as follows:

a. In the Enter Saved Permission Ticket File Name text box, enter the TFTP path and filename (*.lic) for the rehost permission ticket that you generated in Step 4.

b. In the Rehost Ticket File Name text box, enter the TFTP path and filename (*.lic) for the ticket that will be used to rehost this license on another controller.

c. Click **Generate Rehost Ticket**.

d. When the end-user license agreement (EULA) acceptance dialog box appears, read the agreement and click **Accept** to accept the terms of the agreement.

Step 6 Use the rehost ticket generated in Step 5 to obtain a license installation file, which can then be installed on another controller as follows:

a. Click **Cisco Licensing**.

b. On the Product License Registration page, click **Upload Rehost Ticket** under Manage Licenses.

c. On the Upload Ticket page, enter the rehost ticket that you generated in Step 5 in the Enter Rehost Ticket text box and click **Continue**.

d. On the Validate Features page, verify that the license information for your controller is correct, enter the rehost quantity, and click **Continue**.

e. On the Designate Licensee page, enter the product ID and serial number of the controller on which you plan to use the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the text boxes on this page, and click **Continue**.

f. On the Review and Submit page, verify that all information is correct and click **Submit**.

g. When a message appears indicating that the registration is complete, click **Download License**. The rehost license key is e-mailed within 1 hour to the address that you specified.

h. After the e-mail arrives, copy the rehost license key to your TFTP server.

i. Follow the instructions in the "Installing a License" section on page 4-7 to install this license on another controller.

Using the CLI to Rehost a License

To rehost a license using the controller CLI, follow these steps:

Step 1 Save device credential information to a file by entering this command:

license save credential *url*

where *url* is tftp://*server_ip*/*path*/*filename*.

Step 2 Obtain a permission ticket to revoke the license as follows:

a. Go to https://tools.cisco.com/SWIFT/Licensing/PrivateRegistrationServlet. The Product License Registration page appears (see Figure 4-11).

b. Under Manage Licenses, click **Look Up a License**.

c. Enter the product ID and serial number for your controller.

Note To find the controller's product ID and serial number, enter the **show license udi** command on the controller CLI.

d. Open the device credential information file that you saved in Step 1 and copy and paste the contents of the file into the Device Credentials text box.

e. Enter the security code in the blank box and click **Continue**.

f. Choose the licenses that you want to revoke from this controller and click **Start License Transfer**.

g. On the Rehost Quantities page, enter the number of licenses that you want to revoke in the To Rehost text box and click **Continue**.

h. On the Designate Licensee page, enter the product ID and serial number of the controller for which you plan to revoke the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the text boxes on this page, and click **Continue**.

i. On the Review and Submit page, verify that all information is correct and click **Submit**.

j. When a message appears indicating that the registration is complete, click **Download Permission Ticket**. The rehost permission ticket is e-mailed within 1 hour to the address that you specified.

k. After the e-mail arrives, copy the rehost permission ticket to your TFTP server.

Step 3 Use the rehost permission ticket to revoke the license from this controller and generate a rehost ticket as follows:

a. To revoke the license from the controller, enter this command:

license revoke *permission_ticket_url*

where *permission_ticket_url* is tftp://*server_ip*/*path*/*filename*.

b. To generate the rehost ticket, enter this command:

license revoke rehost *rehost_ticket_url*

where *rehost_ticket_url* is tftp://*server_ip*/*path*/*filename*.

c. If prompted, read and accept the terms of the end-user license agreement (EULA).

Step 4 Use the rehost ticket generated in Step 3 to obtain a license installation file, which can then be installed on another controller as follows:

a. Go to https://tools.cisco.com/SWIFT/Licensing/PrivateRegistrationServlet.

b. On the Product License Registration page, click **Upload Rehost Ticket** under Manage Licenses.

c. On the Upload Ticket page, enter the rehost ticket that you generated in Step 3 in the Enter Rehost Ticket text box and click **Continue**.

d. On the Validate Features page, verify that the license information for your controller is correct, enter the rehost quantity, and click **Continue**.

e. On the Designate Licensee page, enter the product ID and serial number of the controller on which you plan to use the license, read and accept the conditions of the end-user license agreement (EULA), complete the rest of the text boxes on this page, and click **Continue**.

f. On the Review and Submit page, verify that all information is correct and click **Submit**.

g. When a message appears indicating that the registration is complete, click **Download License**. The rehost license key is e-mailed within 1 hour to the address that you specified.

h. After the e-mail arrives, copy the rehost license key to your TFTP server.

i. Follow the instructions in the "Installing a License" section on page 4-7 to install this license on another controller.

Transferring Licenses to a Replacement Controller after an RMA

If you return a Cisco 5500 Series Controller to Cisco as part of the Return Material Authorization (RMA) process, you must transfer that controller's licenses within 60 days to a replacement controller that you receive from Cisco.

Replacement controllers come preinstalled with the following licenses: permanent base and evaluation base, base-ap-count. No other permanent licenses are installed. The SKU for replacement controllers is AIR-CT5508-CA-K9.

Because licenses are registered to the serial number of a controller, you can use the licensing portal on Cisco.com to request that the license from your returned controller be revoked and authorized for use on the replacement controller. After your request is approved, you can install the old license on the replacement controller. Before you begin, you need the product ID and serial number of both the returned controller and the replacement controller. This information is included in your purchase records.

Note The evaluation licenses on the replacement controller are designed for temporary use and expire after 60 days. To prevent disruptions in operation, the controller does not switch licenses when an evaluation license expires. You must reboot the controller in order to return to a permanent license. If the evaluation licenses expire before you transfer the permanent licenses from your defective controller to your replacement controller, the replacement controller remains up and running using the permanent base license, but access points are no longer able to join the controller.

To transfer a license to a replacement controller after an RMA, follow these steps:

Step 1 Go to https://tools.cisco.com/SWIFT/Licensing/PrivateRegistrationServlet.

Step 2 On the main Product License Registration page, click **Register for an RMA License** under RMA License Transfer.

Step 3 In the Select a Product drop-down list, choose **Cisco 5500 Series Wireless Controllers**.

Step 4 Enter the security code in the blank box and click **Go to RMA Portal**.

Step 5 On the RMA License Transfer page, enter the product ID and serial number of the controller that you returned and your RMA service contract number, and click **Continue**.

Step 6 On the Validate Features page, verify that the license information for your controller is correct, and click **Continue**.

Step 7 On the Designate Licensee page, enter the product ID and serial number of the replacement controller.

Step 8 Read and accept the conditions of the end-user license agreement (EULA), complete the rest of the text boxes on this page, and click **Submit**.

Step 9 On the Review and Submit page, verify that all information is correct and click **Submit**. A message appears indicating that your registration request has been submitted, and you will receive an e-mail that contains your RMA request ID.

Step 10 Select the status of your RMA registration request by following the instructions in the e-mail.

Step 11 After you receive another e-mail notifying you that your RMA registration request is approved (usually within 1 hour), follow the instructions in the "Installing a License" section on page 4-7 to install the license on the replacement controller.

Configuring the License Agent

If your network contains various Cisco-licensed devices, you might want to consider using the Cisco License Manager (CLM) to manage all of the licenses using a single application. CLM is a secure client/server application that manages Cisco software licenses network wide.

The license agent is an interface module that runs on the controller and mediates between CLM and the controller's licensing infrastructure. CLM can communicate with the controller using various channels, such as HTTP, Telnet, and so on. If you want to use HTTP as the communication method, you must enable the license agent on the controller.

The license agent receives requests from CLM and translates them into license commands. It also sends notifications to CLM. It uses XML messages over HTTP or HTTPS to receive the requests and send the notifications. For example, CLM sends a **license install** command, and the agent notifies CLM after the license expires.

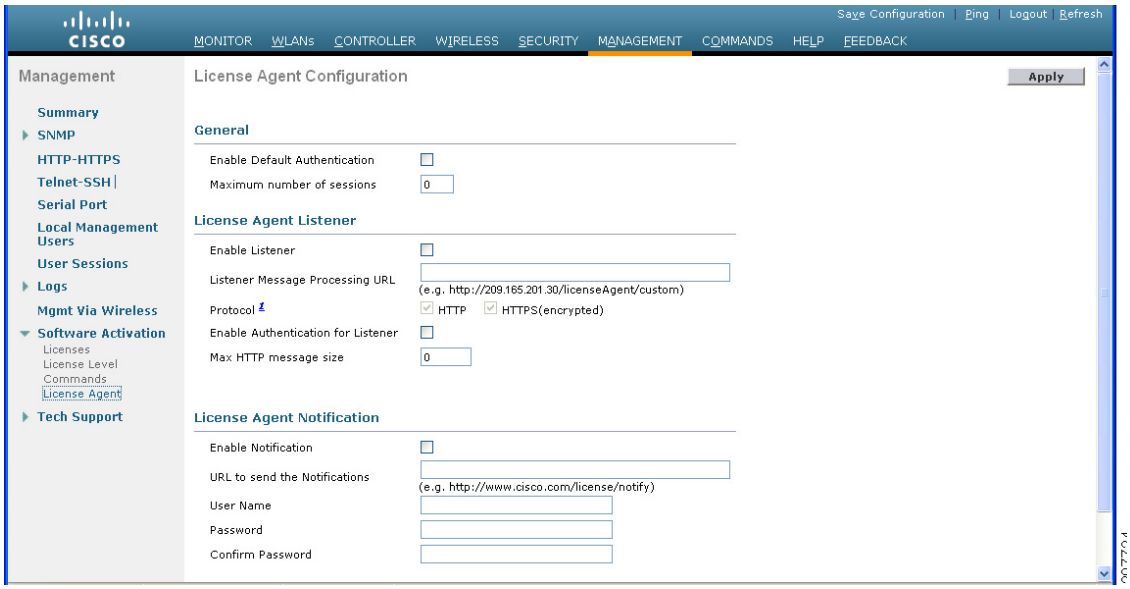
Note You can download the CLM software and access user documentation at this URL: http://www.cisco.com/go/clm

Using the GUI to Configure the License Agent

To configure the license agent on the controller using the controller GUI, follow these steps:

Step 1 Choose **Management > Software Activation > License Agent** to open the License Agent Configuration page (see Figure 4-12).

Figure 4-12 License Agent Configuration Page



Step 2 Select the **Enable Default Authentication** check box to enable the license agent, or leave it unselected to disable this feature. The default value is unselected.

Step 3 In the Maximum Number of Sessions text box, enter the maximum number of sessions for the license agent. The valid range is 1 to 25 sessions (inclusive).

Step 4 Configure the license agent to listen for requests from the CLM as follows:

a. Select the **Enable Listener** check box to enable the license agent to receive license requests from the CLM, or unselect this check box to disable this feature. The default value is unselected.

b. In the Listener Message Processing URL text box, enter the URL where the license agent receives license requests (for example, http://209.165.201.30/licenseAgent/custom). The Protocol parameter indicates whether the URL requires HTTP or HTTPS.

Note You can specify the protocol to use on the HTTP Configuration page. See the "Enabling Web and Secure Web Modes" section on page 2-18 for more information.

c. Select the **Enable Authentication for Listener** check box to enable authentication for the license agent when it is receiving license requests, or unselect this check box to disable this feature. The default value is unselected.

d. In the Max HTTP Message Size text box, enter the maximum size for license requests. The valid range is 0 to 9999 bytes, and the default value is 0.

Step 5 Configure the license agent to send license notifications to the CLM as follows:

a. Select the **Enable Notification** check box to enable the license agent to send license notifications to the CLM, or unselect this check box to disable this feature. The default value is unselected.

b. In the URL to Send the Notifications text box, enter the URL where the license agent sends the notifications (for example, http://www.cisco.com/license/notify).

c. In the User Name text box, enter the username required in order to view the notification messages at this URL.

d. In the Password and Confirm Password text boxes, enter the password required in order to view the notification messages at this URL.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure the License Agent

To configure the license agent on the controller using the controller CLI, follow these steps:

Step 1 Enable the license agent by entering one of these commands:

- **config license agent default authenticate**—Enables the license agent default listener with authentication.
- **config license agent default authenticate none**—Enables the license agent default listener without authentication.

Note To disable the license agent default listener, enter the **config license agent default disable** command. The default value is disabled.

Step 2 Specify the maximum number of sessions for the license agent by entering this command:

config license agent max-sessions *sessions*

The valid range for the *sessions* parameter is 1 to 25 (inclusive), and the default value is 9.

Step 3 Enable the license agent to receive license requests from the CLM and to specify the URL where the license agent receives the requests by entering this command:

config license agent listener http {**plaintext** | **encrypt**} *url* **authenticate** [**none**] [**max-message** *size*] [**acl** *acl*]

The valid range for the *size* parameter is 0 to 65535 bytes, and the default value is 0.

Note To prevent the license agent from receiving license requests from the CLM, enter the **config license agent listener http disable** command. The default value is disabled.

Step 4 Configure the license agent to send license notifications to the CLM and to specify the URL where the license agent sends the notifications by entering this command:

config license agent notify *url username password*

Note To prevent the license agent from sending license notifications to the CLM, enter the **config license agent notify disable** *username password* command. The default value is disabled.

Step 5 Save your changes by entering this command:

save config

Step 6 See statistics for the license agent's counters or sessions by entering this command:

show license agent {**counters** | **sessions**}

Information similar to the following appears for the **show license agent counters** command:

```
License Agent Counters
Request Messages Received:10: Messages with Errors:1
Request Operations Received:9: Operations with Errors:0
Notification Messages Sent:12: Transmission Errors:0: Soap Errors:0
```

Information similar to the following appears for the **show license agent sessions** command:

```
License Agent Sessions: 1 open, maximum is 9
```

Note To clear the license agent's counter or session statistics, enter the **clear license agent** {**counters** | **sessions**} command.

Configuring 802.11 Bands

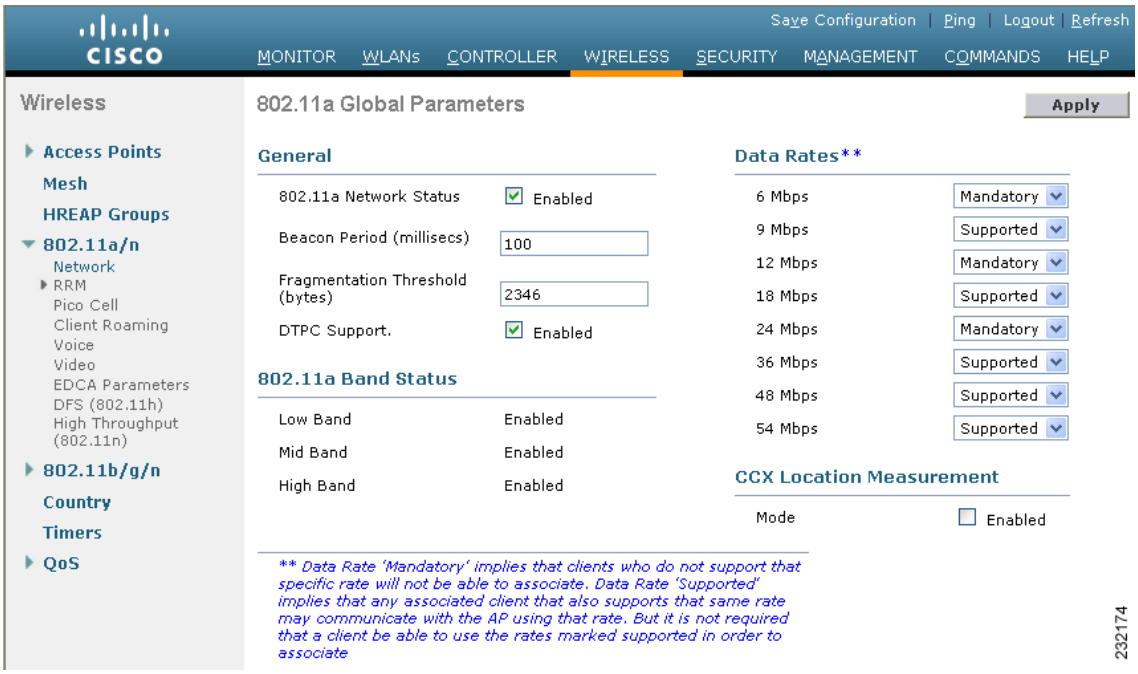
You can configure the 802.11b/g/n (2.4-GHz) and 802.11a/n (5-GHz) bands for the controller to comply with the regulatory requirements in your country. By default, both 802.11b/g/n and 802.11a/n are enabled.

Using the GUI to Configure 802.11 Bands

To configure 802.11 bands using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page (see Figure 4-13).

Figure 4-13 802.11a Global Parameters Page



Step 2 Select the **802.11a** (or **802.11b/g**) **Network Status** check box to enable the 802.11a or 802.11b/g band. To disable the band, unselect the check box. The default value is enabled. You can enable both the 802.11a and 802.11b/g bands.

Step 3 If you enabled the 802.11b/g band in Step 2, select the **802.11g Support** check box if you want to enable 802.11g network support. The default value is enabled. If you disable this feature, the 802.11b band is enabled without 802.11g support.

Step 4 Specify the rate at which the SSID is broadcast by the access point by entering a value between 100 and 600 milliseconds (inclusive) in the Beacon Period text box. The default value is 100 milliseconds.

Note The beacon period in controllers is listed in terms of milliseconds. The beacon period can also be measured in time units, where one time unit equals 1024 microseconds or 102.4 milliseconds. If a beacon interval is listed as 100 milliseconds in a controller, it is only a rounded off value for 102.4 milliseconds. Due to hardware limitation in certain radios, even though the beacon interval is, say 100 time units, it is adjusted to 102 time units, which roughly equals 1044.48 milliseconds. When the beacon period is to be represented in terms of time units, the value is adjusted to the nearest multiple of 17.

Step 5 Specify the size at which packets are fragmented by entering a value between 256 and 2346 bytes (inclusive) in the Fragmentation Threshold text box. Enter a low number for areas where communication is poor or where there is a great deal of radio interference.

Step 6 Make access points advertise their channel and transmit power level in beacons and probe responses. Select the **DTPC Support** check box. Otherwise, unselect this check box. The default value is enabled.

Client devices using dynamic transmit power control (DTPC) receive the channel and power level information from the access points and adjust their settings automatically. For example, a client device used primarily in Japan could rely on DTPC to adjust its channel and power settings automatically when it travels to Italy and joins a network there.

Note On access points that run Cisco IOS software, this feature is called *world mode*.

Note DTPC and 801.11h power constraint cannot be enabled simultaneously.

Step 7 Use the Data Rates options to specify the rates at which data can be transmitted between the access point and the client. These data rates are available:

- 802.11a—6, 9, 12, 18, 24, 36, 48, and 54 Mbps
- 802.11b/g—1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, or 54 Mbps

For each data rate, choose one of these options:

- **Mandatory**—Clients must support this data rate in order to associate to an access point on the controller.
- **Supported**—Any associated clients that support this data rate may communicate with the access point using that rate. However, the clients are not required to be able to use this rate in order to associate.
- **Disabled**—The clients specify the data rates used for communication.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure 802.11 Bands

To configure 802.11 bands using the controller CLI, follow these steps:

Step 1 Disable the 802.11a band by entering this command:

config 802.11a disable network

Note The 802.11a band must be disabled before you can configure the 802.11a network parameters in this section.

Step 2 Disable the 802.11b/g band by entering this command:

config 802.11b disable network

Note The 802.11b band must be disabled before you can configure the 802.11b network parameters in this section.

Step 3 Specify the rate at which the SSID is broadcast by the access point by entering this command:

config {**802.11a** | **802.11b**} **beaconperiod** *time_unit*

where *time_unit* is the beacon interval in time units (TUs). One TU is 1024 microseconds. You can configure the access point to send a beacon every 20 to 1000 milliseconds.

Step 4 Specify the size at which packets are fragmented by entering this command:

config {802.11a | 802.11b} fragmentation *threshold*

where *threshold* is a value between 256 and 2346 bytes (inclusive). Specify a low number for areas where communication is poor or where there is a great deal of radio interference.

Step 5 Make access points advertise their channel and transmit power level in beacons and probe responses by entering this command:

config {802.11a | 802.11b} dtpc {enable | disable}

The default value is enabled. Client devices using dynamic transmit power control (DTPC) receive the channel and power level information from the access points and adjust their settings automatically. For example, a client device used primarily in Japan could rely on DTPC to adjust its channel and power settings automatically when it travels to Italy and joins a network there.

Note On access points that run Cisco IOS software, this feature is called *world mode*.

Step 6 Specify the rates at which data can be transmitted between the controller and the client by entering this command:

config {802.11a | 802.11b} rate {disabled | mandatory | supported} *rate*

where

- **disabled**—Clients specify the data rates used for communication.
- **mandatory**—Clients support this data rate in order to associate to an access point on the controller.
- **supported**—Any associated clients that support this data rate may communicate with the access point using that rate. However, the clients are not required to be able to use this rate in order to associate.
- *rate*—The rate at which data is transmitted:
  - 6, 9, 12, 18, 24, 36, 48, and 54 Mbps (802.11a)
  - 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48, or 54 Mbps (802.11b/g)

Step 7 Enable the 802.11a band by entering this command:

config 802.11a enable network

The default value is enabled.

Step 8 Enable the 802.11b band by entering this command:

config 802.11b enable network

The default value is enabled.

Step 9 Enable or disable 802.11g network support by entering this command:

config 802.11b 11gSupport {enable | disable}

The default value is enabled. You can use this command only if the 802.11b band is enabled. If you disable this feature, the 802.11b band is enabled without 802.11g support.

Step 10 Save your changes by entering this command:

save config

Step 11 View the configuration settings for the 802.11a or 802.11b/g band by entering this command:

show {802.11a | 802.11b}

Information similar to the following appears:

```
802.11a Network.............................. Enabled
```

```
11nSupport..................................... Enabled
    802.11a Low Band........................... Enabled
    802.11a Mid Band........................... Enabled
    802.11a High Band.......................... Enabled
802.11a Operational Rates
  802.11a 6M Rate.............................. Mandatory
  802.11a 9M Rate.............................. Supported
  802.11a 12M Rate............................. Mandatory
  802.11a 18M Rate............................. Supported
  802.11a 24M Rate............................. Mandatory
  802.11a 36M Rate............................. Supported
  802.11a 48M Rate............................. Supported
  802.11a 54M Rate............................. Supported
...
Beacon Interval................................ 100
...
Default Channel................................ 36
Default Tx Power Level......................... 1
DTPC Status.................................... Enabled
Fragmentation Threshold........................ 2346
...
```

Configuring 802.11n Parameters

This section provides instructions for managing 802.11n devices such as the Cisco Aironet 1140 and 1250 Series Access Points on your network. The 802.11n devices support the 2.4- and 5-GHz bands and offer high-throughput data rates.

Note The 802.11n high-throughput rates are available on 1140, 1250, 1260, and 3500 series access points for WLANs using WMM with no Layer 2 encryption or with WPA2/AES encryption enabled.

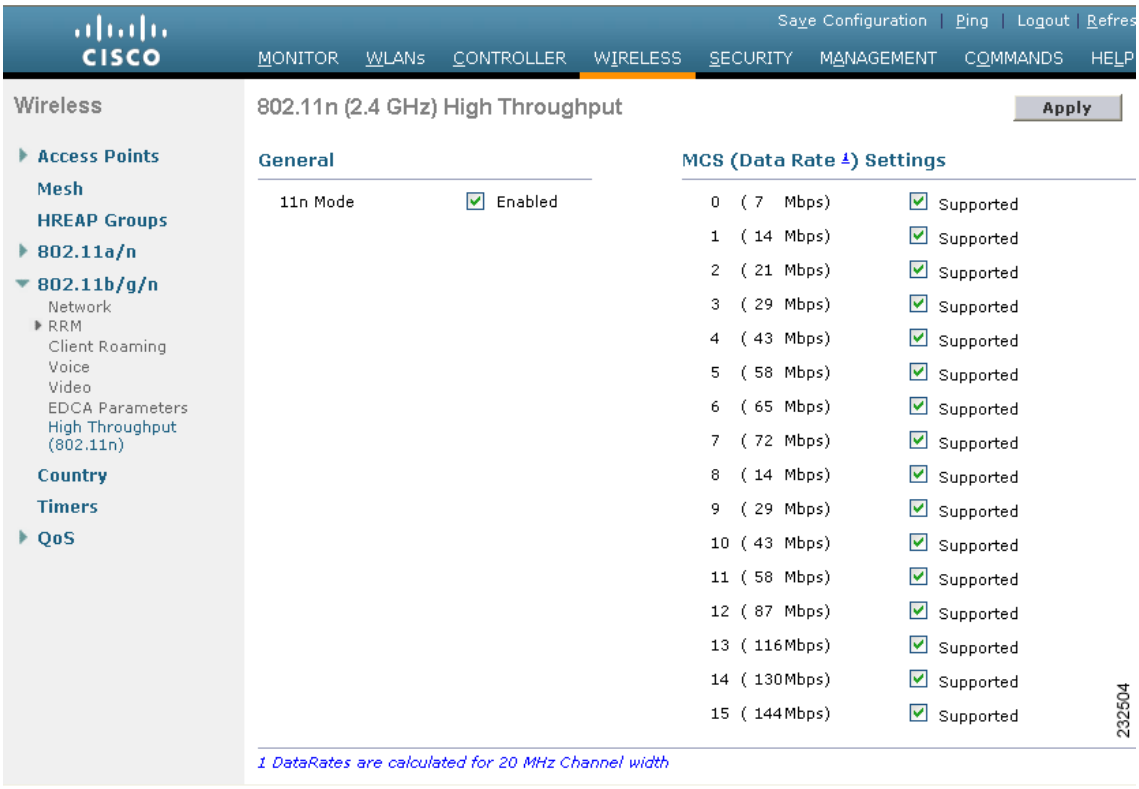
Note For information on configuring radio resource management (RRM) parameters or statically assigning radio parameters for 802.11n access points, see Chapter 13, "Configuring Radio Resource Management."

Using the GUI to Configure 802.11n Parameters

To configure 802.11n parameters using the controller GUI, follow these steps:

Step 1 Choose **Wireless > 802.11a/n** or **802.11b/g/n > High Throughput (802.11n)** to open the 802.11n (5 GHz or 2.4 GHz) High Throughput page (see Figure 4-14).

Figure 4-14 802.11n (2.4 GHz) High Throughput Page



Step 2 Select the **11n Mode** check box to enable 802.11n support on the network. The default value is enabled.

Step 3 Select the check boxes of the desired rates to specify the modulation and coding scheme (MCS) rates at which data can be transmitted between the access point and the client. These data rates, which are calculated for a 20-MHz channel width using a short guard interval, are available:

- 0 (7 Mbps)
- 1 (14 Mbps)
- 2 (21 Mbps)
- 3 (29 Mbps)
- 4 (43 Mbps)
- 5 (58 Mbps)
- 6 (65 Mbps)
- 7 (72 Mbps)
- 8 (14 Mbps)
- 9 (29 Mbps)
- 10 (43 Mbps)
- 11 (58 Mbps)
- 12 (87 Mbps)
- 13 (116 Mbps)
- 14 (130 Mbps)

- 15 (144 Mbps)

Any associated clients that support the selected rates may communicate with the access point using those rates. However, the clients are not required to be able to use this rate in order to associate. The MCS settings determine the number of spatial streams, the modulation, the coding rate, and the data rate values that are used.

Step 4 Click **Apply** to commit your changes.

Step 5 Use the 802.11n data rates that you configured by enabling WMM on the WLAN as follows:

a. Choose **WLANs** to open the WLANs page.

b. Click the ID number of the WLAN for which you want to configure WMM mode.

c. When the WLANs > Edit page appears, choose the **QoS** tab to open the WLANs > Edit (Qos) page.

d. From the WMM Policy drop-down list, choose **Required** or **Allowed** to require or allow client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

e. Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Note To determine if an access point supports 802.11n, look at the 11n Supported text box on either the 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page or the 802.11a/n (or 802.11b/g/n) AP Interfaces > Details page.

Using the CLI to Configure 802.11n Parameters

To configure 802.11n parameters using the controller CLI, follow these steps:

Step 1 Enable 802.11n support on the network by entering this command:

config {**802.11a** | **802.11b**} **11nsupport** {**enable** | **disable**}

Step 2 Specify the modulation and coding scheme (MCS) rates at which data can be transmitted between the access point and the client by entering this command:

config {**802.11a** | **802.11b**} **11nsupport mcs tx** {**0-15**} {**enable** | **disable**}

See the descriptions of the 0 through 15 MCS data rates in the "Using the GUI to Configure 802.11n Parameters" section on page 4-33.

Step 3 Use the 802.11n data rates that you configured by enabling WMM on the WLAN as follows:

config wlan wmm required *wlan_id*

The **required** parameter requires client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

Step 4 Specify the aggregation method used for 802.11n packets as follows:

a. Disable the network by entering this command:

config {**802.11a** | **802.11b**} **disable network**

b. Specify the aggregation method entering this command:

config {**802.11a** | **802.11b**} **11nsupport a-mpdu tx priority {0-7 | all} {enable | disable}**

Aggregation is the process of grouping packet data frames together rather than transmitting them separately. Two aggregation methods are available: Aggregated MAC Protocol Data Unit (A-MPDU) and Aggregated MAC Service Data Unit (A-MSDU). Both A-MPDU and A-MSDU are performed in the software.

You can specify the aggregation method for various types of traffic from the access point to the clients. Table 4-2 defines the priority levels (0-7) assigned per traffic type.

Table 4-2 Traffic Type Priority Levels

User Priority	Traffic Type
0	Best effort
1	Background
2	Spare
3	Excellent effort
4	Controlled load
5	Video, less than 100-ms latency and jitter
6	Voice, less than 10-ms latency and jitter
7	Network control

You can configure each priority level independently, or you can use the **all** parameter to configure all of the priority levels at once. When you use the **enable** command, the traffic associated with that priority level uses A-MPDU transmission. When you use the **disable** command, the traffic associated with that priority level uses A-MSDU transmission. Configure the priority levels to match the aggregation method used by the clients. By default, A-MPDU is enabled for priority level 0, 4 and 5 and the rest are disabled. By default, A-MPDU is enabled for all priorities except 6 and 7.

c. Reenable the network by entering this command:

config {802.11a | 802.11b} enable network

Step 5 Save your changes by entering this command:

save config

Step 6 View the configuration settings for the 802.11a/n or 802.11b/g/n band by entering this command:

show {802.11a | 802.11b}

Information similar to the following appears:

```
802.11a Network.............................. Enabled
11nSupport................................... Enabled
    802.11a Low Band......................... Enabled
    802.11a Mid Band......................... Enabled
    802.11a High Band........................ Enabled
802.11a Operational Rates
   802.11a 6M Rate.............................. Mandatory
   802.11a 9M Rate.............................. Supported
   802.11a 12M Rate............................. Mandatory
   802.11a 18M Rate............................. Supported
   802.11a 24M Rate............................. Mandatory
   802.11a 36M Rate............................. Supported
   802.11a 48M Rate............................. Supported
   802.11a 54M Rate............................. Supported
802.11n MCS Settings:
MCS 0....................................... Supported
   MCS 1....................................... Supported
```

```
   MCS 2..................................... Supported
   MCS 3..................................... Supported
   MCS 4..................................... Supported
   MCS 5..................................... Supported
   MCS 6..................................... Supported
   MCS 7..................................... Supported
   MCS 8..................................... Supported
   MCS 9..................................... Supported
   MCS 10.................................... Supported
   MCS 11.................................... Supported
   MCS 12.................................... Supported
   MCS 13.................................... Supported
   MCS 14.................................... Supported
   MCS 15.................................... Supported
802.11n Status:
   A-MPDU Tx ................................ Enabled
      Priority 0............................. Enabled
      Priority 1............................. Enabled
      Priority 2............................. Enabled
      Priority 3............................. Enabled
      Priority 4............................. Enabled
      Priority 5............................. Disabled
      Priority 6............................. Disabled
      Priority 7............................. Enabled
   A-MSDU Tx ................................ Enabled
     Rifs Tx ................................. Enabled
   Guard Interval ........................... Short
Beacon Interval.............................. 100
CF Pollable mandatory........................ Disabled
CF Poll Request mandatory.................... Disabled
CFP Period................................... 4
CFP Maximum Duration......................... 60
Default Channel.............................. 36
Default Tx Power Level....................... 1
DTPC Status.................................Enabled
Fragmentation Threshold...................... 2346
Long Retry Limit............................. 4
Maximum Rx Life Time......................... 512
Max Tx MSDU Life Time........................ 512
Medium Occupancy Limit....................... 100
RTS Threshold................................ 2347
Short Retry Limit............................ 7
TI Threshold................................. -50
Traffic Stream Metrics Status................ Enabled
Expedited BW Request Status.................. Disabled
EDCA profile type............................ default-wmm
Voice MAC optimization status................ Disabled
Call Admission Control (CAC) configuration
   Voice AC - Admission control (ACM)........ Enabled
   Voice max RF bandwidth.................... 75
   Voice reserved roaming bandwidth.......... 6
   Voice load-based CAC mode................. Disabled
   Voice tspec inactivity timeout............ Disabled
   Video AC - Admission control (ACM)........ Enabled
   Voice Stream-Size......................... 84000
   Voice Max-Streams......................... 2
   Video max RF bandwidth.................... Infinite
   Video reserved roaming bandwidth.......... 0
```

Configuring 802.11h Parameters

802.11h informs client devices about channel changes and can limit the transmit power of those client devices. You can configure the 802.11h parameters using the controller GUI or CLI.

Using the GUI to Configure 802.11h Parameters

To configure 802.11h parameters using the controller GUI, follow these steps:

Step 1 Disable the 802.11a band as follows:

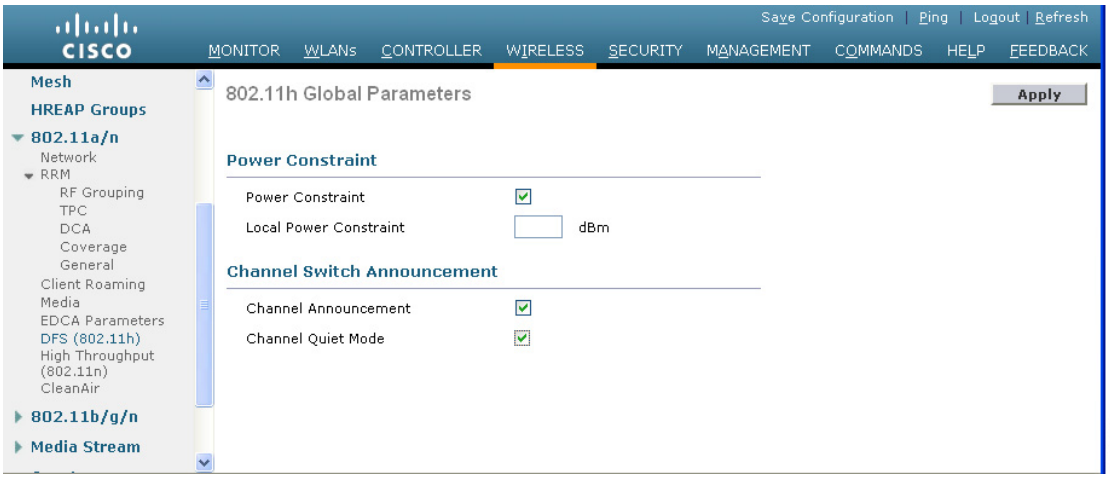
a. Choose **Wireless > 802.11a/n > Network** to open the 802.11a Global Parameters page.

b. Unselect the **802.11a Network Status** check box.

c. Click **Apply** to commit your change.

Step 2 Choose **Wireless > 802.11a/n > DFS (802.11h)** to open the 802.11h Global Parameters page (see Figure 4-15).

Figure 4-15 802.11h Global Parameters Page



Step 3 Select the **Channel Announcement** check box if you want the access point to announce when it is switching to a new channel and the new channel number, or unselect this check box to disable the channel announcement. The default value is disabled.

Step 4 If you enabled the channel announcement in Step 3, the Channel Quiet Mode check box appears. Select this check box if you want the access point to stop transmitting on the current channel, or unselect this check box to disable quiet mode. The default value is disabled.

Step 5 Click **Apply** to commit your changes.

Step 6 Reenable the 802.11a band as follows:

a. Choose **Wireless > 802.11a/n > Network** to open the 802.11a Global Parameters page.

b. Select the **802.11a Network Status** check box.

c. Click **Apply** to commit your change.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure 802.11h Parameters

To configure 802.11h parameters using the controller CLI, follow these steps:

Step 1 Disable the 802.11a network by entering this command:

config 802.11a disable network

Step 2 Enable or disable the access point to announce when it is switching to a new channel and the new channel number by entering this command:

config 802.11h channelswitch {**enable** | **disable**} *switch_mode*

You can enter a 0 or 1 for the *switch_mode* parameter to specify whether transmissions are restricted until the actual channel switch (0) or are not restricted (1). The default value is disabled.

Step 3 Configure a new channel using the 802.11h channel announcement by entering this command:

config 802.11h setchannel channel *channel*

Step 4 Configure the 802.11h power constraint value by entering this command:

config 802.11h powerconstraint *value*

The default value for the *value* parameter is 3 dB.

Step 5 Reenable the 802.11a network by entering this command:

config 802.11a enable network

Step 6 See the status of 802.11h parameters by entering this command:

show 802.11h

Information similar to the following appears:

```
Power Constraint.............................. 0
Channel Switch................................ Disabled
Channel Switch Mode........................... 0
```

Configuring DHCP Proxy

When DHCP proxy is enabled on the controller, the controller unicasts DHCP requests from the client to the configured servers. Consequently, at least one DHCP server must be configured on either the interface associated with the WLAN or the WLAN itself.

When DHCP proxy is disabled on the controller, those DHCP packets transmitted to and from the clients are bridged by the controller without any modification to the IP portion of the packet. Packets received from the client are removed from the CAPWAP tunnel and transmitted on the upstream VLAN. DHCP packets directed to the client are received on the upstream VLAN, converted to 802.11, and transmitted through a CAPWAP tunnel toward the client. As a result, the internal DHCP server cannot be used when DHCP proxy is disabled. The ability to disable DHCP proxy allows organizations to use DHCP servers that do not support Cisco's native proxy mode of operation. It should be disabled only when required by the existing infrastructure.

You can use the controller GUI or CLI to enable or disable DHCP proxy on a global basis, rather than on a WLAN basis. DHCP proxy is enabled by default.

Note DHCP proxy must be enabled in order for DHCP option 82 to operate correctly. See the "Configuring DHCP" section on page 7-10 for information on DHCP option 82.

Note All controllers that will communicate must have the same DHCP proxy setting.

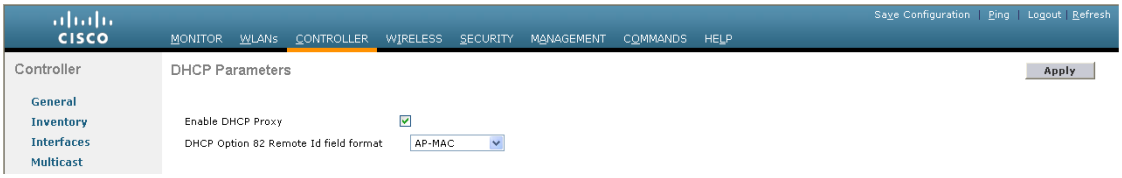
Note See Chapter 7, "Configuring WLANs," for information on configuring DHCP servers.

Using the GUI to Configure DHCP Proxy

To configure DHCP proxy using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Advanced** > **DHCP** to open the DHCP Parameters page (see Figure 4-16).

Figure 4-16 DHCP Parameters Page



Step 2 Select the **Enable DHCP Proxy** check box to enable DHCP proxy on a global basis. Otherwise, unselect the check box. The default value is selected.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure DHCP Proxy

To configure DHCP proxy using the controller CLI, follow these steps:

Step 1 Enable or disable DHCP proxy by entering this command:

config dhcp proxy {**enable** | **disable**}

Step 2 View the DHCP proxy configuration by entering this command:

show dhcp proxy

Information similar to the following appears:

```
DHCP Proxy Behavior: enabled
```

Using the GUI to Configure a DHCP Timeout

To configure a DHCP timeout using the controller GUI, follow these steps:

Step 1 Choose **Controller > Advanced > DHCP** to open the DHCP Parameters page.

Step 2 Select the **DHCP Timeout (5 - 120 seconds)** check box to enable a DHCP timeout on a global basis. Otherwise, unselect the check box. The valid range is 5 through 120 seconds.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure DHCP Timeout

To configure a DHCP timeout using the controller CLI, use the following command:

config dhcp timeout *seconds*

Configuring Administrator Usernames and Passwords

You can configure administrator usernames and passwords to prevent unauthorized users from reconfiguring the controller and viewing configuration information. This section provides instructions for initial configuration and for password recovery.

Configuring Usernames and Passwords

To configure administrator usernames and passwords using the controller CLI, follow these steps:

Step 1 Configure a username and password by entering one of these commands:

- **config mgmtuser add** *username password* **read-write**—Creates a username-password pair with read-write privileges.
- **config mgmtuser add** *username password* **read-only**—Creates a username-password pair with read-only privileges.

Usernames and passwords are case-sensitive and can contain up to 24 ASCII characters. Usernames and passwords cannot contain spaces.

Note If you ever need to change the password for an existing username, enter the **config mgmtuser password** *username new_password* command.

Step 2 List the configured users by entering this command:

show mgmtuser

Restoring Passwords

To configure a new username and password at boot-up using the controller CLI, follow these steps:

Step 1 After the controller boots up, enter **Restore-Password** at the User prompt.

Note For security reasons, the text that you enter does not appear on the controller console.

Step 2 At the Enter User Name prompt, enter a new username.

Step 3 At the Enter Password prompt, enter a new password.

Step 4 At the Re-enter Password prompt, reenter the new password. The controller validates and stores your entries in the database.

Step 5 When the User prompt reappears, enter your new username.

Step 6 When the Password prompt appears, enter your new password. The controller logs you in with your new username and password.

Configuring SNMP

To configure SNMP using the controller CLI, follow these steps:

Step 1 Enter the **config snmp community create** *name* command to create an SNMP community name.

Step 2 Enter the **config snmp community delete** *name* command to delete an SNMP community name.

Step 3 Enter the **config snmp community accessmode ro** *name* command to configure an SNMP community name with read-only privileges. Enter **config snmp community accessmode rw** *name* to configure an SNMP community name with read-write privileges.

Step 4 Enter the **config snmp community ipaddr** *ip-address ip-mask name* command to configure an IP address and subnet mask for an SNMP community.

Note This command behaves like an SNMP access list. It specifies the IP address from which the device accepts SNMP packets with the associated community. The requesting entity's IP address is ANDed with the subnet mask before being compared to the IP address. If the subnet mask is set to 0.0.0.0, an IP address of 0.0.0.0 matches to all IP addresses. The default value is 0.0.0.0.

Note The controller can use only one IP address range to manage an SNMP community.

Step 5 Enter the **config snmp community mode enable** command to enable a community name. Enter the **config snmp community mode disable** command to disable a community name.

Step 6 Enter the **config snmp trapreceiver create** *name ip-address* command to configure a destination for a trap.

Step 7 Enter the **config snmp trapreceiver delete** *name* command to delete a trap.

Step 8 Enter the **config snmp trapreceiver ipaddr** *old-ip-address name new-ip-address* command to change the destination for a trap.

Step 9 Enter the **config snmp trapreceiver mode enable** command to enable traps. Enter the **config snmp trapreceiver mode disable** command to disable traps.

Step 10 Enter **config snmp syscontact** *syscontact-name* to configure the name of the SNMP contact. Enter up to 31 alphanumeric characters for the contact name.

Step 11 Enter the **config snmp syslocation** *syslocation-name* command to configure the SNMP system location. Enter up to 31 alphanumeric characters for the location.

Step 12 Use the **show snmpcommunity** and the **show snmptrap** commands to verify that the SNMP traps and communities are correctly configured.

Step 13 Use the **show trapflags** command to see the enabled and disabled trapflags. If necessary, use the **config trapflags** command to enable or disable trapflags.

Step 14 Starting in release 7.0.116.0, you can also configure the SNMP engine ID. Use the **config snmp engineID** *engine-id-string* command to configure the SNMP engine ID.

Note The engine ID string can be a maximum of 24 characters.

Step 15 Use the **show engineID** command to view the engine ID.

Changing the Default Values of SNMP Community Strings

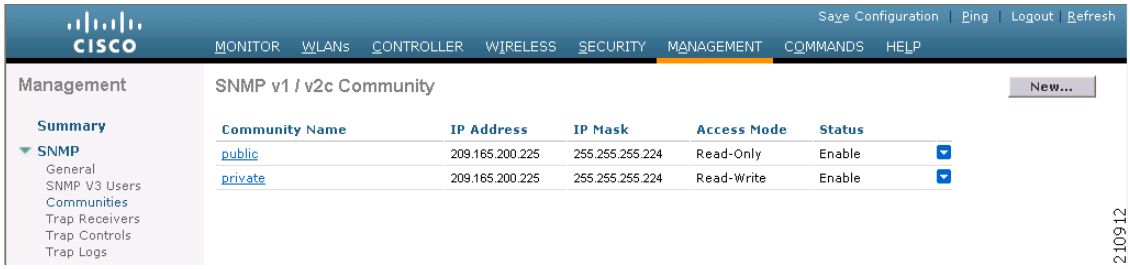
The controller has commonly known default values of “public” and “private” for the read-only and read-write SNMP community strings. Using these standard values presents a security risk. If you use the default community names, and since these are known, the community names could be used to communicate to the controller using the SNMP protocol. Therefore, we strongly advise that you change these values.

Using the GUI to Change the SNMP Community String Default Values

To change the SNMP community string default values using the controller GUI, follow these steps:

Step 1 Choose **Management** and then **Communities** under SNMP. The SNMP v1 / v2c Community page appears (see Figure 4-17).

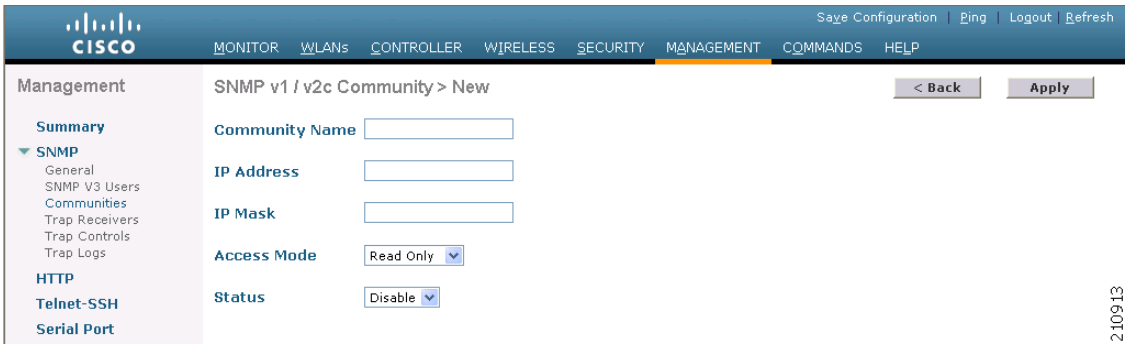
Figure 4-17 SNMP v1 / v2c Community Page



Step 2 If “public” or “private” appears in the Community Name column, hover your cursor over the blue drop-down arrow for the desired community and choose **Remove** to delete this community.

Step 3 Click **New** to create a new community. The SNMP v1 / v2c Community > New page appears (see Figure 4-18).

Figure 4-18 SNMP v1 / v2c Community > New Page



Step 4 In the Community Name text box, enter a unique name containing up to 16 alphanumeric characters. Do not enter “public” or “private.”

Step 5 In the next two text boxes, enter the IP address from which this device accepts SNMP packets with the associated community and the IP mask.

Step 6 Choose **Read Only** or **Read/Write** from the Access Mode drop-down list to specify the access level for this community.

Step 7 Choose **Enable** or **Disable** from the Status drop-down list to specify the status of this community.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your settings.

Step 10 Repeat this procedure if a “public” or “private” community still appears on the SNMP v1 / v2c Community page.

Using the CLI to Change the SNMP Community String Default Values

To change the SNMP community string default values using the controller CLI, follow these steps:

Step 1 See the current list of SNMP communities for this controller by entering this command:

show snmp community

Step 2 If "public" or "private" appears in the SNMP Community Name column, enter this command to delete this community:

config snmp community delete *name*

The *name* parameter is the community name (in this case, "public" or "private").

Step 3 Create a new community by entering this command:

config snmp community create *name*

Enter up to 16 alphanumeric characters for the *name* parameter. Do not enter "public" or "private."

Step 4 Enter the IP address from which this device accepts SNMP packets with the associated community by entering this command:

config snmp community ipaddr *ip_address ip_mask name*

Step 5 Specify the access level for this community by entering this command, where **ro** is read-only mode and **rw** is read/write mode:

config snmp community accessmode {**ro** | **rw**} *name*

Step 6 Enable or disable this SNMP community by entering this command:

config snmp community mode {**enable** | **disable**} *name*

Step 7 Save your changes by entering **save config**.

Step 8 Repeat this procedure if you still need to change the default values for a "public" or "private" community string.

Changing the Default Values for SNMP v3 Users

The controller uses a default value of "default" for the username, authentication password, and privacy password for SNMP v3 users. Using these standard values presents a security risk. Therefore, Cisco strongly advises that you change these values.

Note SNMP v3 is time sensitive. Make sure that you have configured the correct time and time zone on your controller.

Using the GUI to Change the SNMP v3 User Default Values

To change the SNMP v3 user default values using the controller GUI, follow these steps:

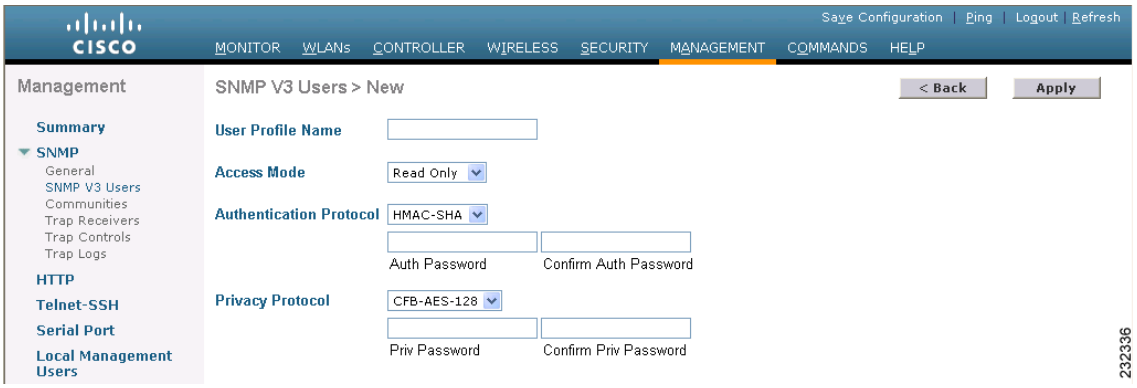
Step 1 Choose **Management > SNMP > SNMP V3 Users** to open the SNMP V3 Users page (see Figure 4-19).

Figure 4-19 SNMP V3 Users Page

Step 2 If "default" appears in the User Name column, hover your cursor over the blue drop-down arrow for the desired user and choose **Remove** to delete this SNMP v3 user.

Step 3 Click **New** to add a new SNMP v3 user. The SNMP V3 Users > New page appears (see Figure 4-20).

Figure 4-20 SNMP V3 Users > New Page



Step 4 In the User Profile Name text box, enter a unique name. Do not enter "default."

Step 5 Choose **Read Only** or **Read Write** from the Access Mode drop-down list to specify the access level for this user. The default value is Read Only.

Step 6 From the Authentication Protocol drop-down list, choose the desired authentication method: **None**, **HMAC-MD5** (Hashed Message Authentication Coding-Message Digest 5), or **HMAC-SHA** (Hashed Message Authentication Coding-Secure Hashing Algorithm). The default value is HMAC-SHA.

Step 7 In the Auth Password and Confirm Auth Password text boxes, enter the shared secret key to be used for authentication. You must enter at least 12 characters.

Step 8 From the Privacy Protocol drop-down list, choose the desired encryption method: **None**, **CBC-DES** (Cipher Block Chaining-Digital Encryption Standard), or **CFB-AES-128** (Cipher Feedback Mode-Advanced Encryption Standard-128). The default value is CFB-AES-128.

Note In order to configure CBC-DES or CFB-AES-128 encryption, you must have selected either HMAC-MD5 or HMAC-SHA as the authentication protocol in Step 6.

Step 9 In the Priv Password and Confirm Priv Password text boxes, enter the shared secret key to be used for encryption. You must enter at least 12 characters.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your settings.

Step 12 Reboot the controller so that the SNMP v3 user that you added takes effect.

Using the CLI to Change the SNMP v3 User Default Values

To change the SNMP v3 user default values using the controller CLI, follow these steps:

Step 1 See the current list of SNMP v3 users for this controller by entering this command:

show snmpv3user

Step 2 If "default" appears in the SNMP v3 User Name column, enter this command to delete this user:

config snmp v3user delete *username*

The *username* parameter is the SNMP v3 username (in this case, "default").

Step 3 Create a new SNMP v3 user by entering this command:

config snmp v3user create *username* {**ro** | **rw**} {**none** | **hmacmd5** | **hmacsha**} {**none** | **des** | **aescfb128**} *auth_key encrypt_key*

where

- *username* is the SNMP v3 username.
- **ro** is read-only mode and **rw** is read-write mode.
- **none**, **hmacmd5**, and **hmacsha** are the authentication protocol options.
- **none**, **des**, and **aescfb128** are the privacy protocol options.
- *auth_key* is the authentication shared secret key.
- *encrypt_key* is the encryption shared secret key.

Do not enter "default" for the *username*, *auth_key*, and *encrypt_key* parameters.

Step 4 Save your changes by entering the **save config** command.

Step 5 Reboot the controller so that the SNMP v3 user that you added takes effect by entering **reset system** command.

Configuring Aggressive Load Balancing

Enabling aggressive load balancing on the controller allows lightweight access points to load balance wireless clients across access points. You can enable aggressive load balancing using the controller GUI or CLI.

Note Clients are load balanced between access points on the same controller. Load balancing does not occur between access points on different controllers.

When a wireless client attempts to associate to a lightweight access point, association response packets are sent to the client with an 802.11 response packet including status code 17. This code indicates whether the access point can accept any more associations. If the access point is too busy, the client attempts to associate to a different access point in the area. The system determines if an access point is relatively more busy than its neighbor access points that are also accessible to the client.

For example, if the number of clients on AP1 is more than the number of clients on AP2 plus the load-balancing window, then AP1 is considered to be busier than AP2. When a client attempts to associate to AP1, it receives an 802.11 response packet with status code 17, indicating that the access point is busy, and the client attempts to associate to a different access point.

You can configure the controller to deny client associations up to 10 times (if a client attempted to associate 11 times, it would be allowed to associate on the 11th try). You can also enable or disable load balancing on a particular WLAN, which is useful if you want to disable load balancing for a select group of clients (such as time-sensitive voice clients).

Note OEAP 600 Series access points do not support client load balancing.

Client Association Limits

The maximum number of client associations that the access points can support is dependent upon the following factors:

- The maximum number of client associations differs for lightweight and autonomous Cisco IOS access points.
- There may be a limit per radio and an overall limit per AP.
- AP hardware (the 16-MB APs have a lower limit than the 32-MB and higher APs).

Client Association Limits for Lightweight Access Points

The Per-AP limits are as follows:

- For 16-MB APs, the limit is 128 clients per AP. This limit is applicable to 1100 and 1200 series APs.
- For 32-MB and higher APs, there is no per-AP limit.

The per-radio limits are as follows:

- For all Cisco IOS APs, the limit is 200 associations per radio.
- For all 1000 and 1500 series APs, which are not supported beyond release 4.2, the limit is 250 associations per radio.

With 32-MB and higher lightweight Cisco IOS APs, with two radios, up to 200 + 200 = 400 associations are supported.

Client Association Limits for Autonomous Cisco IOS Access Points

The client association limits for autonomous Cisco IOS access points are as follows:

The limit is around 80 to 127 clients per AP. This number varies depending on the following factors:

- AP model (whether it is 16 MB or 32 MB or higher).
- Cisco IOS version.

- Hardware configuration (two radios use more memory than one).
- Enabled features (WDS functionality in particular).

The per-radio limits are as follows:

The per-radio limit is about 200 associations. One association will likely hit the per-AP limit first.

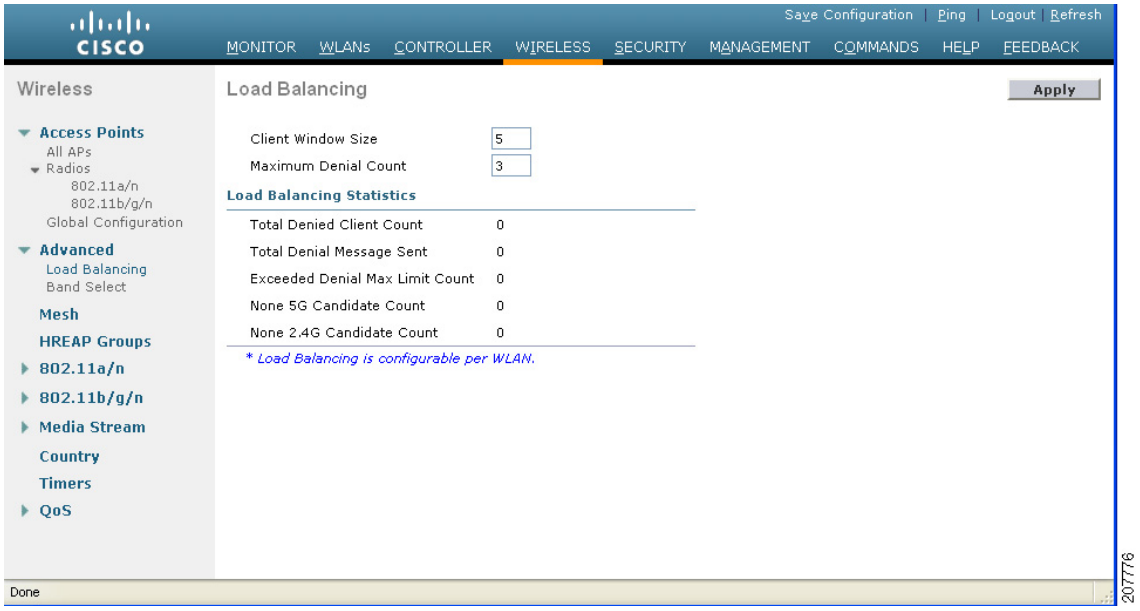
Unlike Cisco Unified Wireless Network, autonomous Cisco IOS supports per-SSID/per-AP association limits. This limit is configured using the **max-associations** CLI, under dot11 SSID. The maximum number is 255 associations (which is also the default number).

Using the GUI to Configure Aggressive Load Balancing

To configure aggressive load balancing using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Advanced > Load Balancing** to open the Load Balancing page (see Figure 4-21).

Figure 4-21 Wireless > Advanced > Load Balancing Page



Step 2 In the Client Window Size text box, enter a value between 1 and 20. The window size becomes part of the algorithm that determines whether an access point is too heavily loaded to accept more client associations:

load-balancing window + client associations on AP with highest load = load-balancing threshold

In the group of access points accessible to a client device, each access point has a different number of client associations. The access point with the lowest number of clients has the lightest load. The client window size plus the number of clients on the access point with the lightest load forms the threshold. Access points with more client associations than this threshold is considered busy, and clients can associate only to access points with client counts lower than the threshold.

Step 3 In the Maximum Denial Count text box, enter a value between 0 and 10. The denial count sets the maximum number of association denials during load balancing.

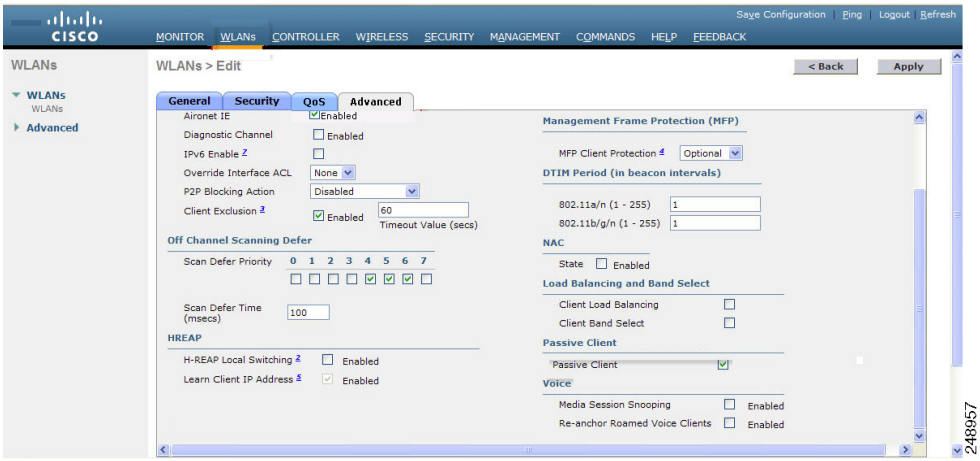
Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Step 6 To enable or disable aggressive load balancing on specific WLANs, choose **WLANs > WLAN ID**. The WLANs > Edit page appears.

Step 7 Click the **Advanced** tab (see Figure 4-22).

Figure 4-22 WLANs > Advanced Page



Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your settings

Using the CLI to Configure Aggressive Load Balancing

To configure aggressive load balancing using the controller CLI, follow these steps:

Step 1 Set the client window for aggressive load balancing by entering this command:

config load-balancing window *client_count*

You can enter a value between 0 and 20 for the *client_count* parameter.

Step 2 Set the denial count for load balancing by entering this command:

config load-balancing denial *denial_count*

You can enter a value between 1 and 10 for the *denial_count* parameter.

Step 3 Save your changes by entering this command:

save config

Step 4 Enable or disable aggressive load balancing on specific WLANs by entering this command:

config wlan load-balance allow {**enable** | **disable**} *wlan_ID*

You can enter a value between 1 and 512 for *wlan_ID* parameter.

Step 5 Verify your settings by entering this command:

show load-balancing

Information similar to the following appears:

```
Aggressive Load Balancing..................... Enabled
Aggressive Load Balancing Window.............. 1 clients
Aggressive Load Balancing Denial Count........... 3

                                                  Statistics
Total Denied Count............................ 5 clients
Total Denial Sent............................. 10 messages
Exceeded Denial Max Limit Count............... 0 times
None 5G Candidate Count....................... 0 times
None 2.4G Candidate Count..................... 0 times
```

Step 6 Save your changes by entering this command:

save config

Configuring Band Selection

Band selection enables client radios that are capable of dual-band (2.4- and 5-GHz) operation to move to a less congested 5-GHz access point. The 2.4-GHz band is often congested. Clients on this band typically experience interference from Bluetooth devices, microwave ovens, and cordless phones as well as co-channel interference from other access points because of the 802.11b/g limit of three nonoverlapping channels. To combat these sources of interference and improve overall network performance, you can configure band selection on the controller.

Band selection works by regulating probe responses to clients. It makes 5-GHz channels more attractive to clients by delaying probe responses to clients on 2.4-GHz channels.

Band selection is enabled globally by default.

Note Band-selection enabled WLANs do not support time-sensitive applications like voice and video because of roaming delays.

Guidelines for Using the Band Selection

Follow these guidelines when using band selection:

- Band selection can be used only with Cisco Aironet 1140 and 1250 Series and the 3500 series access points.
- Band selection operates only on access points that are connected to a controller. A hybrid-REAP access point without a controller connection does not perform band selection after a reboot.

Note OEAP 600 Series access points do not support band select.

- The band-selection algorithm directs dual-band clients only from the 2.4-GHz radio to the 5-GHz radio of the same access point, and it only runs on an access point when both the 2.4-GHz and 5-GHz radios are up and running.

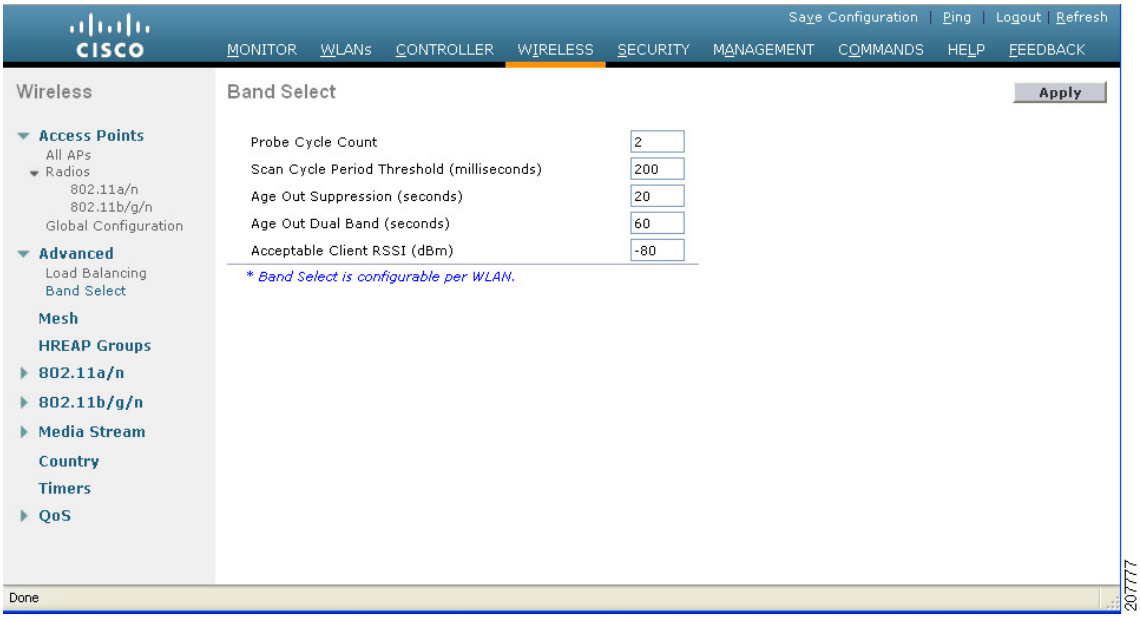
- You can enable both band selection and aggressive load balancing on the controller. They run independently and do not impact one another.

Using the GUI to Configure Band Selection

To configure band selection using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Advanced** > **Band Select** to open the Band Select page (see Figure 4-23).

Figure 4-23 Wireless > Advanced > Band Select Page



Step 2 In the Probe Cycle Count text box, enter a value between 1 and 10. The cycle count sets the number of suppression cycles for a new client. The default cycle count is 2.

Step 3 In the Scan Cycle Period Threshold (milliseconds) text box, enter a value between 1 and 1000 milliseconds for the scan cycle period threshold. This setting determines the time threshold during which new probe requests from a client come from a new scanning cycle. The default cycle threshold is 200 milliseconds.

Step 4 In the Age Out Suppression (seconds) text box, enter a value between 10 and 200 seconds. Age-out suppression sets the expiration time for pruning previously known 802.11b/g clients. The default value is 20 seconds. After this time elapses, clients become new and are subject to probe response suppression.

Step 5 In the Age Out Dual Band (seconds) text box, enter a value between 10 and 300 seconds. The age-out period sets the expiration time for pruning previously known dual-band clients. The default value is 60 seconds. After this time elapses, clients become new and are subject to probe response suppression.

Step 6 In the Acceptable Client RSSI (dBm) text box, enter a value between –20 and –90 dBm. This parameter sets the minimum RSSI for a client to respond to a probe. The default value is –80 dBm.

Step 7 Click **Apply** to commit your changes.

Step 8 Click **Save Configuration** to save your changes.

Step 9 To enable or disable aggressive load balancing on specific WLANs, choose **WLANs** > **WLAN ID**. The WLANs > Edit page appears.

Step 10 Click the **Advanced** tab (see Figure 4-22).

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Configure Band Selection

To configure band selection using the controller CLI, follow these steps:

Step 1 Set the probe cycle count for band select by entering this command:

config band-select cycle-count *cycle_count*

You can enter a value between 1 and 10 for the *cycle_count* parameter.

Step 2 Set the time threshold for a new scanning cycle period by entering this command:

config band-select cycle-threshold *milliseconds*

You can enter a value for threshold between 1 and 1000 for the *milliseconds* parameter.

Step 3 Set the suppression expire to the band select by entering this command:

config band-select expire suppression *seconds*

You can enter a value for suppression between 10 to 200 for the *seconds* parameter.

Step 4 Set the dual band expire by entering this command:

config band-select expire dual-band *seconds*

You can enter a value for dual band between 10 and 300 for the *seconds* parameter.

Step 5 Set the client RSSI threshold by entering this command:

config band-select client-rssi *client_rssi*

You can enter a value for minimum dBm of a client RSSI to respond to a probe between 20 and 90 for the *client_rssi* parameter.

Step 6 Save your changes by entering this command:

save config

Step 7 Enable or disable band selection on specific WLANs by entering this command:

config wlan band-select allow {enable | disable} *wlan_ID*

You can enter a value between 1 and 512 for *wlan_ID* parameter.

Step 8 Verify your settings by entering this command:

show band-select

Information similar to the following appears:

```
Band Select Probe Response..................... Enabled
   Cycle Count................................. 3 cycles
   Cycle Threshold............................. 300 milliseconds
   Age Out Suppression......................... 20 seconds
   Age Out Dual Band........................... 20 seconds
   Client RSSI................................. -30 dBm
```

Step 9 Save your changes by entering this command:

save config

Configuring Fast SSID Changing

When fast SSID changing is enabled, the controller allows clients to move between SSIDs. When the client sends a new association for a different SSID, the client entry in the controller connection table is cleared before the client is added to the new SSID. When fast SSID changing is disabled, the controller enforces a delay before clients are allowed to move to a new SSID.

Using the GUI to Configure Fast SSID Changing

To configure fast SSID changing for mobile clients using the controller GUI, follow these steps:

Step 1 Choose **Controller** to open the General page.

Step 2 From the Fast SSID Change drop-down list, choose **Enabled** to enable this feature or **Disabled** to disable it. The default value is disabled.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure Fast SSID Changing

To configure fast SSID changing for mobile clients using the controller CLI, follow these steps:

Step 1 Enable or disable fast SSID changing by entering this command:

config network fast-ssid-change {**enable** | **disable**}

Step 2 Save your changes by entering this command:

save config

Enabling 802.3X Flow Control

802.3X Flow Control is disabled by default. To enable it, enter the **config switchconfig flowcontrol enable** command.

Configuring 802.3 Bridging

The controller supports 802.3 frames and the applications that use them, such as those typically used for cash registers and cash register servers. However, to make these applications work with the controller, the 802.3 frames must be bridged on the controller.

Support for raw 802.3 frames allows the controller to bridge non-IP frames for applications not running over IP. Only this raw 802.3 frame format is currently supported:

```
+------------------+--------------------+----------------+-----------------------+
| Destination      | Source             | Total packet | Payload .....
| MAC address      | MAC address        | length       |
+------------------+--------------------+----------------+-----------------------
```

You can configure 802.3 bridging through the controller GUI in software release 4.1 or later releases and through the controller CLI in software release 4.0 or later releases.

Note In controller software release 5.2 or later releases, the software-based forwarding architecture for 2100-series-based controllers is being replaced with a new forwarding plane architecture. As a result, Cisco 2100 Series Controller and the Cisco Wireless LAN Controller Network Module for Cisco Integrated Services Routers (as well as Cisco 5500 Series Controllers) bridge 802.3 packets by default. Therefore, 802.3 bridging can now be disabled only on 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Wireless LAN Controller Switch.

Note By default, Cisco 2100 Series Controllers that run software release 5.2 or later releases and Cisco 5500 Series Controllers bridge all non-IPv4 packets (such as AppleTalk, IPv6, and so on). If desired, you can use ACLs to block the bridging of these protocols.

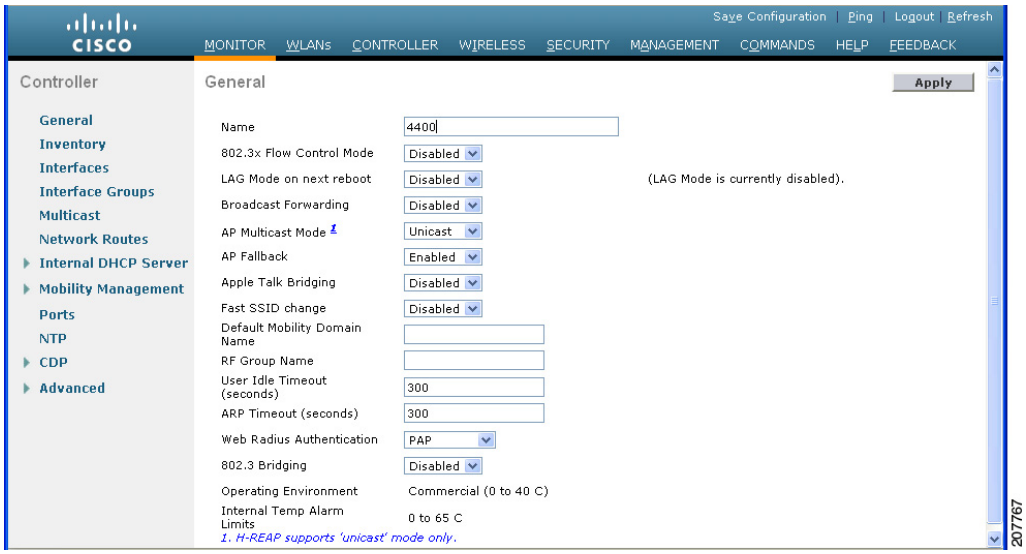
Note You can also configure 802.3 bridging using the Cisco Wireless Control System (WCS). See the *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to Configure 802.3 Bridging

To configure 802.3 bridging using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **General** to open the General page (see Figure 4-24).

Figure 4-24 General Page



Step 2 From the 802.3 Bridging drop-down list, choose **Enabled** to enable 802.3 bridging on your controller or **Disabled** to disable this feature. The default value is Disabled.

Note In controller software release 5.2 or later releases, you can disable 802.3 bridging only for 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Wireless LAN Controller Switch.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure 802.3 Bridging

To configure 802.3 bridging using the controller CLI, follow these steps:

Step 1 See the current status of 802.3 bridging for all WLANs by entering this command:

show network

Step 2 Enable or disable 802.3 bridging globally on all WLANs by entering this command:

config network 802.3-bridging {**enable** | **disable**}

The default value is disabled.

Note In controller software release 5.2 or later releases, you can disable 802.3 bridging only for 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Wireless LAN Controller Switch.

Step 3 Save your settings by entering this command:

save config

Configuring Multicast Mode

If your network supports packet multicasting, you can configure the multicast method that the controller uses. The controller performs multicasting in two modes:

- Unicast mode—In this mode, the controller unicasts every multicast packet to every access point associated to the controller. This mode is inefficient but might be required on networks that do not support multicasting.
- Multicast mode—In this mode, the controller sends multicast packets to a CAPWAP multicast group. This method reduces overhead on the controller processor and shifts the work of packet replication to your network, which is much more efficient than the unicast method.

You can enable multicast mode using the controller GUI or CLI.

Understanding Multicast Mode

When you enable multicast mode and the controller receives a multicast packet from the wired LAN, the controller encapsulates the packet using CAPWAP and forwards the packet to the CAPWAP multicast group address. The controller always uses the management interface for sending multicast packets. Access points in the multicast group receive the packet and forward it to all the BSSIDs mapped to the interface on which clients receive multicast traffic. From the access point perspective, the multicast appears to be a broadcast to all SSIDs.

In controller software release 4.2 or later releases, Internet Group Management Protocol (IGMP) snooping is introduced to better direct multicast packets. When this feature is enabled, the controller gathers IGMP reports from the clients, processes them, creates unique multicast group IDs (MGIDs) from the IGMP reports after selecting the Layer 3 multicast address and the VLAN number, and sends the IGMP reports to the infrastructure switch. The controller sends these reports with the source address as the interface address on which it received the reports from the clients. The controller then updates the access point MGID table on the access point with the client MAC address. When the controller receives multicast traffic for a particular multicast group, it forwards it to all the access points, but only those access points that have active clients listening or subscribed to that multicast group send multicast traffic on that particular WLAN. IP packets are forwarded with an MGID that is unique for an ingress VLAN and the destination multicast group. Layer 2 multicast packets are forwarded with an MGID that is unique for the ingress interface.

When IGMP snooping is disabled, the following is true:

- The controller always uses Layer 2 MGID when it sends multicast data to the access point. Every interface created is assigned one Layer 2 MGID. For example, the management interface has an MGID of 0, and the first dynamic interface created is assigned an MGID of 8, which increments as each dynamic interface is created.
- The IGMP packets from clients are forwarded to the router. As a result, the router IGMP table is updated with the IP address of the clients as the last reporter.

When IGMP snooping is enabled, the following is true:

- The controller always uses Layer 3 MGID for all Layer 3 multicast traffic sent to the access point. For all Layer 2 multicast traffic, it continues to use Layer 2 MGID.
- IGMP report packets from wireless clients are consumed or absorbed by the controller, which generates a query for the clients. After the router sends the IGMP query, the controller sends the IGMP reports with its interface IP address as the listener IP address for the multicast group. As a result, the router IGMP table is updated with the controller IP address as the multicast listener.

- When the client that is listening to the multicast groups roams from one controller to another, the first controller transmits all the multicast group information for the listening client to the second controller. As a result, the second controller can immediately create the multicast group information for the client. The second controller sends the IGMP reports to the network for all multicast groups to which the client was listening. This process aids in the seamless transfer of multicast data to the client.
- If the listening client roams to a controller in a different subnet, the multicast packets are tunneled to the anchor controller of the client to avoid the reverse path filtering (RPF) check. The anchor then forwards the multicast packets to the infrastructure switch.

Note The MGIDs are controller specific. The same multicast group packets coming from the same VLAN in two different controllers may be mapped to two different MGIDs.

Note If Layer 2 multicast is enabled, a single MGID is assigned to all the multicast addresses coming from an interface (see Figure 4-26).

Guidelines for Using Multicast Mode

Follow these guidelines when you enable multicast mode on your network:

- The Cisco Unified Wireless Network solution uses some IP address ranges for specific purposes, and you should keep these ranges in mind when configuring a multicast group:
  - 224.0.0.0 through 224.0.0.255—Reserved link local addresses
  - 224.0.1.0 through 238.255.255.255—Globally scoped addresses
  - 239.0.0.0 through 239.255.x.y /16—Limited scope addresses
- When you enable multicast mode on the controller, you also must configure a CAPWAP multicast group address. Access points subscribe to the CAPWAP multicast group using IGMP.
- Cisco 1100, 1130, 1200, 1230, and 1240 access points use IGMP versions 1, 2, and 3.
- Access points in monitor mode, sniffer mode, or rogue detector mode do not join the CAPWAP multicast group address.
- The CAPWAP multicast group configured on the controllers should be different for different controllers.
- Multicast mode does not operate across intersubnet mobility events such as guest tunneling. It does, however, operate with interface overrides using RADIUS (but only when IGMP snooping is enabled) and with site-specific VLANs (access point group VLANs).
- For LWAPP, the controller drops multicast packets sent to UDP control port 12223. For CAPWAP, the controller drops multicast packets sent to UDP control and data ports 5246 and 5247, respectively. Therefore, you may want to consider not using these port numbers with the multicast applications on your network.
- We recommend that any multicast applications on your network not use the multicast address configured as the CAPWAP multicast group address on the controller.
- Cisco 2100 Series Controllers do not support multicast-unicast mode. They do, however, support multicast-multicast mode, except when access points are connected directly to the local port of a 2100 series controller.

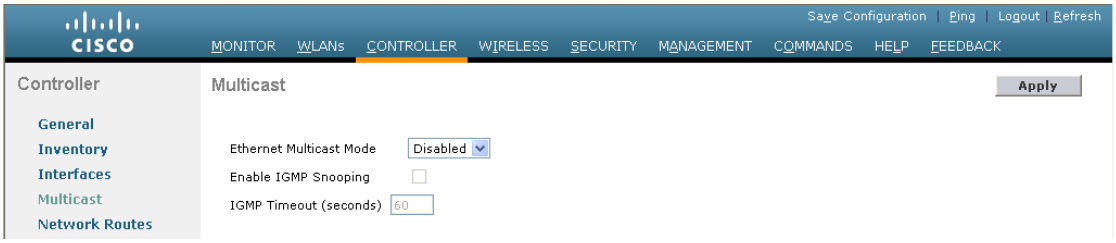
- Cisco Flex 7500 Series Controllers do not support multicast-unicast mode.

Using the GUI to Enable Multicast Mode

To enable multicast mode using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Multicast** to open the Multicast page (see Figure 4-25).

Figure 4-25 Multicast Page



Step 2 Choose one of the following options from the Ethernet Multicast Mode drop-down list:

- **Disabled**—Disables multicasting on the controller. This is the default value.
- **Unicast**—Configures the controller to use the unicast method to send multicast packets.
- **Multicast**—Configures the controller to use the multicast method to send multicast packets to a CAPWAP multicast group.

Note Hybrid REAP supports unicast mode only.

Step 3 If you chose Multicast in Step 2, enter the IP address of the multicast group in the Multicast Group Address text box.

Step 4 If you want to enable IGMP snooping, select the **Enable IGMP Snooping** check box. If you want to disable IGMP snooping, leave the check box unselected. The default value is disabled.

Step 5 To set the IGMP timeout, enter a value between 30 and 7200 seconds in the IGMP Timeout text box. The controller sends three queries in one timeout value at an interval of *timeout*/ 3 to see if any clients exist for a particular multicast group. If the controller does not receive a response through an IGMP report from the client, the controller times out the client entry from the MGID table. When no clients are left for a particular multicast group, the controller waits for the IGMP timeout value to expire and then deletes the MGID entry from the controller. The controller always generates a general IGMP query (that is, to destination address 224.0.0.1) and sends it on all WLANs with an MGID value of 1.

Step 6 Enter the IGMP Query Interval (seconds).

Step 7 Click **Apply** to commit your changes.

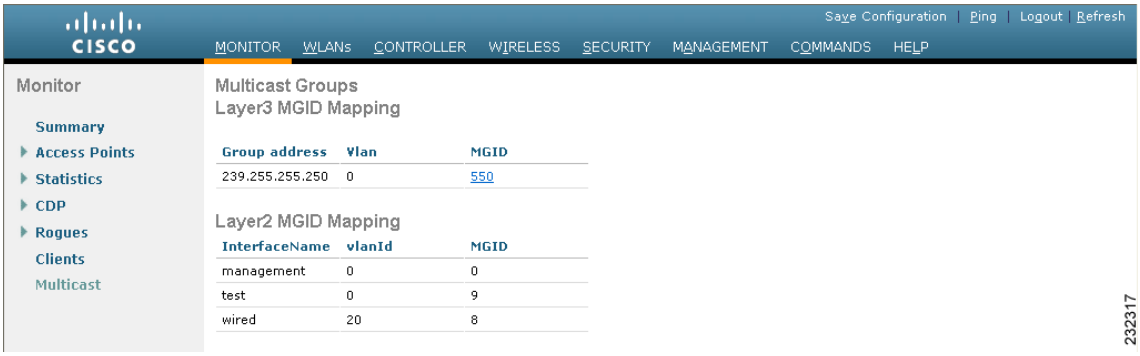
Step 8 Click **Save Configuration** to save your changes.

Using the GUI to View Multicast Groups

To view multicast groups using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Multicast**. The Multicast Groups page appears (see Figure 4-26).

Figure 4-26 Multicast Groups Page



This page shows all the multicast groups and their corresponding MGIDs.

Step 2 Click the link for a specific MGID (such as MGID 550) to see a list of all the clients joined to the multicast group in that particular MGID.

Using the CLI to Enable Multicast Mode

To enable multicast mode using the controller CLI, follow these steps:

Step 1 Enable or disable multicasting on the controller by entering this command:

config network multicast global {**enable** | **disable**}

The default value is disabled.

Note The **config network broadcast** {**enable** | **disable**} command allows you to enable or disable broadcasting without enabling or disabling multicasting as well. This command uses the multicast mode currently on the controller to operate.

Step 2 Perform one of the following:

a. Configure the controller to use the unicast method to send multicast packets by entering this command:

config network multicast mode unicast

b. Configure the controller to use the multicast method to send multicast packets to a CAPWAP multicast group by entering this command:

config network multicast mode multicast *multicast_group_ip_address*

Step 3 Enable or disable IGMP snooping by entering this command:

config network multicast igmp snooping {**enable** | **disable**}

The default value is disabled.

Step 4 Set the IGMP timeout value by entering this command:

config network multicast igmp timeout *timeout*

You can enter a *timeout* value between 30 and 7200 seconds. The controller sends three queries in one timeout value at an interval of *timeout*/3 to see if any clients exist for a particular multicast group. If the controller does not receive a response through an IGMP report from the client, the controller times out the client entry from the MGID table. When no clients are left for a particular multicast group, the controller waits for the IGMP timeout value to expire and then deletes the MGID entry from the controller. The controller always generates a general IGMP query (that is, to destination address 224.0.0.1) and sends it on all WLANs with an MGID value of 1.

Step 5 Save your changes by entering this command:

save config

Using the CLI to View Multicast Groups

To view multicast groups using the controller CLI, use these commands:

- See all the multicast groups and their corresponding MGIDs by entering this command:

  show network multicast mgid summary

  Information similar to the following appears:

```
Layer2 MGID Mapping:
--------------------
InterfaceName                    vlanId   MGID
-------------------------------- ------   ----
management                       0        0
test                             0        9
wired                            20       8

Layer3 MGID Mapping:
--------------------
Number of Layer3 MGIDs.......................... 1

 Group address    Vlan  MGID
 ---------------  ----  ----
 239.255.255.250  0     550
```

- See all the clients joined to the multicast group in a specific MGID by entering this command:

  show network multicast mgid detail *mgid_value*

  where the *mgid_value* parameter is a number between 550 and 4095.

  Information similar to the following appears:

```
Mgid.......................................... 550
Multicast Group Address..................... 239.255.255.250
Vlan.......................................... 0
Rx Packet Count............................... 807399588
No of clients................................. 1
Client List..................................
        Client MAC             Expire Time (mm:ss)
```

```
00:13:02:23:82:ad      0:20
```

Using the CLI to View an Access Point's Multicast Client Table

To help troubleshoot roaming events, you can view an access point's multicast client table from the controller by performing a remote debug of the access point.

To view an access point's multicast client table using the controller CLI, follow these steps:

Step 1 Initiate a remote debug of the access point by entering this command:

debug ap enable *Cisco_AP*

Step 2 See all of the MGIDs on the access point and the number of clients per WLAN by entering this command:

debug ap command "**show capwap mcast mgid all**" *Cisco_AP*

Step 3 See all of the clients per MGID on the access point and the number of clients per WLAN by entering this command:

debug ap command "**show capwap mcast mgid id** *mgid_value*" *Cisco_AP*

Configuring Client Roaming

The Cisco UWN Solution supports seamless client roaming across lightweight access points managed by the same controller, between controllers in the same mobility group on the same subnet, and across controllers in the same mobility group on different subnets. Also, in controller software release 4.1 or later releases, client roaming with multicast packets is supported.

You can adjust the default RF settings (RSSI, hysteresis, scan threshold, and transition time) to fine-tune the operation of client roaming using the controller GUI or CLI.

Intra-Controller Roaming

Each controller supports same-controller client roaming across access points managed by the same controller. This roaming is transparent to the client as the session is sustained, and the client continues using the same DHCP-assigned or client-assigned IP address. The controller provides DHCP functionality with a relay function. Same-controller roaming is supported in single-controller deployments and in multiple-controller deployments.

Inter-Controller Roaming

Multiple-controller deployments support client roaming across access points managed by controllers in the same mobility group and on the same subnet. This roaming is also transparent to the client because the session is sustained and a tunnel between controllers allows the client to continue using the same DHCP- or client-assigned IP address as long as the session remains active. The tunnel is torn down, and the client must reauthenticate when the client sends a DHCP Discover with a 0.0.0.0 client IP address or a 169.254.*.* client auto-IP address or when the operator-set session timeout is exceeded.

Inter-Subnet Roaming

Multiple-controller deployments support client roaming across access points managed by controllers in the same mobility group on different subnets. This roaming is transparent to the client because the session is sustained and a tunnel between the controllers allows the client to continue using the same DHCP-assigned or client-assigned IP address as long as the session remains active. The tunnel is torn down, and the client must reauthenticate when the client sends a DHCP Discover with a 0.0.0.0 client IP address or a 169.254.*.* client auto-IP address or when the operator-set user timeout is exceeded.

Voice-over-IP Telephone Roaming

802.11 voice-over-IP (VoIP) telephones actively seek out associations with the strongest RF signal to ensure the best quality of service (QoS) and the maximum throughput. The minimum VoIP telephone requirement of 20-millisecond or shorter latency time for the roaming handover is easily met by the Cisco UWN Solution, which has an average handover latency of 5 or fewer milliseconds when open authentication is used. This short latency period is controlled by controllers rather than allowing independent access points to negotiate roaming handovers.

The Cisco UWN Solution supports 802.11 VoIP telephone roaming across lightweight access points managed by controllers on different subnets, as long as the controllers are in the same mobility group. This roaming is transparent to the VoIP telephone because the session is sustained and a tunnel between controllers allows the VoIP telephone to continue using the same DHCP-assigned IP address as long as the session remains active. The tunnel is torn down, and the VoIP client must reauthenticate when the VoIP telephone sends a DHCP Discover with a 0.0.0.0 VoIP telephone IP address or a 169.254.*.* VoIP telephone auto-IP address or when the operator-set user timeout is exceeded.

CCX Layer 2 Client Roaming

The controller supports five CCX Layer 2 client roaming enhancements:

- Access point assisted roaming—This feature helps clients save scanning time. When a CCXv2 client associates to an access point, it sends an information packet to the new access point listing the characteristics of its previous access point. Roaming time decreases when the client recognizes and uses an access point list built by compiling all previous access points to which each client was associated and sent (unicast) to the client immediately after association. The access point list contains the channels, BSSIDs of neighbor access points that support the client's current SSID(s), and time elapsed since disassociation.
- Enhanced neighbor list—This feature focuses on improving a CCXv4 client's roam experience and network edge performance, especially when servicing voice applications. The access point provides its associated client information about its neighbors using a neighbor-list update unicast message.
- Enhanced neighbor list request (E2E)—The End-2-End specification is a Cisco and Intel joint program that defines new protocols and interfaces to improve the overall voice and roaming experience. It applies only to Intel clients in a CCX environment. Specifically, it enables Intel clients to request a neighbor list at will. When this occurs, the access point forwards the request to the controller. The controller receives the request and replies with the current CCX roaming sublist of neighbors for the access point to which the client is associated.

Note To see whether a particular client supports E2E, choose **Wireless > Clients** on the controller GUI, click the **Detail** link for the desired client, and look at the E2E Version text box under Client Properties.

- Roam reason report—This feature enables CCXv4 clients to report the reason why they roamed to a new access point. It also allows network administrators to build and monitor a roam history.
- Directed roam request—This feature enables the controller to send directed roam requests to the client in situations when the controller can better service the client on an access point different from the one to which it is associated. In this case, the controller sends the client a list of the best access points that it can join. The client can either honor or ignore the directed roam request. Non-CCX clients and clients running CCXv3 or below must not take any action. No configuration is required for this feature.

Controller software release 4.2 or later releases support CCX versions 1 through 5. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. The controller stores the CCX version of the client in its client database and uses it to generate and respond to CCX frames appropriately. Clients must support CCXv4 or v5 (or CCXv2 for access point assisted roaming) in order to utilize these roaming enhancements. See the "Configuring Cisco Client Extensions" section on page 7-52 for more information on CCX.

The roaming enhancements mentioned above are enabled automatically, with the appropriate CCX support.

Note Hybrid-REAP access points in standalone mode do not support CCX Layer 2 roaming.

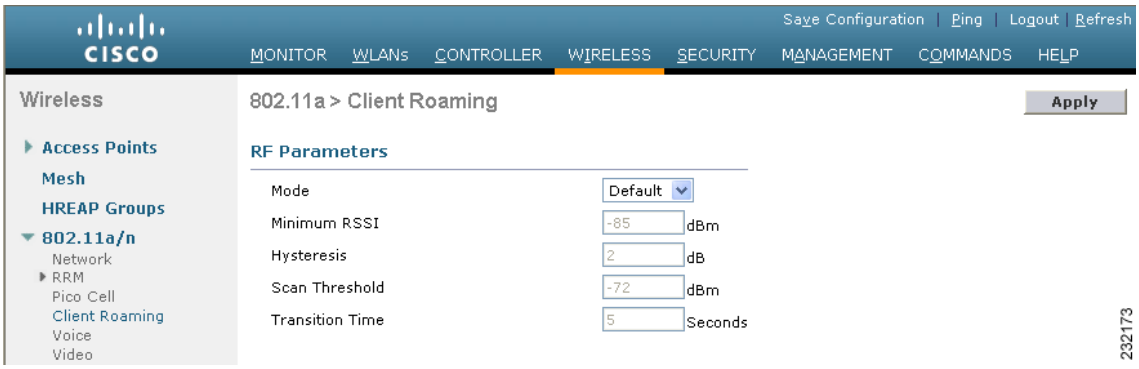
Note Client roaming between 600 Series Access points is not supported.

Using the GUI to Configure CCX Client Roaming Parameters

To configure CCX client roaming parameters using the controller GUI, follow these steps:

Step 1 Choose **Wireless > 802.11a/n** (or **802.11b/g/n**) **> Client Roaming**. The 802.11a (or 802.11b) > Client Roaming page appears (see Figure 4-27).

Figure 4-27 802.11a > Client Roaming Page



Step 2 If you want to fine-tune the RF parameters that affect client roaming, choose **Custom** from the Mode drop-down list and go to Step 3. If you want to leave the RF parameters at their default values, choose **Default** and go to Step 8.

Step 3 In the Minimum RSSI text box, enter a value for the minimum received signal strength indicator (RSSI) required for the client to associate to an access point. If the client's average received signal power dips below this threshold, reliable communication is usually impossible. Therefore, clients must already have found and roamed to another access point with a stronger signal before the minimum RSSI value is reached.

The range is –80 to –90 dBm.

The default is –85 dBm.

Step 4 In the Hysteresis text box, enter a value to indicate how much greater the signal strength of a neighboring access point must be in order for the client to roam to it. This parameter is intended to reduce the amount of roaming between access points if the client is physically located on or near the border between two access points.

The range is 3 to 20 dB.

The default is 3 dB.

Step 5 In the Scan Threshold text box, enter the minimum RSSI that is allowed before the client should roam to a better access point. When the RSSI drops below the specified value, the client must be able to roam to a better access point within the specified transition time. This parameter also provides a power-save method to minimize the time that the client spends in active or passive scanning. For example, the client can scan slowly when the RSSI is above the threshold and scan more rapidly when the RSSI is below the threshold.

The range is –70 to –77 dBm.

The default is –72 dBm.

Step 6 In the Transition Time text box, enter the maximum time allowed for the client to detect a suitable neighboring access point to roam to and to complete the roam, whenever the RSSI from the client's associated access point is below the scan threshold.

The Scan Threshold and Transition Time parameters guarantee a minimum level of client roaming performance. Together with the highest expected client speed and roaming hysteresis, these parameters make it possible to design a wireless LAN network that supports roaming simply by ensuring a certain minimum overlap distance between access points.

The range is 1 to 10 seconds.

The default is 5 seconds.

Step 7 Click **Apply** to commit your changes.

Step 8 Click **Save Configuration** to save your changes.

Step 9 Repeat this procedure if you want to configure client roaming for another radio band (802.11a or 802.11b/g).

Using the CLI to Configure CCX Client Roaming Parameters

Configure CCX Layer 2 client roaming parameters by entering this command:

config {**802.11a** | **802.11b**} **l2roam rf-params** {**default** | **custom** *min_rssi roam_hyst scan_thresh trans_time*}

Note See the description, range, and default value of each RF parameter in the "Using the GUI to Configure CCX Client Roaming Parameters" section on page 4-64.

Using the CLI to Obtain CCX Client Roaming Information

To view information about CCX Layer 2 client roaming using the controller CLI, follow these steps:

Step 1 View the current RF parameters configured for client roaming for the 802.11a or 802.11b/g network by entering this command:

show {**802.11a** | **802.11b**} **l2roam rf-param**

Step 2 View the CCX Layer 2 client roaming statistics for a particular access point by entering this command:

show {**802.11a** | **802.11b**} **l2roam statistics** *ap_mac*

This command provides the following information:

- The number of roam reason reports received
- The number of neighbor list requests received
- The number of neighbor list reports sent
- The number of broadcast neighbor updates sent

Step 3 View the roaming history for a particular client by entering this command:

show client roam-history *client_mac*

This command provides the following information:

- The time when the report was received
- The MAC address of the access point to which the client is currently associated
- The MAC address of the access point to which the client was previously associated
- The channel of the access point to which the client was previously associated
- The SSID of the access point to which the client was previously associated
- The time when the client disassociated from the previous access point
- The reason for the client roam

Using the CLI to Debug CCX Client Roaming Issues

If you experience any problems with CCX Layer 2 client roaming, enter this command:

debug l2roam [**detail** | **error** | **packet** | **all**] {**enable** | **disable**}

Configuring IP-MAC Address Binding

In controller software release 5.2 or later releases, the controller enforces strict IP address-to-MAC address binding in client packets. The controller checks the IP address and MAC address in a packet, compares them to the addresses that are registered with the controller, and forwards the packet only if they both match. In previous releases, the controller checks only the MAC address of the client and ignores the IP address.

Note If the IP address or MAC address of the packet has been spoofed, the check does not pass, and the controller discards the packet. Spoofed packets can pass through the controller only if both the IP and MAC addresses are spoofed together and changed to that of another valid client on the same controller.

To configure IP-MAC address binding using the controller CLI, follow these steps:

Step 1 Enable or disable IP-MAC address binding by entering this command:

config network ip-mac-binding {**enable** | **disable**}

The default value is enabled.

Note You might want to disable this binding check if you have a routed network behind a workgroup bridge (WGB).

Note You must disable this binding check in order to use an access point in sniffer mode if the access point is joined to a Cisco 5500 Series Controller, a Cisco 2100 Series Controller, or a controller network module that runs software release 6.0 or later releases.

Step 2 Save your changes by entering this command:

save config

Step 3 View the status of IP-MAC address binding by entering this command:

show network summary

Information similar to the following appears:

```
RF-Network Name............................. ctrl4404
Web Mode.................................... Disable
Secure Web Mode............................. Enable
Secure Web Mode Cipher-Option High.......... Disable
Secure Web Mode Cipher-Option SSLv2......... Enable
...
IP/MAC Addr Binding Check ................ Enabled
...
```

Configuring Quality of Service

Quality of service (QoS) refers to the capability of a network to provide better service to selected network traffic over various technologies. The primary goal of QoS is to provide priority including dedicated bandwidth, controlled jitter and latency (required by some real-time and interactive traffic), and improved loss characteristics.

The controller supports four QoS levels:

- Platinum/Voice—Ensures a high quality of service for voice over wireless.
- Gold/Video—Supports high-quality video applications.
- Silver/Best Effort—Supports normal bandwidth for clients. This is the default setting.
- Bronze/Background—Provides the lowest bandwidth for guest services.

Note VoIP clients should be set to Platinum.

You can configure the bandwidth of each QoS level using QoS profiles and then apply the profiles to WLANs. The profile settings are pushed to the clients associated to that WLAN. In addition, you can create QoS roles to specify different bandwidth levels for regular and guest users. Follow the instructions in this section to configure QoS profiles and QoS roles.

Configuring Quality of Service Profiles

You can use the controller GUI or CLI to configure the Platinum, Gold, Silver, and Bronze QoS profiles.

Using the GUI to Configure QoS Profiles

To configure QoS profiles using the controller GUI, follow these steps:

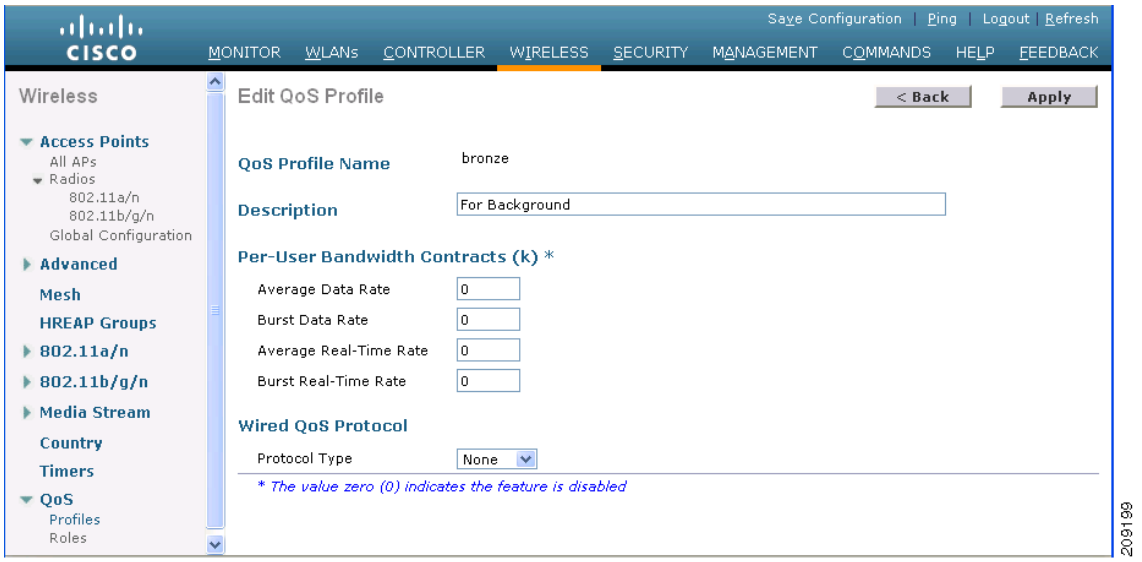
Step 1 Disable the 802.11a and 802.11b/g networks so that you can configure the QoS profiles.

To disable the radio networks, choose **Wireless > 802.11a/n** or **802.11b/g/n > Network**, unselect the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 2 Choose **Wireless > QoS > Profiles** to open the QoS Profiles page.

Step 3 Click the name of the profile that you want to configure to open the Edit QoS Profile page (see Figure 4-28).

Figure 4-28 Edit QoS Profile Page



Step 4 Change the description of the profile by modifying the contents of the Description text box.

Step 5 Define the average data rate for TCP traffic per user by entering the rate in Kbps in the Average Data Rate text box. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the profile.

Step 6 Define the peak data rate for TCP traffic per user by entering the rate in Kbps in the Burst Data Rate text box. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the profile.

Note The Burst Data Rate should be greater than or equal to the Average Data Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Step 7 Define the average real-time rate for UDP traffic on a per-user basis by entering the rate in Kbps in the Average Real-Time Rate text box. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the profile.

Step 8 Define the peak real-time rate for UDP traffic on a per-user basis by entering the rate in Kbps in the Burst Real-Time Rate text box. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the profile.

Note The Burst Real-Time Rate should be greater than or equal to the Average Real-Time Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Step 9 In the Maximum RF Usage Per AP text box, enter the maximum percentage of bandwidth given to a user class.

For example, if you set 50% for Bronze QoS, all the Bronze WLAN users combined will not get more than 50% of the available RF bandwidth. Actual throughput could be less than 50%, but it will never be more than 50%.

Step 10 In the Queue Depth text box, enter the maximum number of packets that access points keep in their queues. Any additional packets are dropped.

Step 11 Choose **802.1p** from the Protocol Type drop-down list and enter the maximum priority value in the 802.1p Tag text box to define the maximum value (0–7) for the priority tag associated with packets that fall within the profile.

The tagged packets include CAPWAP data packets (between access points and the controller) and packets sent toward the core network.

Note If a QoS profile has 802.1p tagging configured and if this QoS profile is assigned to a WLAN that uses an untagged interface on the controller, the client traffic will be blocked.

Step 12 Click **Apply** to commit your changes.

Step 13 Click **Save Configuration** to save your changes.

Step 14 Reenable the 802.11a and 802.11b/g networks.

To enable the radio networks, choose **Wireless > 802.11a/n** or **802.11b/g/n > Network**, select the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 15 Follow the instructions in the "Assigning a QoS Profile to a WLAN" section on page 7-37 to assign a QoS profile to a WLAN.

Using the CLI to Configure QoS Profiles

To configure the Platinum, Gold, Silver, and Bronze QoS profiles using the controller CLI, follow these steps:

Step 1 Disable the 802.11a and 802.11b/g networks so that you can configure the QoS profiles by entering these commands:

config 802.11a disable network

config 802.11b disable network

Step 2 Change the profile description by entering this command:

config qos description {**bronze | silver | gold | platinum**} *description*

Step 3 Define the average data rate in Kbps for TCP traffic per user by entering this command:

config qos average-data-rate {**bronze | silver | gold | platinum**} *rate*

Note For the *rate* parameter, you can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS profile.

Step 4 Define the peak data rate in Kbps for TCP traffic per user by entering this command:

config qos burst-data-rate {**bronze | silver | gold | platinum**} *rate*

Step 5 Define the average real-time rate in Kbps for UDP traffic per user by entering this command:

config qos average-realtime-rate {**bronze | silver | gold | platinum**} *rate*

Step 6 Define the peak real-time rate in Kbps for UDP traffic per user by entering this command:

config qos burst-realtime-rate {**bronze | silver | gold | platinum**} *rate*

Step 7 Specify the maximum percentage of RF usage per access point by entering this command:

config qos max-rf-usage {**bronze** | **silver** | **gold** | **platinum**} *usage_percentage*

Step 8 Define the maximum value (0–7) for the priority tag associated with packets that fall within the profile, by entering these commands:

config qos protocol-type {**bronze** | **silver** | **gold** | **platinum**} **dot1p**

config qos dot1p-tag {**bronze** | **silver** | **gold** | **platinum**} *tag*

The tagged packets include CAPWAP data packets (between access points and the controller) and packets sent toward the core network.

Note If a QoS profile has 802.1p tagging configured and if this QoS profile is assigned to a WLAN that uses an untagged interface on the controller, the client traffic will be blocked.

Step 9 Reenable the 802.11a and 802.11b/g networks so that you can configure the QoS profiles by entering these commands:

config 802.11a enable network

config 802.11b enable network

Step 10 Follow the instructions in the "Assigning a QoS Profile to a WLAN" section on page 7-37 to assign a QoS profile to a WLAN.

Configuring Quality of Service Roles

After you configure a QoS profile and apply it to a WLAN, it limits the bandwidth level of clients associated to that WLAN. Multiple WLANs can be mapped to the same QoS profile, which can result in bandwidth contention between regular users (such as employees) and guest users. In order to prevent guest users from using the same level of bandwidth as regular users, you can create QoS roles with different (and presumably lower) bandwidth contracts and assign them to guest users.

You can use the controller GUI or CLI to configure up to ten QoS roles for guest users.

Note If you choose to create an entry on the RADIUS server for a guest user and enable RADIUS authentication for the WLAN on which web authentication is performed rather than adding a guest user to the local user database from the controller, you need to assign the QoS role on the RADIUS server itself. To do so, a "guest-role" Airespace attribute needs to be added on the RADIUS server with a datatype of "string" and a return value of "11." This attribute is sent to the controller when authentication occurs. If a role with the name returned from the RADIUS server is found configured on the controller, the bandwidth associated to that role is enforced for the guest user after authentication completes successfully.

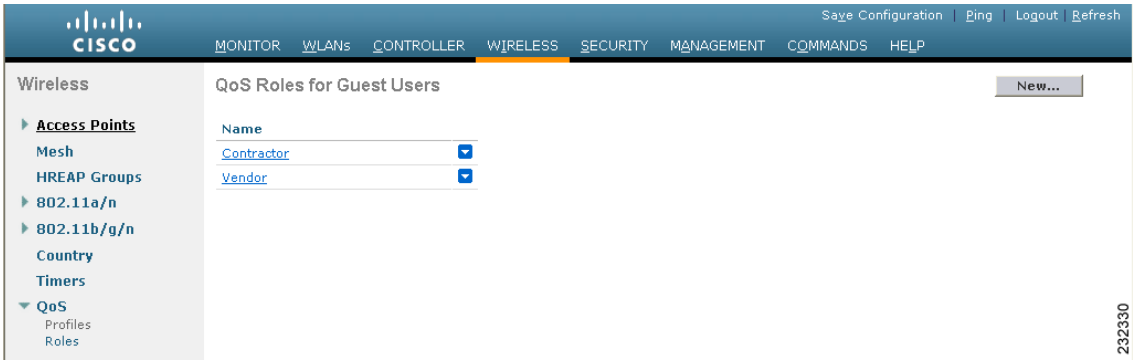
Using the GUI to Configure QoS Roles

To configure QoS roles using the controller GUI, follow these steps:

Note Guest User role is not supported on Cisco 2106 Controller.

Step 1 Choose **Wireless > QoS > Roles** to open the QoS Roles for Guest Users page (see Figure 4-29).

Figure 4-29 QoS Roles for Guest Users Page



This page shows any existing QoS roles for guest users.

Note If you want to delete a QoS role, hover your cursor over the blue drop-down arrow for that role and choose **Remove**.

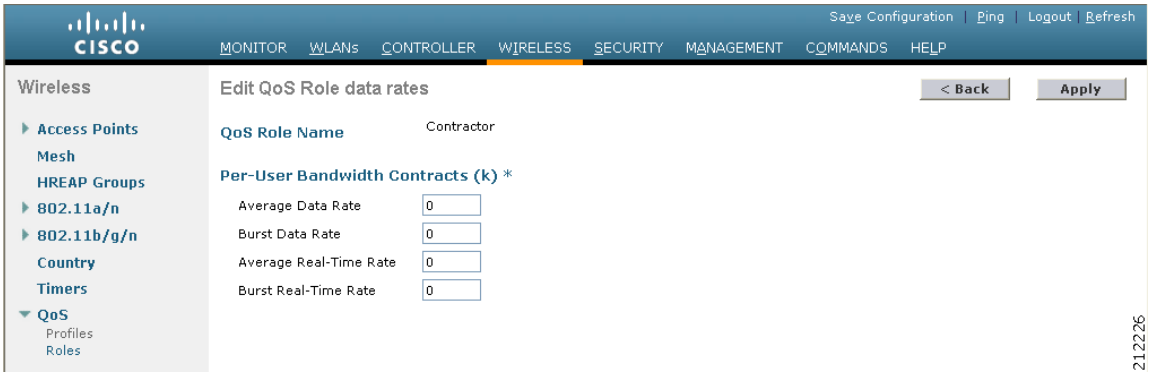
Step 2 Click **New** to create a new QoS role. The QoS Role Name > New page appears.

Step 3 In the Role Name text box, enter a name for the new QoS role. The name should uniquely identify the role of the QoS user (such as Contractor, Vendor, and so on).

Step 4 Click **Apply** to commit your changes.

Step 5 Click the name of the QoS role to edit the bandwidth of a QoS role. The Edit QoS Role Data Rates page appears (see Figure 4-30).

Figure 4-30 Edit QoS Role Data Rates Page



Note The values that you configure for the per-user bandwidth contracts affect only the amount of bandwidth going downstream (from the access point to the wireless client). They do not affect the bandwidth for upstream traffic (from the client to the access point).

Step 6 Define the average data rate for TCP traffic on a per-user basis by entering the rate in Kbps in the Average Data Rate text box. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Step 7 Define the peak data rate for TCP traffic on a per-user basis by entering the rate in Kbps in the Burst Data Rate text box. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Note The Burst Data Rate should be greater than or equal to the Average Data Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Step 8 Define the average real-time rate for UDP traffic on a per-user basis by entering the rate in Kbps in the Average Real-Time Rate text box. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Step 9 Define the peak real-time rate for UDP traffic on a per-user basis by entering the rate in Kbps in the Burst Real-Time Rate text box. You can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Note The Burst Real-Time Rate should be greater than or equal to the Average Real-Time Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Step 12 Apply a QoS role to a guest user, by following the steps in the "Using the GUI to Configure Local Network Users" section on page 6-32.

Using the CLI to Configure QoS Roles

To configure QoS roles using the controller CLI, follow these steps:

Step 1 Create a QoS role for a guest user by entering this command:

config netuser guest-role create *role_name*

Note If you want to delete a QoS role, enter this command:
config netuser guest-role delete *role_name*

Step 2 Configure the bandwidth contracts for a QoS role by entering these commands:

- **config netuser guest-role qos data-rate average-data-rate** *role_name rate*—Configures the average data rate for TCP traffic on a per-user basis.
- **config netuser guest-role qos data-rate burst-data-rate** *role_name rate*—Configures the peak data rate for TCP traffic on a per-user basis.

Note The Burst Data Rate should be greater than or equal to the Average Data Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

- **config netuser guest-role qos data-rate average-realtime-rate** *role_name rate*—Configures the average real-time rate for UDP traffic on a per-user basis.
- **config netuser guest-role qos data-rate burst-realtime-rate** *role_name rate*—Configures the peak real-time rate for UDP traffic on a per-user basis.

Note The Burst Real-Time Rate should be greater than or equal to the Average Real-Time Rate. Otherwise, the QoS policy may block traffic to and from the wireless client.

Note For the *role_name* parameter in each of these commands, enter a name for the new QoS role. The name should uniquely identify the role of the QoS user (such as Contractor, Vendor, and so on). For the *rate* parameter, you can enter a value between 0 and 60,000 Kbps (inclusive). A value of 0 imposes no bandwidth restriction on the QoS role.

Step 3 Apply a QoS role to a guest user by entering this command:

config netuser guest-role apply *username role_name*

For example, the role of *Contractor* could be applied to guest user *jsmith*.

Note If you do not assign a QoS role to a guest user, the Role text box in the User Details shows the role as "default." The bandwidth contracts for this user are defined in the QoS profile for the WLAN.

Note If you want to unassign a QoS role from a guest user, enter the **config netuser guest-role apply** *username* **default** command. This user now uses the bandwidth contracts defined in the QoS profile for the WLAN.

Step 4 Save your changes by entering this command:

save config

Step 5 See a list of the current QoS roles and their bandwidth parameters by entering this command:

show netuser guest-roles

Information similar to the following appears:

```
Role Name..................................... Contractor
     Average Data Rate........................ 10
     Burst Data Rate.......................... 10
     Average Realtime Rate.................... 100
     Burst Realtime Rate...................... 100

Role Name..................................... Vendor
     Average Data Rate........................ unconfigured
     Burst Data Rate.......................... unconfigured
     Average Realtime Rate.................... unconfigured
     Burst Realtime Rate..................... unconfigured
```

Configuring Voice and Video Parameters

Three parameters on the controller affect voice and/or video quality:

- Call admission control
- Expedited bandwidth requests
- Unscheduled automatic power save delivery

Each of these parameters is supported in Cisco Compatible Extensions (CCX) v4 and v5. See the "Configuring Access Point Groups" section on page 7-55 for more information on CCX.

Note CCX is not supported on the AP1030.

Traffic stream metrics (TSM) can be used to monitor and report issues with voice quality.

Call Admission Control

Call admission control (CAC) enables an access point to maintain controlled quality of service (QoS) when the wireless LAN is experiencing congestion. The Wi-Fi Multimedia (WMM) protocol deployed in CCXv3 ensures sufficient QoS as long as the wireless LAN is not congested. However, in order to maintain QoS under differing network loads, CAC in CCXv4 is required. Two types of CAC are available: bandwidth-based CAC and load-based CAC.

Bandwidth-Based CAC

Bandwidth-based, or static, CAC enables the client to specify how much bandwidth or shared medium time is required to accept a new call and in turn enables the access point to determine whether it is capable of accommodating this particular call. The access point rejects the call if necessary in order to maintain the maximum allowed number of calls with acceptable quality.

The QoS setting for a WLAN determines the level of bandwidth-based CAC support. To use bandwidth-based CAC with voice applications, the WLAN must be configured for Platinum QoS. To use bandwidth-based CAC with video applications, the WLAN must be configured for Gold QoS. Also, make sure that WMM is enabled for the WLAN. See the "Configuring 802.3 Bridging" section on page 4-55 for QoS and WMM configuration instructions.

Note You must enable admission control (ACM) for CCXv4 clients that have WMM enabled. Otherwise, bandwidth-based CAC does not operate properly.

Load-Based CAC

Load-based CAC incorporates a measurement scheme that takes into account the bandwidth consumed by all traffic types (including that from clients), co-channel access point loads, and collocated channel interference, for voice applications. Load-based CAC also covers the additional bandwidth consumption resulting from PHY and channel impairment.

In load-based CAC, the access point continuously measures and updates the utilization of the RF channel (that is, the percentage of bandwidth that has been exhausted), channel interference, and the additional calls that the access point can admit. The access point admits a new call only if the channel has enough unused bandwidth to support that call. By doing so, load-based CAC prevents oversubscription of the channel and maintains QoS under all conditions of WLAN loading and interference.

Note Load-based CAC is supported only on lightweight access points. If you disable load-based CAC, the access points start using bandwidth-based CAC.

Expedited Bandwidth Requests

The expedited bandwidth request feature enables CCXv5 clients to indicate the urgency of a WMM traffic specifications (TSPEC) request (for example, an e911 call) to the WLAN. When the controller receives this request, it attempts to facilitate the urgency of the call in any way possible without potentially altering the quality of other TSPEC calls that are in progress.

You can apply expedited bandwidth requests to both bandwidth-based and load-based CAC. Expedited bandwidth requests are disabled by default. When this feature is disabled, the controller ignores all expedited requests and processes TSPEC requests as normal TSPEC requests.

See Table 4-3 for examples of TSPEC request handling for normal TSPEC requests and expedited bandwidth requests.

Table 4-3 TSPEC Request Handling Examples

CAC Mode	Reserved bandwidth for voice calls[1]	Usage[2]	Normal TSPEC Request	TSPEC with Expedited Bandwidth Request
Bandwidth-based CAC	75% (default setting)	Less than 75%	Admitted	Admitted
		Between 75% and 90% (reserved bandwidth for voice calls exhausted)	Rejected	Admitted
		More than 90%	Rejected	Rejected
Load-based CAC		Less than 75%	Admitted	Admitted
		Between 75% and 85% (reserved bandwidth for voice calls exhausted)	Rejected	Admitted
		More than 85%	Rejected	Rejected

1. For bandwidth-based CAC, the voice call bandwidth usage is per access point and does not take into account co-channel access points. For load-based CAC, the voice call bandwidth usage is measured for the entire channel.
2. Bandwidth-based CAC (consumed voice and video bandwidth) or load-based CAC (channel utilization [Pb]).

Note Controller software release 6.0 or later releases support admission control for TSPEC g711-40ms codec type.

Note When video ACM is enabled, the controller rejects a video TSPEC if the non-MSDU size in the TSPEC is greater than 149 or the mean data rate is greater than 1 Kbps.

U-APSD

Unscheduled automatic power save delivery (U-APSD) is a QoS facility defined in IEEE 802.11e that extends the battery life of mobile clients. In addition to extending battery life, this feature reduces the latency of traffic flow delivered over the wireless media. Because U-APSD does not require the client to poll each individual packet buffered at the access point, it allows delivery of multiple downlink packets by sending a single uplink trigger packet. U-APSD is enabled automatically when WMM is enabled.

Traffic Stream Metrics

In a voice-over-wireless LAN (VoWLAN) deployment, traffic stream metrics (TSM) can be used to monitor voice-related metrics on the client-access point air interface. It reports both packet latency and packet loss. You can isolate poor voice quality issues by studying these reports.

The metrics consist of a collection of uplink (client side) and downlink (access point side) statistics between an access point and a client device that supports CCX v4 or later releases. If the client is not CCX v4 or CCXv5 compliant, only downlink statistics are captured. The client and access point measure these metrics. The access point also collects the measurements every 5 seconds, prepares 90-second reports, and then sends the reports to the controller. The controller organizes the uplink measurements on a client basis and the downlink measurements on an access point basis and maintains an hour's worth of historical data. To store this data, the controller requires 32 MB of additional memory for uplink metrics and 4.8 MB for downlink metrics.

TSM can be configured through either the GUI or the CLI on a per radio-band basis (for example, all 802.11a radios). The controller saves the configuration in flash memory so that it persists across reboots. After an access point receives the configuration from the controller, it enables TSM on the specified radio band.

Note Access points support TSM in both local and hybrid-REAP modes.

Table 4-4 shows the upper limit for TSM in different controller series.

Table 4-4 Upper Limit for TSM in controller series

TSM Entries	5500	4400	2100	7500
MAX AP TSM entries	100	40	10	100
MAX Client TSM entries	250	200	50	250
MAX TSM entries	100*250=25000	40*200=8000	10*50=500	100*250=25000

Note Once the upper limit is reached, additional TSM entries cannot be stored and sent to WCS. If client TSM entries are full and AP TSM entries are available, then only the AP entries are stored, and vice versa. This leads to partial output.

TSM cleanup occurs every one hour. Entries are removed only for those APs and clients that are not in the system.

Using the GUI to Configure Voice Parameters

To configure voice parameters using the controller GUI, follow these steps:

Note SIPs are available only on the Cisco 4400 Series and Cisco 5500 Series Controllers, and on the 1240, 1130, and 11n access points.

Note SIP CAC should only be used for phones that support status code 17 and do not support TSPEC-based admission control.

Note SIP CAC will be supported only if SIP snooping is enabled.

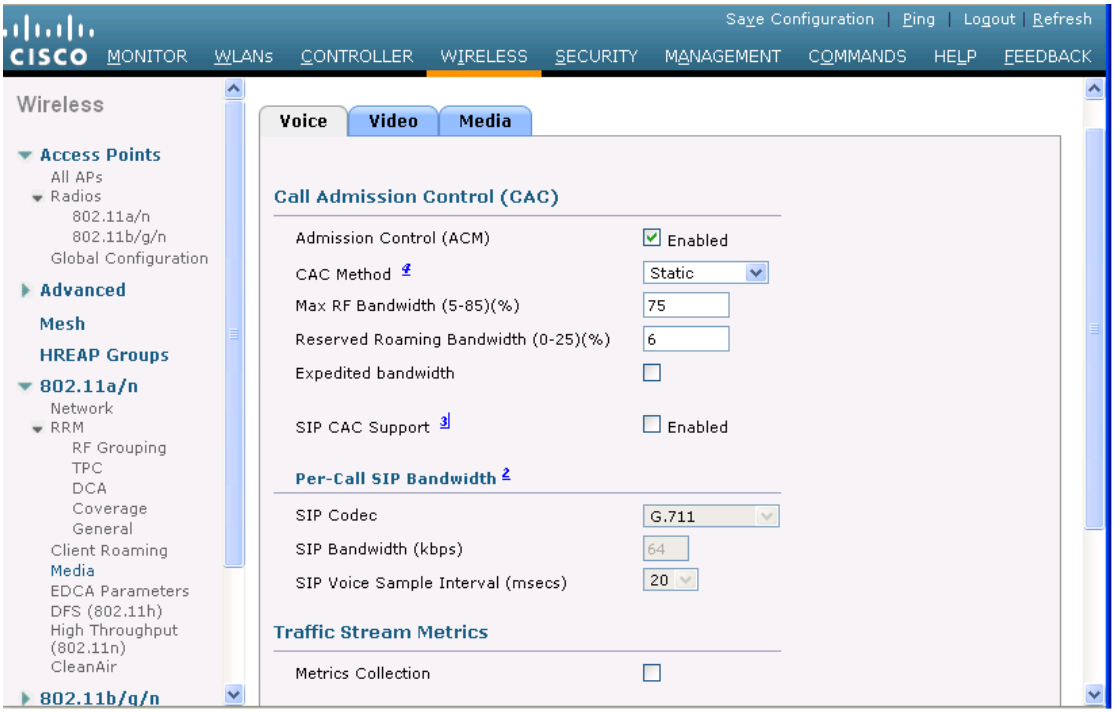
Step 1 Make sure that the WLAN is configured for WMM and the Platinum QoS level.

Step 2 Disable all WLANs with WMM enabled and click **Apply**.

Step 3 Choose **Wireless** and then **Network** under 802.11a/n or 802.11b/g/n, unselect the 802.11a (or 802.11b/g) Network Status check box, and click **Apply** to disable the radio network.

Step 4 Choose **Wireless > 802.11a/n or 802.11b/g/n > Media**. The 802.11a (or 802.11b) > Media page appears (see Figure 4-31). The Voice tab is displayed by default.

Figure 4-31 802.11a/n > Voice Parameters Page



Step 5 Select the **Admission Control (ACM)** check box to enable bandwidth-based CAC for this radio band. The default value is disabled.

Step 6 Select the **Admission Control (ACM)** you want to use by choosing from the following choices:

- **Load-based**—To enable channel-based CAC. This is the default option.
- **Static—**To enable radio-based CAC.

Step 7 In the Max RF Bandwidth text box, enter the percentage of the maximum bandwidth allocated to clients for voice applications on this radio band. Once the client reaches the value specified, the access point rejects new calls on this radio band.

The range is 5 to 85%. The sum of max bandwidth% of voice and video should not exceed 85%.

The default is 75%.

Step 8 In the Reserved Roaming Bandwidth text box, enter the percentage of maximum allocated bandwidth that is reserved for roaming voice clients. The controller reserves this bandwidth from the maximum allocated bandwidth for roaming voice clients.

The range is 0 to 25%.

The default is 6%.

Step 9 To enable expedited bandwidth requests, select the **Expedited Bandwidth** check box. By default, this text box is disabled.

Step 10 To enable SIP CAC support, select the **SIP CAC Support** check box. By default, SIP CAC this check box is disabled.

Step 11 From the SIP Codec drop-down list, choose one of the following options to set the codec name. The default value is G.711. The options are as follows:

- User Defined
- G.711
- G.729

Step 12 In the SIP Bandwidth (kbps) text box, enter the bandwidth in kilo bits per second.

The possible range is 8 to 64.

The default value is 64.

Note The SIP Bandwidth (kbps) text box is highlighted only when you select the SIP codec as User-Defined. If you choose the SIP codec as G.711, the SIP Bandwidth (kbps) text box is set to 64. If you choose the SIP codec as G.729, the SIP Bandwidth (kbps) text box is set to 8.

Step 13 In the SIP Voice Sample Interval (msecs) text box, enter the value for the sample interval.

Step 14 In the Maximum Calls text box, enter the maximum number of calls that can be made to this radio. The maximum call limit includes both direct and roaming-in calls. If the maximum call limit is reached, new or roaming-in calls will fail.

The possible range is 0 to 25.

The default value is 0, which indicates that there is no check for maximum call limit.

Note If SIP CAC is supported and the CAC method is static, the Maximum Possible Voice Calls and Maximum Possible Roaming Reserved Calls fields appear.

Step 15 Select the **Metrics Collection** check box to collect Traffic Stream Metrics. By default, this box is unselected. That is, the traffic stream metrics is not collected by default.

Step 16 Click **Apply** to commit your changes.

Step 17 Reenable all WMM WLANs and click **Apply**.

Step 18 Choose **Network** under 802.11a/n or 802.11b/g/n, select the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply** to reenable the radio network.

Step 19 Click **Save Configuration** to save your changes.

Step 20 Repeat this procedure if you want to configure voice parameters for another radio band (802.11a or 802.11b/g).

Using the GUI to Configure Video Parameters

To configure video parameters using the controller GUI, follow these steps:

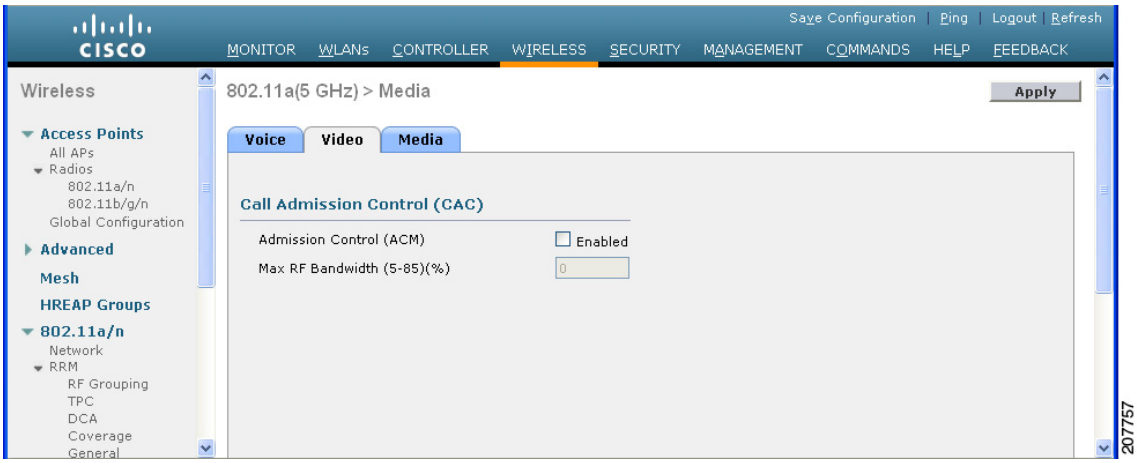
Step 1 Make sure that the WLAN is configured for WMM and the Gold QoS level.

Step 2 Disable all WLANs with WMM enabled and click **Apply**.

Step 3 Choose **Wireless** and then **Network** under 802.11a/n or 802.11b/g/n, unselect the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply** to disable the radio network.

Step 4 Choose **Wireless** > **802.11a/n or 802.11b/g/n** > **Media**. The 802.11a (or 802.11b) > Media page appears (see Figure 4-32).

Figure 4-32 802.11a > Video Parameters Page



Step 5 Choose the **Video** tab to configure the CAC for Video parameters.

Step 6 Select the **Admission Control (ACM)** check box to enable video CAC for this radio band. The default value is disabled.

Step 7 In the Max RF Bandwidth text box, enter the percentage of the maximum bandwidth allocated to clients for video applications on this radio band. Once the client reaches the value specified, the access point rejects new requests on this radio band.

The range is 5 to 85%. The sum of maximum bandwidth% of voice and video should not exceed 85%.

The default is 0%.

Step 8 Click **Apply** to commit your changes.

Step 9 Reenable all WMM WLANs and click **Apply**.

Step 10 Choose **Network** under 802.11a/n or 802.11b/g/n, select the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply** to reenable the radio network.

Step 11 Click **Save Configuration** to save your changes.

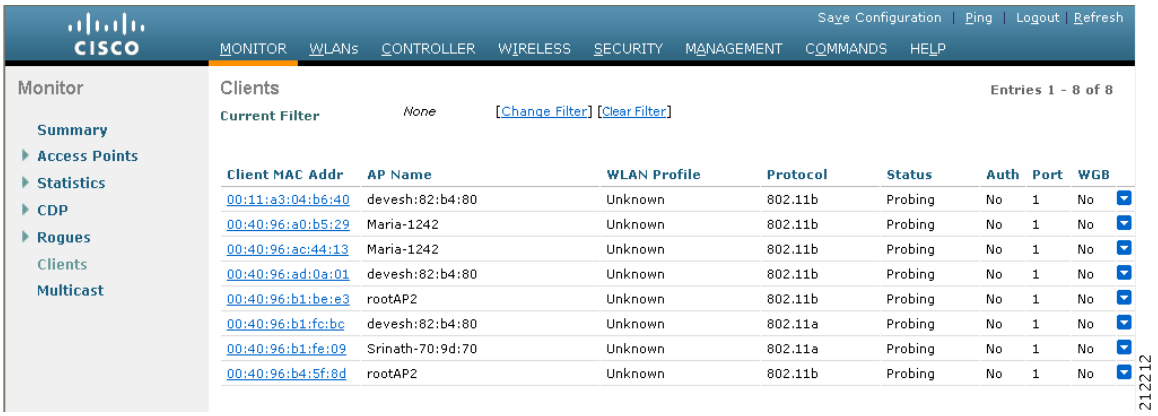
Step 12 Repeat this procedure if you want to configure video parameters for another radio band (802.11a or 802.11b/g).

Using the GUI to View Voice and Video Settings

To view voice and video settings using the controller GUI, follow these steps:

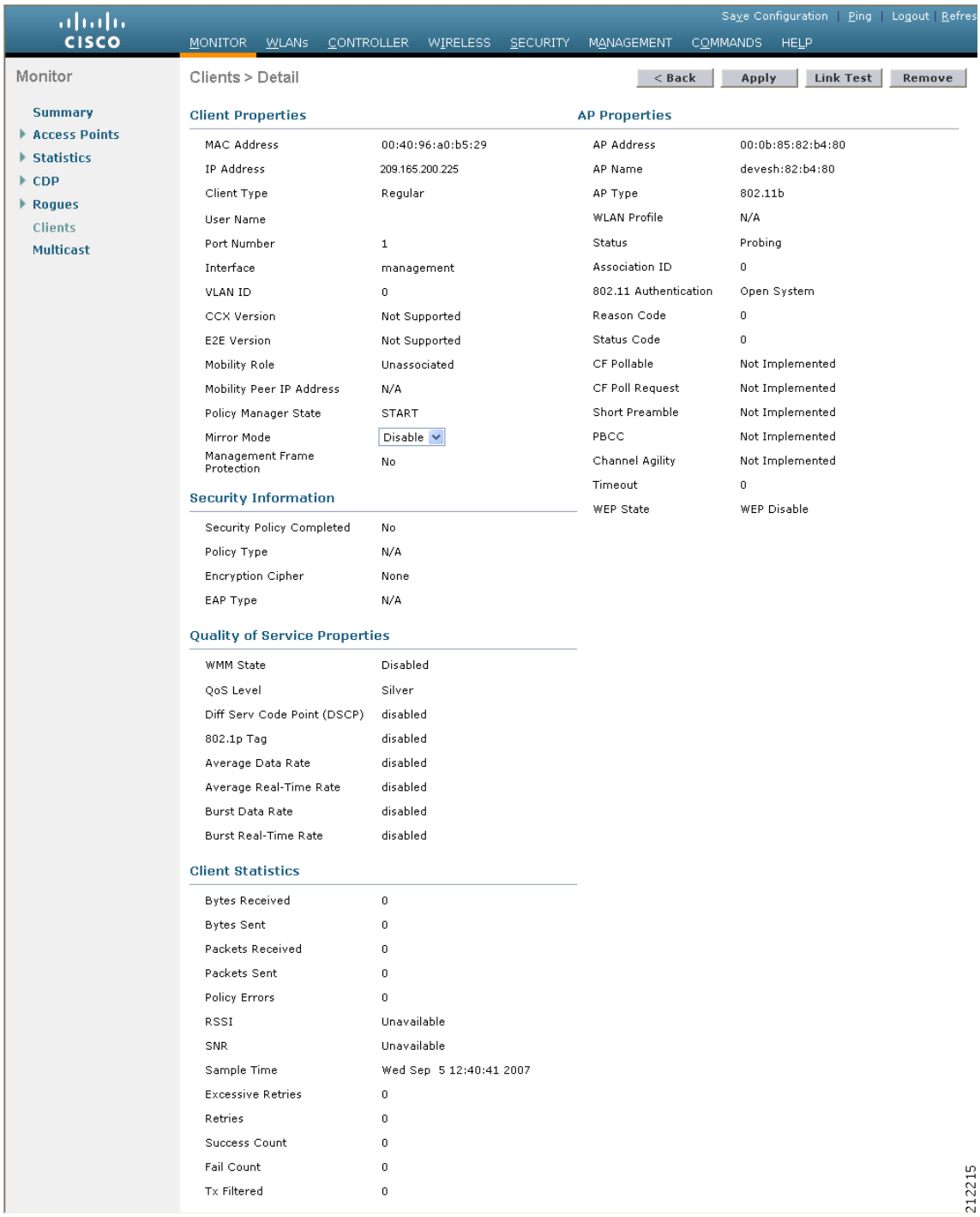
Step 1 Choose **Monitor > Clients** to open the Clients page (see Figure 4-33).

Figure 4-33 Clients Page



Step 2 Click the MAC address of the desired client to open the Clients > Detail page (see Figure 4-34).

Figure 4-34 Clients > Detail Page



This page shows the U-APSD status (if enabled) for this client under Quality of Service Properties.

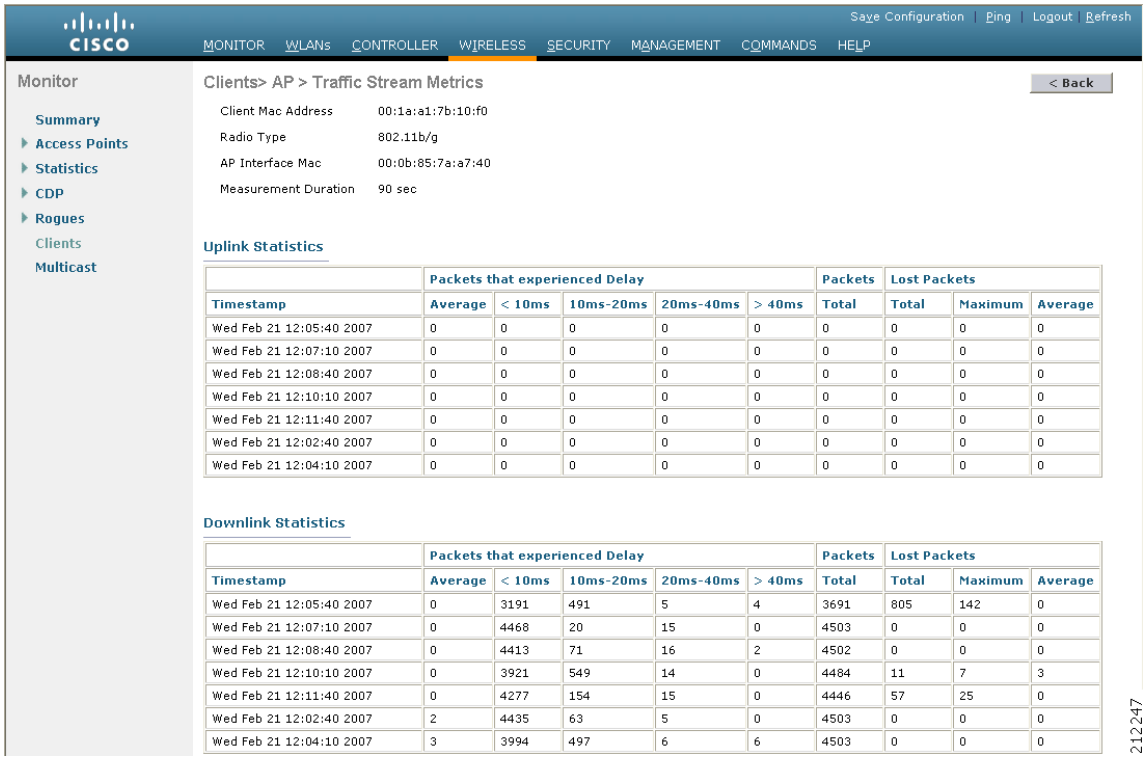
Step 3 Click **Back** to return to the Clients page.

Step 4 See the TSM statistics for a particular client and the access point to which this client is associated as follows:

a. Hover your cursor over the blue drop-down arrow for the desired client and choose **802.11aTSM** or **802.11b/g TSM**. The Clients > AP page appears.

b. Click the **Detail** link for the desired access point to open the Clients > AP > Traffic Stream Metrics page (see Figure 4-35).

Figure 4-35 Clients > AP > Traffic Stream Metrics Page

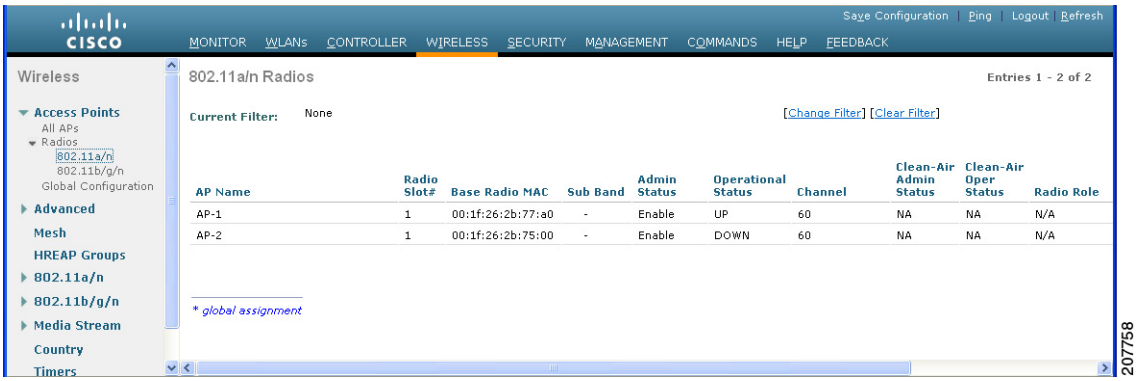


This page shows the TSM statistics for this client and the access point to which it is associated. The statistics are shown in 90-second intervals. The timestamp text box shows the specific interval when the statistics were collected.

Step 5 See the TSM statistics for a particular access point and a particular client associated to this access point, as follows:

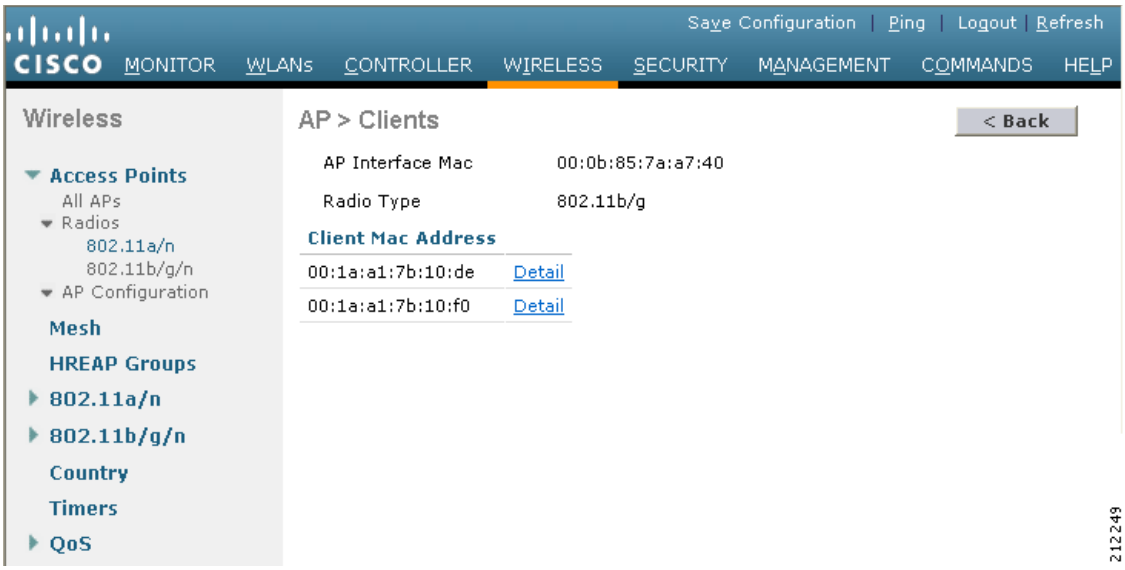
a. Choose **Wireless > Access Points > Radios > 802.11a/n** or **802.11b/g/n**. The 802.11a/n Radios or 802.11b/g/n Radios page appears (see Figure 4-36).

Figure 4-36 802.11a/n Radios Page



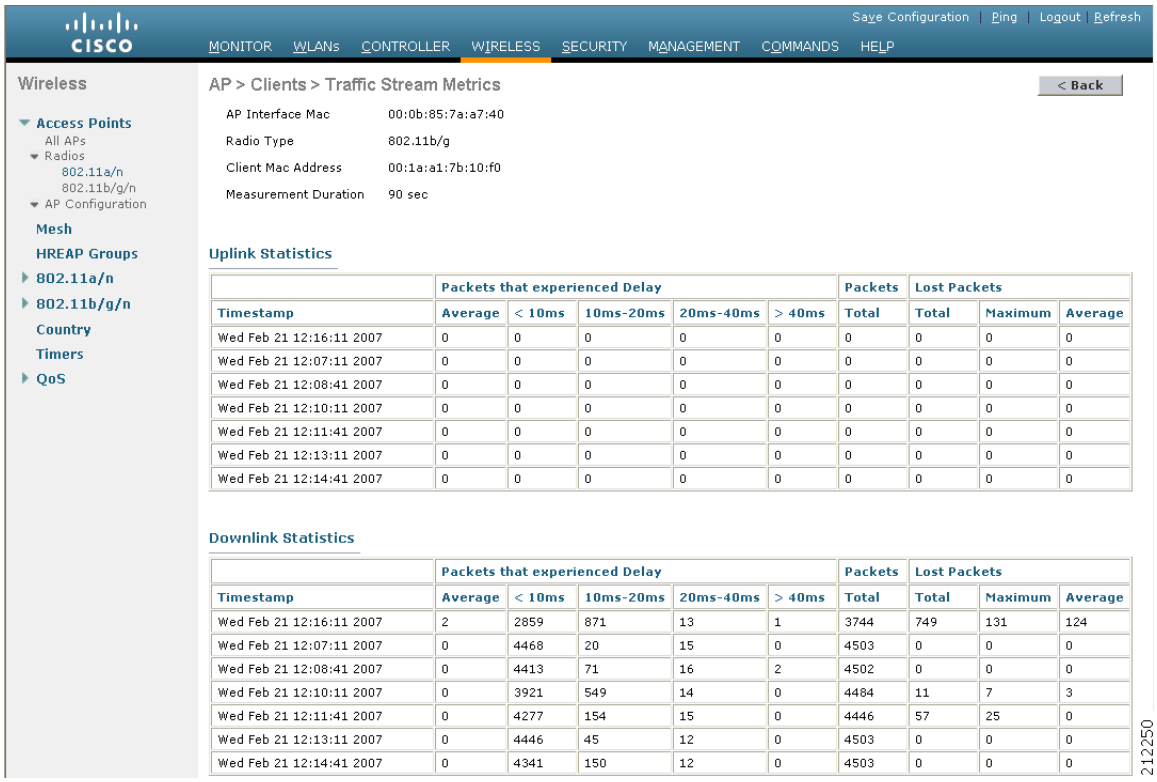
b. Hover your cursor over the blue drop-down arrow for the desired access point and choose **802.11aTSM** or **802.11b/g TSM**. The AP > Clients page appears (see Figure 4-37).

Figure 4-37 AP > Clients Page



c. Click the **Detail** link for the desired client to open the AP > Clients > Traffic Stream Metrics page (see Figure 4-38).

Figure 4-38 AP > Clients > Traffic Stream Metrics Page



This page shows the TSM statistics for this access point and a client associated to it. The statistics are shown in 90-second intervals. The timestamp text box shows the specific interval when the statistics were collected.

Using the GUI to Configure Media Parameters

To configure Media parameters using the controller GUI, follow these steps:

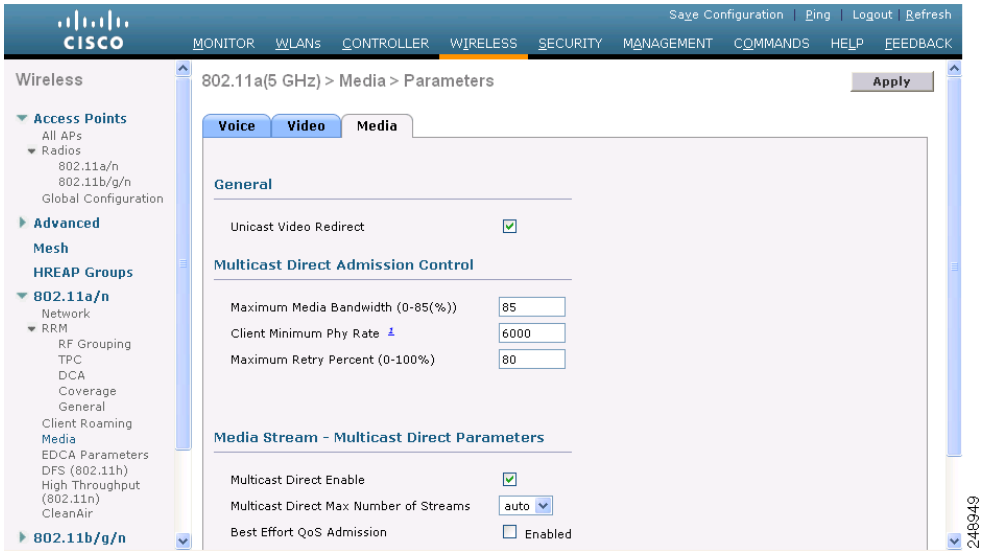
Step 1 Make sure that the WLAN is configured for WMM and the Gold QoS level.

Step 2 Disable all WLANs with WMM enabled and click **Apply**.

Step 3 Choose **Wireless** and then **Network** under 802.11a/n or 802.11b/g/n, unselect the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply** to disable the radio network.

Step 4 Choose **Wireless > 802.11a/n or 802.11b/g/n > Media**. The 802.11a (or 802.11b) > Media > Parameters page appears (see Figure 4-39).

Figure 4-39 802.11a > Media Parameters Page



Step 5 Choose the **Media** tab to open the Media page.

Step 6 Select the **Unicast Video Redirect** check box to enable Unicast Video Redirect. The default value is disabled.

Step 7 In the Maximum Media Bandwidth (0-85%) text box, enter the percentage of the maximum bandwidth to be allocated for media applications on this radio band. Once the client reaches the specified value, the access point rejects new calls on this radio band.

The default value is 85%; valid values are from 0 to 85%.

Step 8 In the Client Phy Rate text box, enter the value for the rate in kilobits per second at which the client operates.

Step 9 In the Maximum Retry Percent (0-100%) text box, enter the percentage of the maximum retry. The default value is 80.

Step 10 Select the **Multicast Direct Enable** check box to enable the Multicast Direct Enable text box. The default value is enabled.

Step 11 From the Multicast Direct Max Number of Streams drop-down list, choose the maximum number of allowed multicast direct streams per radio. The range is 0 to 20 and auto. The default value is set to auto.

Step 12 If you want to enable the best radio queue for this radio, select the **Best Effort QoS Admission** check box. The default value is disabled.

Using the CLI to Configure SIP Based CAC

To configure the SIP based CAC using the controller CLI, follow these steps:

Step 1 Set the voice to the platinum QoS level by entering this command:

config wlan qos *wlan-id* **Platinum**

Step 2 Enable the call-snooping feature for a particular WLAN by entering this command:

config wlan call-snoop enable *wlan-id*

Step 3 Enable the ACM to this radio by entering this command:

config {**802.11a** | **802.11b**} **cac** {**voice** | **video**} **acm enable**

Using the CLI to Configure Voice Parameters

Note Make sure that you perform the "Using the CLI to Configure SIP Based CAC" procedure on page 4-86 before you do this procedure.

To configure voice parameters using the controller CLI, follow these steps:

Step 1 See all of the WLANs configured on the controller by entering this command:

show wlan summary

Step 2 Make sure that the WLAN that you are planning to modify is configured for WMM and the QoS level is set to Platinum by entering this command:

show wlan *wlan_id*

Step 3 Disable all WLANs with WMM enabled prior to changing the voice parameters by entering command:

config wlan disable *wlan_id*

Step 4 Disable the radio network by entering this command:

config {**802.11a** | **802.11b**} **disable network**

Step 5 Save your settings by entering this command:

save config

Step 6 Enable or disable bandwidth-based voice CAC for the 802.11a or 802.11b/g network by entering this command:

config {**802.11a** | **802.11b**} **cac voice acm** {**enable** | **disable**}

Step 7 Set the percentage of maximum bandwidth allocated to clients for voice applications on the 802.11a or 802.11b/g network by entering this command:

config {**802.11a** | **802.11b**} **cac voice max-bandwidth** *bandwidth*

The *bandwidth* range is 5 to 85%, and the default value is 75%. Once the client reaches the value specified, the access point rejects new calls on this network.

Step 8 Set the percentage of maximum allocated bandwidth reserved for roaming voice clients by entering this command:

config {**802.11a** | **802.11b**} **cac voice roam-bandwidth** *bandwidth*

The *bandwidth* range is 0 to 25%, and the default value is 6%. The controller reserves this much bandwidth from the maximum allocated bandwidth for roaming voice clients.

Step 9 Configure the codec name and sample interval as parameters and to calculate the required bandwidth per call by entering this command:

config {802.11a | 802.11b} cac voice sip codec {g711 | g729} sample-interval *number_msecs*

Step 10 Configure the bandwidth that is required per call by entering this command:

config {802.11a | 802.11b} cac voice sip bandwidth *bandwidth_kbps* **sample-interval** *number_msecs*

Step 11 Reenable all WLANs with WMM enabled by entering this command:

config wlan enable *wlan_id*

Step 12 Reenable the radio network by entering this command:

config {**802.11a** | **802.11b**} **enable network**

Step 13 To view the TSM voice metrics, by entering this command:

show [802.11a | 802.11b] cu-metrics *AP_Name*

The command also displays the channel utilization metrics.

Step 14 Save your changes by entering this command:

save config

Using the CLI to Configure Video Parameters

Note Make sure that the"Using the CLI to Configure SIP Based CAC" procedure on page 4-86 are met.

To configure video parameters using the controller CLI, follow these steps:

Step 1 See all of the WLANs configured on the controller by entering this command:

show wlan summary

Step 2 Make sure that the WLAN that you are planning to modify is configured for WMM and the QoS level is set to Gold by entering this command:

show wlan *wlan_id*

Step 3 Disable all WLANs with WMM enabled prior to changing the video parameters by entering this command:

config wlan disable *wlan_id*

Step 4 Disable the radio network by entering this command:

config {**802.11a** | **802.11b**} **disable network**

Step 5 Save your settings by entering this command:

save config

Step 6 Enable or disable video CAC for the 802.11a or 802.11b/g network by entering this command:

config {**802.11a** | **802.11b**} **cac video acm** {**enable** | **disable**}

Step 7 Set the percentage of maximum bandwidth allocated to clients for video applications on the 802.11a or 802.11b/g network by entering this command:

config {**802.11a** | **802.11b**} **cac video max-bandwidth** *bandwidth*

The *bandwidth* range is 5 to 85%, and the default value is 5%. However, the maximum RF bandwidth cannot exceed 85% for voice and video. Once the client reaches the value specified, the access point rejects new calls on this network.

Note If this parameter is set to zero (0), the controller assumes that you do not want to do any bandwidth allocation and, therefore, allows all bandwidth requests.

Step 8 Process or ignore the TSPEC inactivity timeout received from an access point by entering this command:

config {**802.11a** | **802.11b**} **cac video tspec-inactivity-timeout** {**enable** | **ignore**}

Step 9 Reenable all WLANs with WMM enabled by entering this command:

config wlan enable *wlan_id*

Step 10 Reenable the radio network by entering this command:

config {**802.11a** | **802.11b**} **enable network**

Step 11 Save your settings by entering this command:

save config

Using the CLI to View Voice and Video Settings

To view voice and video settings using the controller CLI, follow these steps:

Step 1 See the CAC configuration for the 802.11a or 802.11b/g network by entering this command:

show ap stats {802.11a | 802.11b}

Step 2 See the CAC statistics for a particular access point by entering this command:

show ap stats {802.11a | 802.11b} *ap_name*

Information similar to the following appears:

```
Call Admission Control (CAC) Stats
  Voice Bandwidth in use(% of config bw)..... 0
Total channel MT free..................... 0
Total voice MT free....................... 0
Na Direct................................. 0
Na Roam................................... 0
  Video Bandwidth in use(% of config bw)..... 0
  Total num of voice calls in progress...... 0
  Num of roaming voice calls in progress..... 0
  Total Num of voice calls since AP joined..... 0
  Total Num of roaming calls since AP joined..... 0
    Total Num of exp bw requests received.......... 5
  Total Num of exp bw requests admitted.......... 2

Num of voice calls rejected since AP joined..... 0
  Num of roam calls rejected since AP joined..... 0
  Num of calls rejected due to insufficient bw....0
  Num of calls rejected due to invalid params.... 0
  Num of calls rejected due to PHY rate.......... 0
  Num of calls rejected due to QoS policy..... 0
```

In the example above, “MT” is medium time, “Na” is the number of additional calls, and “exp bw” is expedited bandwidth.

Note Suppose an AP has to be rebooted when a voice client associated with the AP is on an active call. After the AP is rebooted, the client continues to maintain the call, and during the time the AP is down, the database is not refreshed by the controller. Therefore, we recommend that all active calls are ended before the AP is taken down.

Step 3 See the U-APSD status for a particular client by entering this command:

show client detail *client_mac*

Step 4 See the TSM statistics for a particular client and the access point to which this client is associated by entering this command:

show client tsm {**802.11a** | **802.11b**} *client_mac* {*ap_mac* | **all**}

The optional **all** command shows all access points to which this client has associated. Information similar to the following appears:

```
Client Interface Mac:                00:01:02:03:04:05
Measurement Duration:                90 seconds

  Timestamp                            1st Jan 2006, 06:35:80
    UpLink Stats
    ================
       Average Delay (5sec intervals).....................35
       Delay less than 10 ms..............................20
       Delay bet 10 - 20 ms...............................20
       Delay bet 20 - 40 ms...............................20
       Delay greater than 40 ms...........................20
      Total packet Count..................................80
      Total packet lost count (5sec).....................10
      Maximum Lost Packet count(5sec).....................5
      Average Lost Packet count(5secs)....................2
    DownLink Stats
    ================
       Average Delay (5sec intervals).....................35
       Delay less than 10 ms..............................20
       Delay bet 10 - 20 ms...............................20
       Delay bet 20 - 40 ms...............................20
       Delay greater than 40 ms...........................20
      Total packet Count..................................80
      Total packet lost count (5sec).....................10
      Maximum Lost Packet count(5sec).....................5
      Average Lost Packet count(5secs)....................2
```

Note The statistics are shown in 90-second intervals. The timestamp text box shows the specific interval when the statistics were collected.

Note To clear the TSM statistics for a particular access point or all the access points to which this client is associated, enter the **clear client tsm** {**802.11a** | **802.11b**} *client_mac* {*ap_mac* | **all**} command.

Step 5 See the TSM statistics for a particular access point and a particular client associated to this access point by entering this command:

show ap stats {**802.11a** | **802.11b**} *ap_name* **tsm** {*client_mac* | **all**}

The optional **all** command shows all clients associated to this access point. Information similar to the following appears:

```
AP Interface Mac:                   00:0b:85:01:02:03
Client Interface Mac:               00:01:02:03:04:05
Measurement Duration:               90 seconds

  Timestamp                           1st Jan 2006, 06:35:80
    UpLink Stats
    ================
       Average Delay (5sec intervals).............................35
       Delay less than 10 ms......................................20
       Delay bet 10 - 20 ms.......................................20
       Delay bet 20 - 40 ms.......................................20
       Delay greater than 40 ms...................................20
      Total packet Count..........................................80
      Total packet lost count (5sec)..............................10
      Maximum Lost Packet count(5sec).............................5
      Average Lost Packet count(5secs)............................2
    DownLink Stats
    ================
       Average Delay (5sec intervals).............................35
       Delay less than 10 ms......................................20
       Delay bet 10 - 20 ms.......................................20
       Delay bet 20 - 40 ms.......................................20
       Delay greater than 40 ms...................................20
      Total packet Count..........................................80
      Total packet lost count (5sec)..............................10
      Maximum Lost Packet count(5sec).............................5
      Average Lost Packet count(5secs)............................2
```

Note The statistics are shown in 90-second intervals. The timestamp text box shows the specific interval when the statistics were collected.

Step 6 Enable or disable debugging for call admission control (CAC) messages, events, or packets by entering this command:

debug cac {**all** | **event** | **packet**}{**enable** | **disable**}

where **all** configures debugging for all CAC messages, **event** configures debugging for all CAC events, and **packet** configures debugging for all CAC packets.

Step 7 Use the following command to perform voice diagnostics and to view the debug messages between a maximum of two 802.11 clients:

debug client voice-diag {enable | disable} *mac-id mac-id2* **[verbose]**

The verbose mode is an optional argument. When the verbose option is used, all debug messages are displayed in the console. You can use this command to monitor a maximum of two 802.11 clients. If one of the clients is a non-WiFi client, only the 802.11 client is monitored for debug messages.

Note It is implicitly assumed that the clients being monitored are on call.

Note The debug command automatically stops after 60 minutes.

Step 8 Use the following commands to view various voice-related parameters:

- **show client voice-diag status**

  Displays information about whether voice diagnostics is enabled or disabled. If enabled, will also displays information about the clients in the watch list and the time remaining for the diagnostics of the voice call.

If voice diagnostics is disabled when the following commands are invoked, a message indicating that voice diagnostics is disabled appears.

- **show client voice-diag tspec**

  Displays the TSPEC information sent from the clients that are enabled for voice diagnostics.

- **show client voice-diag qos-map**

  Displays information about the QoS/DSCP mapping and packet statistics in each of the four queues: VO, VI, BE, BK. The different DSCP values are also displayed.

- **show client voice-diag avrg_rssi**

  Display the client's RSSI values in the last 5 seconds when voice diagnostics is enabled.

- **show client voice-diag roam-history**

  Displays information about the last three roaming calls. The output contains the timestamp, access point associated with roaming, roaming reason, and if there is a roaming failure, reason for roaming-failure.

- **show client calls {active | rejected} {802.11a | 802.11bg | all}**

  This command lists the details of active TSPEC and SIP calls on the controller.

Step 9 Use the following commands to troubleshoot video debug messages and statistics:

- **debug ap show stats {802.11b | 802.11a}** *ap-name* multicast—Displays the access point's supported multicast rates.
- **debug ap show stats {802.11b | 802.11a}** *ap-name* load—Displays the access point's QBSS and other statistics.
- **debug ap show stats {802.11b | 802.11a}** *ap-name* tx-queue—Displays the access point's transmit queue traffic statistics.
- **debug ap show stats {802.11b | 802.11a}** *ap-name* client {all | video | <client-mac>}—Displays the access point's client metrics.
- **debug ap show stats {802.11b | 802.11a}** *ap-name* packet—Displays the access point's packet statistics.
- **debug ap show stats {802.11b | 802.11a}** *ap-name* video metrics—Displays the access point's video metrics.
- **debug ap show stats video** *ap-name* **multicast mgid** *number* —Displays an access point's Layer 2 MGID database number.
- **debug ap show stats video** *ap-name* **admission**—Displays an access point's admission control statistics.
- **debug ap show stats video** *ap-name* **bandwidth**—Displays an access point's video bandwidth.

Configuring Voice Prioritization Using Preferred Call Numbers

You can configure a controller to support calls from clients that do not support TSPEC-based calls. This feature is known as voice prioritization. These calls are given priority over other clients utilizing the voice pool. Voice prioritization is available only for SIP-based calls and not for TSPEC-based calls. If the bandwidth is available, it takes the normal flow and allocates the bandwidth to those calls.

You can configure up to six preferred call numbers. When a call comes to one of the configured preferred numbers, the controller does not check on the maximum call limit. It invokes the CAC to allocate bandwidth for the preferred call. The bandwidth allocation is 85 percent of the entire bandwidth pool, not just from the maximum configured voice pool. The bandwidth allocation is the same even for roaming calls.

You must configure the following before configuring voice prioritization:

- Set WLAN QoS to platinum.
- Enable ACM for the radio.
- Enable SIP call snoopint on the WLAN.

Note Cisco 4400, 5500, and 2106 Series Controllers and all nonmesh access points do not support voice prioritization.

This section cotains the followig topics:

Using the GUI to Configure a Preferred Call Number

To configure voice prioritization using the controller GUI, follow these steps:

Step 1 Set the WLAN QoS profile to Platinum. See the "Using the GUI to Assign a QoS Profile to a WLAN" section on page 7-38.

Step 2 Enable ACM for the WLAN radio. See the "Using the GUI to Configure Voice Parameters" section on page 4-78.

Step 3 Enable SIP call snooping for the WLAN. See the "Using the GUI to Configure Media Session Snooping" section on page 7-43.

Step 4 Choose **Wireless > Advanced > Preferred Call** to open the Preferred Call page.

All calls configured on the controller appear.

Note To remove a preferred call, hover your cursor over the blue drop-down arrow and choose **Remove**.

Step 5 Click **Add Number** to add a new preferred call.

Step 6 In the Call Index text box, enter the index that you want to assign to the call. Valid values are from 1 through 6.

Step 7 In the Call Number text box, enter the number.

Step 8 Click **Apply** to add the new number.

Using the CLI to Configure a Preferred Call Number

To configure voice prioritization using the controller CLI, follow these steps:

Step 1 Set the voice to the platinum QoS level by entering this command:

config wlan qos wlan-id Platinum

Step 2 Enable the ACM to this radio by entering this command:

config {802.11a | 802.11b} cac {voice | video} acm enable

Step 3 Enable the call-snooping feature for a particular WLAN by entering this command:

config wlan call-snoop enable *wlan-id*

Step 4 Add a new preferred call by entering this command:

config advanced sip-preferred-call-no *call_index* {*call_number* | none}

Step 5 Remove a preferred call by entering this command:

config advanced sip-preferred-call-no *call_index* none

Step 6 View the preferred call statistics by entering the following command:

show ap stats {802.11{a | b} | wlan} *ap_name*

Step 7 Enter the following command to list the preferred call numbers:

show advanced sip-preferred-call-no

Configuring EDCA Parameters

Enhanced distributed channel access (EDCA) parameters are designed to provide preferential wireless channel access for voice, video, and other quality-of-service (QoS) traffic. Follow the instructions in this section to configure EDCA parameters using the controller GUI or CLI.

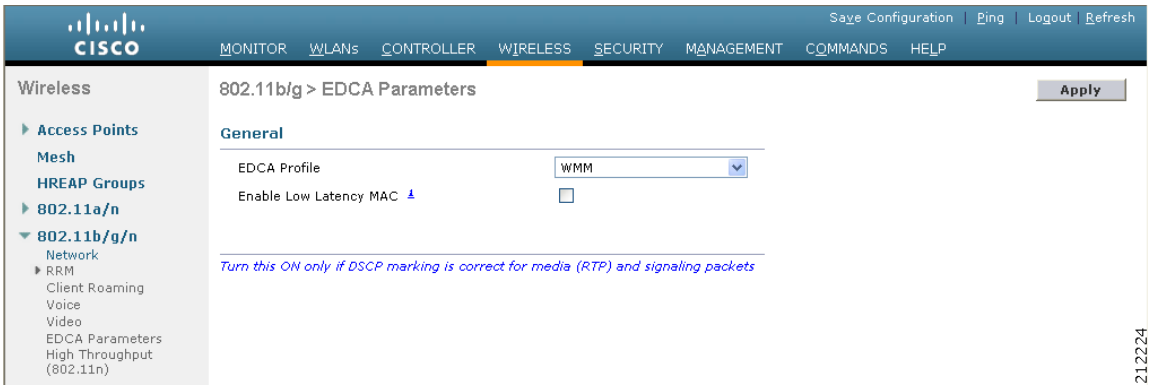
Using the GUI to Configure EDCA Parameters

To configure EDCA parameters using the controller GUI, follow these steps:

Step 1 Choose **Wireless** and then **Network** under 802.11a/n or 802.11b/g/n, unselect the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply** to disable the radio network.

Step 2 Choose **EDCA Parameters** under 802.11a/n or 802.11b/g/n. The 802.11a (or 802.11b/g) > EDCA Parameters page appears (see Figure 4-40).

Figure 4-40 802.11a > EDCA Parameters Page



Step 3 Choose one of the following options from the EDCA Profile drop-down list:

- **WMM**—Enables the Wi-Fi Multimedia (WMM) default parameters. This is the default value. Choose this option when voice or video services are not deployed on your network.
- **Spectralink Voice Priority**—Enables SpectraLink voice priority parameters. Choose this option if SpectraLink phones are deployed on your network to improve the quality of calls.
- **Voice Optimized**—Enables EDCA voice-optimized profile parameters. Choose this option when voice services other than SpectraLink are deployed on your network.
- **Voice & Video Optimized**—Enables EDCA voice- and video-optimized profile parameters. Choose this option when both voice and video services are deployed on your network.

Note If you deploy video services, admission control (ACM) must be disabled.

Step 4 If you want to enable MAC optimization for voice, select the **Enable Low Latency MAC** check box. Otherwise, leave this check box unselected, which is the default value. This feature enhances voice performance by controlling packet retransmits and appropriately aging out voice packets on lightweight access points, which improves the number of voice calls serviced per access point.

Note We do not recommend you to enable low latency MAC. You should enable low latency MAC only if the WLAN allows WMM clients. If WMM is enabled, then low latency MAC can be used with any of the EDCA profiles. See the "Configuring QoS Enhanced BSS" section on page 7-39 for instructions on enabling WMM.

Step 5 Click **Apply** to commit your changes.

Step 6 To reenable the radio network, choose **Network** under 802.11a/n or 802.11b/g/n, select the **802.11a** (or **802.11b/g**) **Network Status** check box, and click **Apply**.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure EDCA Parameters

To configure EDCA parameters using the controller CLI, follow these steps:

Step 1 Disable the radio network by entering this command:

config {802.11a | 802.11b} disable network

Step 2 Save your settings by entering this command:

save config

Step 3 Enable a specific EDCA profile by entering this command:

config advanced {802.11a | 802.11b} edca-parameters *?*

where *?* is one of the following:

- **wmm-default**—Enables the Wi-Fi Multimedia (WMM) default parameters. This is the default value. Choose this option when voice or video services are not deployed on your network.
- **svp-voice**—Enables SpectraLink voice priority parameters. Choose this option if SpectraLink phones are deployed on your network to improve the quality of calls.
- **optimized-voice**—Enables EDCA voice-optimized profile parameters. Choose this option when voice services other than SpectraLink are deployed on your network.
- **optimized-video-voice**—Enables EDCA voice- and video-optimized profile parameters. Choose this option when both voice and video services are deployed on your network.

Note If you deploy video services, admission control (ACM) must be disabled.

Step 4 View the current status of MAC optimization for voice by entering this command:

show {802.11a | 802.11b}

Information similar to the following appears:

```
Voice-mac-optimization.................Disabled
```

Step 5 Enable or disable MAC optimization for voice by entering this command:

config advanced {802.11a | 802.11b} voice-mac-optimization {enable | disable}

This feature enhances voice performance by controlling packet retransmits and appropriately aging out voice packets on lightweight access points, which improves the number of voice calls serviced per access point. The default value is disabled.

Step 6 Reenable the radio network by entering this command:

config {802.11a | 802.11b} enable network

Step 7 Save your settings by entering this command:

save config

Configuring the Cisco Discovery Protocol

The Cisco Discovery Protocol (CDP) is a device discovery protocol that runs on all Cisco-manufactured equipment. A device enabled with CDP sends out periodic interface updates to a multicast address in order to make itself known to neighboring devices.

The default value for the frequency of periodic transmissions is 60 seconds, and the default advertised time-to-live value is 180 seconds. The second and latest version of the protocol, CDPv2, introduces new time-length-values (TLVs) and provides a reporting mechanism that allows for more rapid error tracking, which reduces downtime.

CDPv1 and CDPv2 are supported on the following devices:

- Cisco 5500, 4400, 2500, and 2100 Series Controllers

Note CDP is not supported on the controllers that are integrated into Cisco switches and routers, including those in the Catalyst 3750G Integrated Wireless LAN Controller Switch, the Cisco WiSM, and the Cisco 28/37/38xx Series Integrated Services Router. However, you can use the **show ap cdp neighbors detail** {*Cisco_AP* | **all**} command on these controllers in order to see the list of CDP neighbors for the access points that are connected to the controller.

- CAPWAP-enabled access points
- An access point connected directly to a Cisco 5500, 4400, or 2100 Series Controller

Note To use the Intelligent Power Management feature, ensure that CDPv2 is enabled on the Cisco 2100 and 2500 Series Controllers. CDP v2 is enabled by default.

Note The OEAP 600 access points do not support CDP.

This support enables network management applications to discover Cisco devices.

These TLVs are supported by both the controller and the access point:

- Device-ID TLV: 0x0001—The host name of the controller, the access point, or the CDP neighbor.
- Address TLV: 0x0002—The IP address of the controller, the access point, or the CDP neighbor.
- Port-ID TLV: 0x0003—The name of the interface on which CDP packets are sent out.
- Capabilities TLV: 0x0004—The capabilities of the device. The controller sends out this TLV with a value of Host: 0x10, and the access point sends out this TLV with a value of Transparent Bridge: 0x02.
- Version TLV: 0x0005—The software version of the controller, the access point, or the CDP neighbor.
- Platform TLV: 0x0006—The hardware platform of the controller, the access point, or the CDP neighbor.
- Power Available TLV: 0x001a— The amount of power available to be transmitted by power sourcing equipment to permit a device to negotiate and select an appropriate power setting.
- Full/Half Duplex TLV: 0x000b—The full- or half-duplex mode of the Ethernet link on which CDP packets are sent out.

These TLVs are supported only by the access point:

- Power Consumption TLV: 0x0010—The maximum amount of power consumed by the access point.
- Power Request TLV:0x0019—The amount of power to be transmitted by a powerable device in order to negotiate a suitable power level with the supplier of the network power.

You can configure CDP and view CDP information using the GUI in controller software release 4.1 or later or the CLI in controller software release 4.0 or later releases. Figure 4-41 shows a sample network that you can use as a reference when performing the procedures in this section.

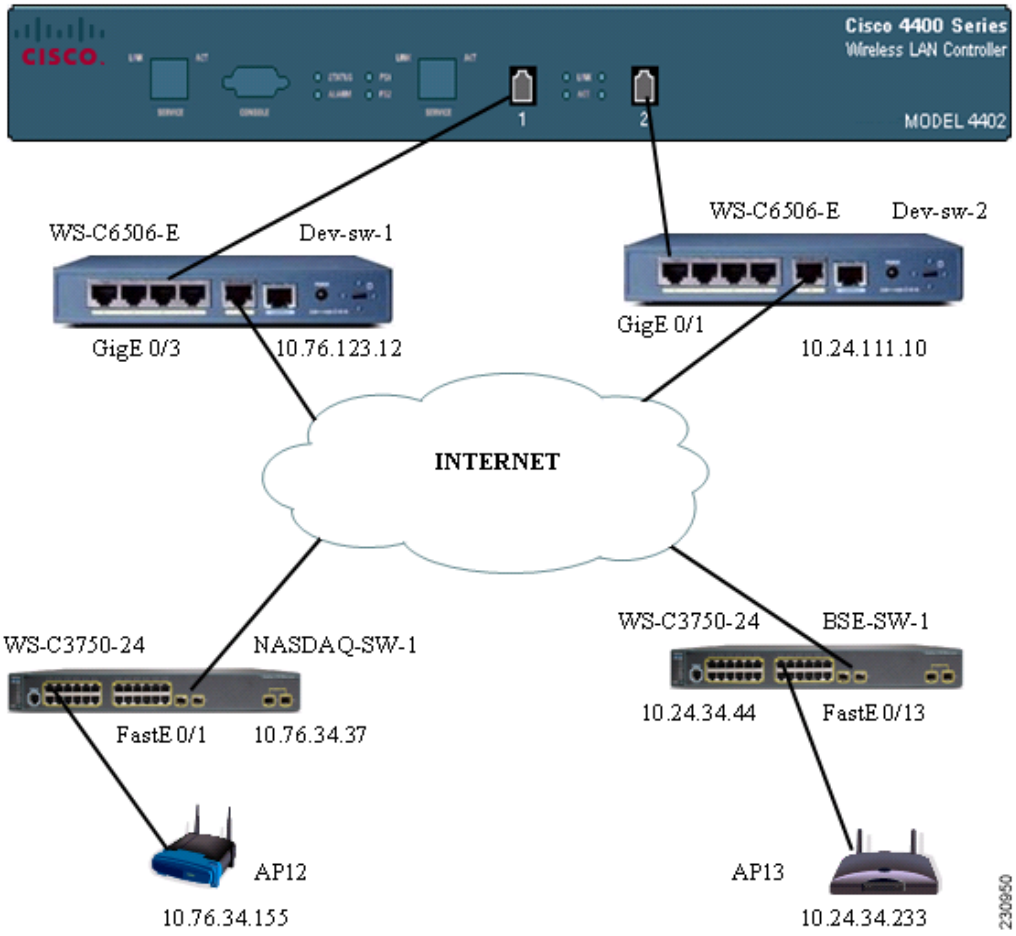
Note Changing the CDP configuration on the controller does not change the CDP configuration on the access points that are connected to the controller. You must enable and disable CDP separately for each access point.

You can enable or disable the CDP state on all or specific interfaces and radios. This configuration can be applied to all access points or a specific access point. For more information on how to configure CDP on the interfaces and radios, see the "Using the GUI to Configure the Cisco Discovery Protocol" section on page 4-99 and the "Using the CLI to Configure the Cisco Discovery Protocol" section on page 4-105.

The following is the behavior assumed for various interfaces and access points:

- CDP is disabled on radio interfaces on indoor (nonindoor mesh) access points.
- Nonmesh access points have CDPs disabled on radio interfaces when they join the controller. The persistent CDP configuration is used for the APs that had CDP support in its previous image.
- CDP is enabled on radio interfaces on indoor-mesh and mesh access points.
- Mesh access points will have CDP enabled on their radio interfaces when they join the controller. The persistent CDP configuration is used for the access points that had CDP support in a previous image. The CDP configuration for radio interfaces is applicable only for mesh APs.

Figure 4-41 Sample Network Illustrating CDP

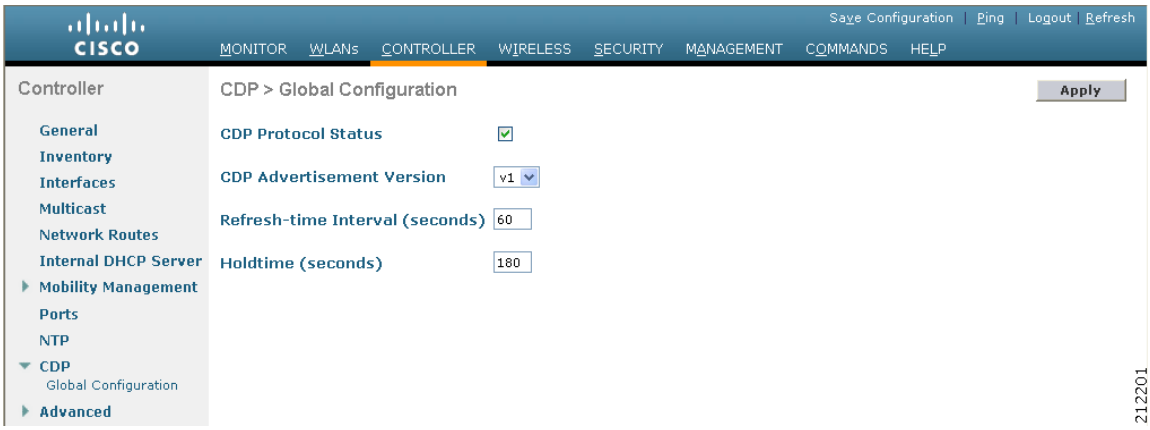


Using the GUI to Configure the Cisco Discovery Protocol

To configure CDP using the controller GUI, follow these steps:

Step 1 Choose **Controller > CDP > Global Configuration** to open the CDP > Global Configuration page (see Figure 4-42).

Figure 4-42 CDP > Global Configuration Page



Step 2 Select the **CDP Protocol Status** check box to enable CDP on the controller or unselect it to disable this feature. The default value is selected.

Note Enabling or disabling this feature is applicable to all controller ports.

Step 3 From the CDP Advertisement Version drop-down list, choose **v1** or **v2** to specify the highest CDP version supported on the controller. The default value is v1.

Step 4 In the Refresh-time Interval text box, enter the interval at which CDP messages are to be generated. The range is 5 to 254 seconds, and the default value is 60 seconds.

Step 5 In the Holdtime text box, enter the amount of time to be advertised as the time-to-live value in generated CDP packets. The range is 10 to 255 seconds, and the default value is 180 seconds.

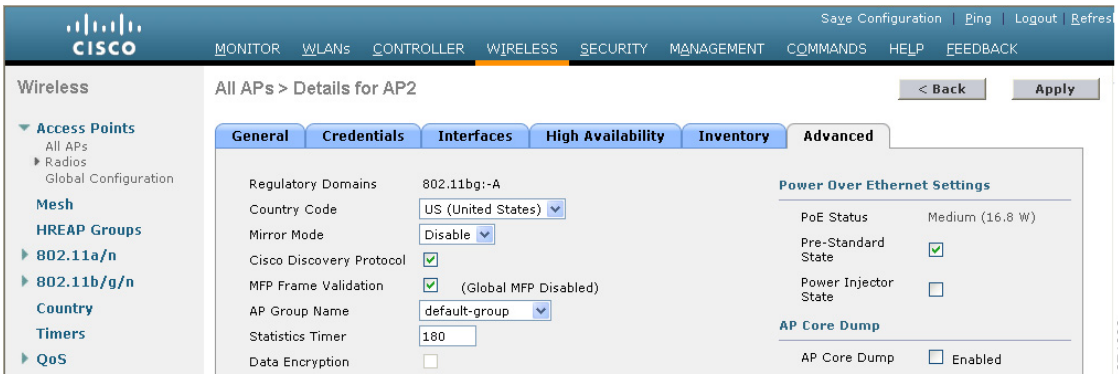
Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Step 8 Perform one of the following:

- To enable or disable CDP on a specific access point, follow these steps:
  - **a.** Choose **Wireless > Access Points > All APs** to open the All APs page.
  - **b.** Click the link for the desired access point.
  - **c.** Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 4-43).

Figure 4-43 All APs > Details for (Advanced) Page



d. Select the **Cisco Discovery Protocol** check box to enable CDP on this access point or unselect it to disable this feature. The default value is enabled.

Note If CDP is disabled in Step 2, a message indicating that the Controller CDP is disabled appears.

- Enable CDP for a specific Ethernet interface, radio, or slot as follows:
  a. Choose **Wireless > Access Points > All APs** to open the All APs page.
  b. Click the link for the desired access point.
  a. Choose the **Interfaces** tab and select the corresponding check boxes for the radios or slots from the CDP Configuration section.

Note Configuration for radios is only applicable for mesh access points.

  b. Click **Apply** to commit your changes.
- To enable or disable CDP on all access points currently associated to the controller, follow these steps:
  a. Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page.
  b. Select the **CDP State** check box to enable CDP on all access points associated to the controller or unselect it to disable CDP on all access points. The default value is selected. You can enable CDP on a specific Ethernet interface, radio, or slot by selecting the corresponding check box. This configuration will be applied to all access points associated with the controller.
  c. Click **Apply** to commit your changes.

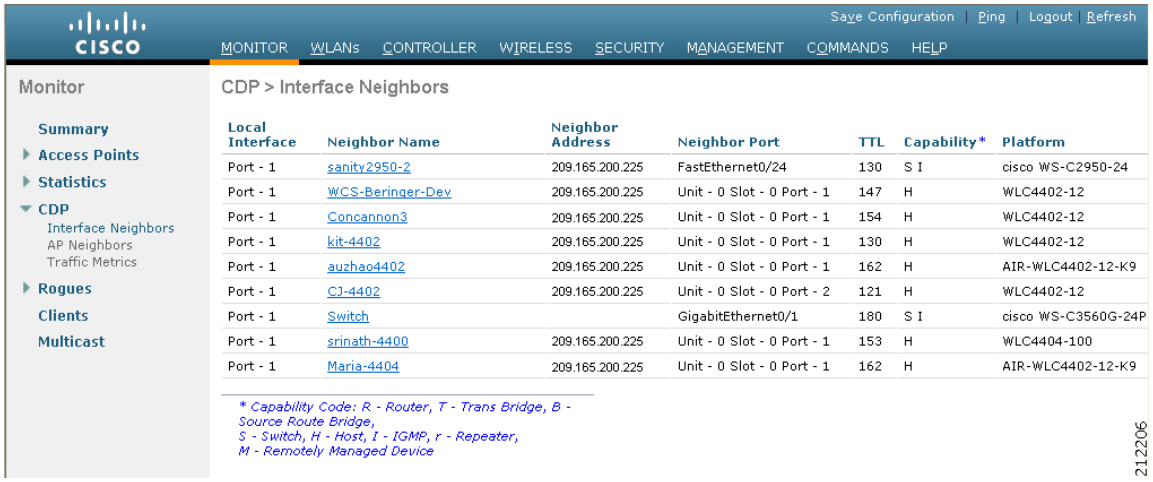
Step 9 Click **Save Configuration** to save your changes.

Using the GUI to View Cisco Discovery Protocol Information

To view CDP information using the controller GUI, follow these steps:

Step 1 Choose **Monitor > CDP > Interface Neighbors** to open the CDP > Interface Neighbors page appears (see Figure 4-44).

Figure 4-44 CDP > Interface Neighbors Page

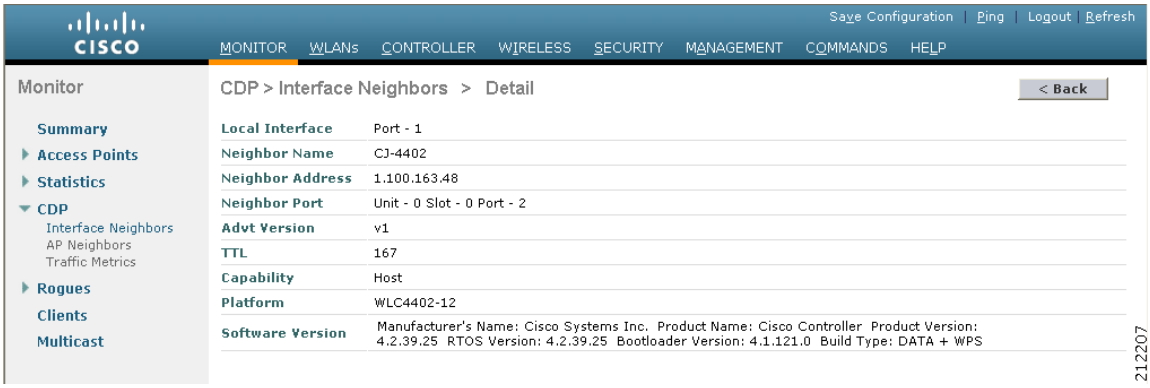


This page shows the following information:

- The controller port on which the CDP packets were received
- The name of each CDP neighbor
- The IP address of each CDP neighbor
- The port used by each CDP neighbor for transmitting CDP packets
- The time left (in seconds) before each CDP neighbor entry expires
- The functional capability of each CDP neighbor, defined as follows: R - Router, T - Trans Bridge, B - Source Route Bridge, S - Switch, H - Host, I - IGMP, r - Repeater, or M - Remotely Managed Device
- The hardware platform of each CDP neighbor device

Step 2 Click the name of the desired interface neighbor to see more detailed information about each interface's CDP neighbor. The CDP > Interface Neighbors > Detail page appears (see Figure 4-45).

Figure 4-45 CDP > Interface Neighbors > Detail Page



This page shows the following information:

- The controller port on which the CDP packets were received
- The name of the CDP neighbor
- The IP address of the CDP neighbor
- The port used by the CDP neighbor for transmitting CDP packets
- The CDP version being advertised (v1 or v2)
- The time left (in seconds) before the CDP neighbor entry expires
- The functional capability of the CDP neighbor, defined as follows: Router, Trans Bridge, Source Route Bridge, Switch, Host, IGMP, Repeater, or Remotely Managed Device
- The hardware platform of the CDP neighbor device
- The software running on the CDP neighbor

Step 3 Choose **AP Neighbors** to see a list of CDP neighbors for all access points connected to the controller. The CDP AP Neighbors page appears (see Figure 4-46).

Figure 4-46 CDP AP Neighbors Page

Step 4 Click the **CDP Neighbors** link for the desired access point to see a list of CDP neighbors for a specific access point. The CDP > AP Neighbors page appears (see Figure 4-47).

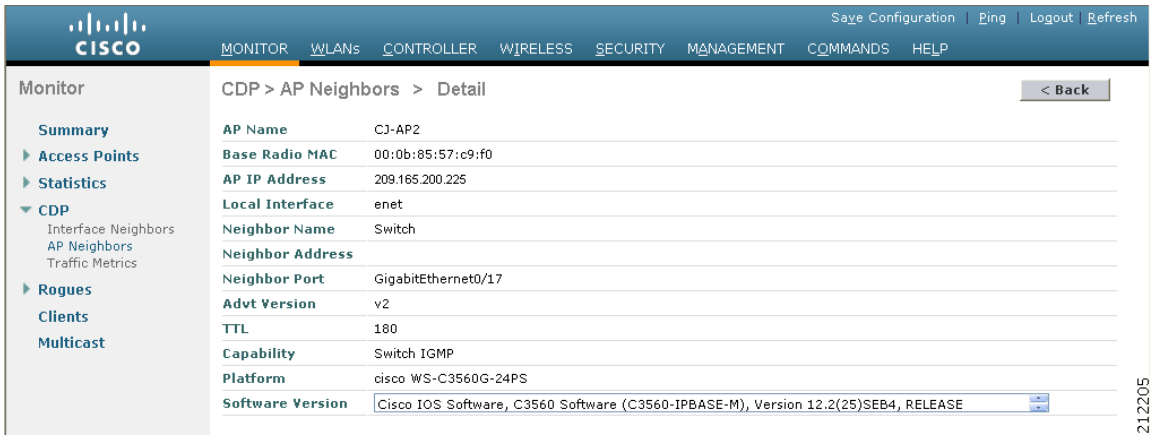
Figure 4-47 CDP > AP Neighbors Page

This page shows the following information:

- The name of each access point
- The IP address of each access point
- The name of each CDP neighbor
- The IP address of each CDP neighbor
- The port used by each CDP neighbor
- The CDP version being advertised (v1 or v2)

Step 5 Click the name of the desired access point to see detailed information about an access point's CDP neighbors. The CDP > AP Neighbors > Detail page appears (see Figure 4-48).

Figure 4-48 CDP > AP Neighbors > Detail Page



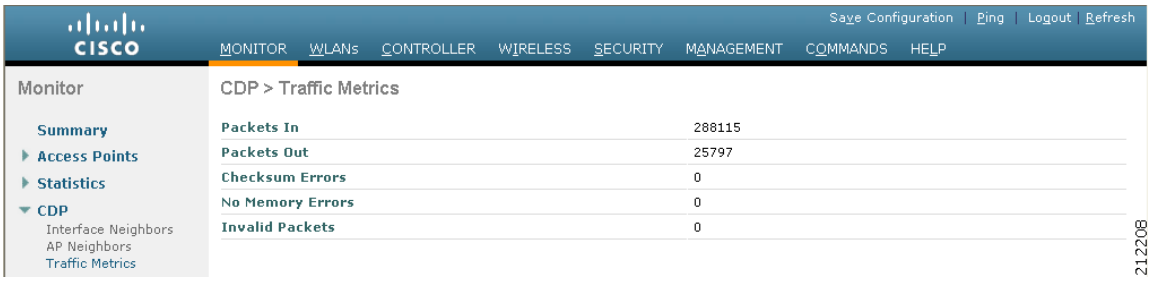
This page shows the following information:

- The name of the access point
- The MAC address of the access point's radio
- The IP address of the access point
- The interface on which the CDP packets were received
- The name of the CDP neighbor
- The IP address of the CDP neighbor
- The port used by the CDP neighbor

- The CDP version being advertised (v1 or v2)
- The time left (in seconds) before the CDP neighbor entry expires
- The functional capability of the CDP neighbor, defined as follows: R - Router, T - Trans Bridge, B - Source Route Bridge, S - Switch, H - Host, I - IGMP, r - Repeater, or M - Remotely Managed Device
- The hardware platform of the CDP neighbor device
- The software running on the CDP neighbor

Step 6 Choose **Traffic Metrics** to see CDP traffic information. The CDP > Traffic Metrics page appears (see Figure 4-49).

Figure 4-49 CDP > Traffic Metrics Page



This page shows the following information:

- The number of CDP packets received by the controller
- The number of CDP packets sent from the controller
- The number of packets that experienced a checksum error
- The number of packets dropped due to insufficient memory
- The number of invalid packets

Using the CLI to Configure the Cisco Discovery Protocol

To configure CDP using the controller CLI, follow these steps:

Step 1 Enable or disable CDP on the controller by entering this command:

config cdp {**enable** | **disable**}

CDP is enabled by default.

Step 2 Specify the interval at which CDP messages are to be generated by entering this command:

config cdp timer *seconds*

The range is 5 to 254 seconds, and the default value is 60 seconds.

Step 3 Specify the amount of time to be advertised as the time-to-live value in generated CDP packets by entering this command:

config cdp holdtime *seconds*

The range is 10 to 255 seconds, and the default value is 180 seconds.

Step 4 Specify the highest CDP version supported on the controller by entering this command:

config cdp advertise {**v1** | **v2**}

The default value is v1.

Step 5 Enable or disable CDP on all access points that are joined to the controller by entering the **config ap cdp** {**enable** | **disable**} **all** command.

The **config ap cdp disable all** command disables CDP on all access points that are joined to the controller and all access points that join in the future. CDP remains disabled on both current and future access points even after the controller or access point reboots. To enable CDP, enter the **config ap cdp enable all** command.

Note After you enable CDP on all access points joined to the controller, you may disable and then reenable CDP on individual access points using the command in Step 6. After you disable CDP on all access points joined to the controller, you may not enable and then disable CDP on individual access points.

Step 6 Enable or disable CDP on a specific access point by entering this command:

config ap cdp {**enable** | **disable**} *Cisco_AP*

Step 7 Configure CDP on a specific or all access points for a specific interface by entering this command:

config ap cdp {ethernet | radio} *interface_number slot_id* **{enable | disable} {all | Cisco_AP}**

Note When you use the config ap cdp command to configure CDP on radio interfaces, a warning message appears indicating that the configuration is applicable only for mesh access points.

Step 8 Save your changes by entering this command:

save config

Using the CLI to View Cisco Discovery Protocol Information

To obtain information about CDP neighbors on the controller using the controller CLI, follow these steps:

Step 1 See the status of CDP and to view CDP protocol information by entering this command:

show cdp

Step 2 See a list of all CDP neighbors on all interfaces by entering this command:

show cdp neighbors [detail]

The optional detail command provides detailed information for the controller's CDP neighbors.

Note This command shows only the CDP neighbors of the controller. It does not show the CDP neighbors of the controller's associated access points. Additional commands are provided below to show the list of CDP neighbors per access point.

Step 3 See all CDP entries in the database by entering this command:

show cdp entry all

Step 4 See CDP traffic information on a given port (for example, packets sent and received, CRC errors, and so on) by entering this command:

show cdp traffic

Step 5 See the CDP status for a specific access point by entering this command:

show ap cdp ap-name *Cisco_AP*

Step 6 See the CDP status for all access points that are connected to the controller by entering this command:

show ap cdp all

Step 7 See a list of all CDP neighbors for a specific access point by entering these commands:

- **show ap cdp neighbors ap-name** *Cisco_AP*
- **show ap cdp neighbors detail** *Cisco_AP*

Note The access point sends CDP neighbor information to the controller only when the information changes.

Step 8 See a list of all CDP neighbors for all access points connected to the controller by entering these commands:

- **show ap cdp neighbors all**
- **show ap cdp neighbors detail all**

Information similar to the following appears when you enter the **show ap cdp neighbors all** command:

```
AP Name            AP IP          Neighbor Name  Neighbor IP    Neighbor Port
--------           --------       -------------  -----------    -------------
AP0013.601c.0a0    10.76.108.123        6500-1   10.76.108.207  GigabitEthernet1/26
AP0013.601c.0b0    10.76.108.111        6500-1   10.76.108.207  GigabitEthernet1/27
AP0013.601c.0c0   10.76.108.125        6500-1    10.76.108.207  GigabitEthernet1/28
```

Information similar to the following appears when you enter the **show ap cdp neighbors detail all** command:

```
AP Name: AP0013.601c.0a0
AP IP Address: 10.76.108.125
---------------------------------
Device ID: 6500-1
Entry address(es): 10.76.108.207
Platform: cisco WS-C6506-E,  Capabilities: Router Switch IGMP
Interface: Port - 1,  Port ID (outgoing port): GigabitEthernet1/26
Holdtime: 157 sec

Version:
Cisco Internetwork Operating System Software  IOS (tm) s72033_rp Software
(s72033_rp-PSV-M), Version 12.2(18)SXD5, RELEASE SOFTWARE (fc3) Technical Support:
http://www.cisco.com/techsupport Copyright (c) 1986-2005 by cisco Systems, Inc.
Compiled Fri 13-Ma
```

Note The access point sends CDP neighbor information to the controller only when the information changes.

To obtain CDP debug information for the controller using the controller CLI, follow these steps:

Step 1 Obtain debug information related to CDP packets by entering by entering this command:

debug cdp packets

Step 2 Obtain debug information related to CDP events by entering this command:

debug cdp events

Configuring Authentication for the Controller and NTP Server

Starting in release 7.0.116.0, the controller software is now compliant with RFC 1305. As per this requirement, controllers must synhronize time with an NTP server by authentication. By default, an MD5 checksum is used.

Using the GUI to Configure the NTP Server for Authentication

To configure NTP Server Authentication using the controller GUI, follow these steps:

Step 1 Choose **Controller > NTP > Severs** to open the NTP Severs page.

Step 2 Click **New** to add a new NTP Server.

Step 3 In the Server Index (Priority) text box, enter the NTP server index.

The controller tries Index 1 first, then Index 2 through 3, in a descending order. Set this to 1 if your network is using only one NTP server.

Step 4 Enter the server IP address in the **Server IP** Address field.

Step 5 Select the **Enable NTP Authentication** check box to enable NTP Authentication.

Step 6 Enter the Key index.

Step 7 Click **Apply**.

Using the CLI to Configure the NTP Server for Authentication

To configure NTP server authentication using the CLI, use the following commands:

- **config time ntp auth enable** ***server-index key-index***—Enables NTP authentication on a given NTP server.
- **config time ntp key-auth** ***addkey-index*** **md5** ***key-format key***—Adds an authentication key. By default MD5 is used. The key format can be "ascii" or "hex".
- **config time ntp key-auth delete** ***key-index***—Deletes authentication keys.
- **config time ntp auth disable** ***server-index***—Disables NTP authentication.
- **show ntp-keys**—Displays the NTP authentication related parameter.

Configuring RFID Tag Tracking

The controller enables you to configure radio-frequency identification (RFID) tag tracking. RFID tags are small wireless devices that are affixed to assets for real-time location tracking. They operate by advertising their location using special 802.11 packets, which are processed by access points, the controller, and the location appliance.

To know more about the tags supported by controller, see http://www.cisco.com/web/partners/pr46/pr147/ccx_wifi_tags.html. See Table 4-5 for details. The location appliance receives telemetry and chokepoint information from tags that are compliant with this CCX specification.

Table 4-5 Cisco Compatible Extensions for RFID Tags Summary

Partners	AeroScout		WhereNet	Pango (InnerWireless)
Product Name	T2	T3	Wheretag IV	V3
Telemetry				
Temperature	X	X	—	X
Pressure	—	—	—	—
Humidity	—	—	—	—
Status	—	—	—	—
Fuel	—	—	—	—
Quantity	—	—	—	—
Distance	—	—	—	—
Motion Detection	X	X	—	X
Number of Panic Buttons	1	2	0	1
Tampering		X	X	X
Battery Information	X	X	X	X
Multiple-Frequency Tags[1]	X	X	X	

1. For chokepoint systems, note that the tag can work only with chokepoints coming from the same vendor.

Note The Network Mobility Services Protocol (NMSP) runs on location appliance software release 3.0 or later releases. In order for NMSP to function properly, the TCP port (16113) over which the controller and location appliance communicate must be open (not blocked) on any firewall that exists between these two devices. See the *Cisco Location Appliance Configuration Guide* for additional information on NMSP and RFID tags.

The Cisco-approved tags support these capabilities:

- Information notifications—Enable you to view vendor-specific and emergency information.
- Information polling—Enables you to monitor battery status and telemetry data. Many telemetry data types provide support for sensory networks and a large range of applications for RFID tags.
- Measurement notifications—Enable you to deploy chokepoints at strategic points within your buildings or campuses. Whenever an RFID tag moves to within a defined proximity of a chokepoint, the tag begins transmitting packets that advertise its location in relation to the chokepoint.

The number of tags supported varies depending on controller platform. Table 4-6 lists the number of tags supported per controller.

Table 4-6 RFID Tags Supported per Controller

Controller	Number of RFID Tags Supported
5508	2500
Cisco WiSM	5000
4404	2500
4402	1250
Catalyst 3750G Integrated Wireless LAN Controller Switch	1250
2106	500
Controller Network Module within the Cisco 28/37/38xx Series Integrated Services Routers	500
2500	500

You can configure and view RFID tag tracking information through the controller CLI.

Using the CLI to Configure RFID Tag Tracking

To configure RFID tag tracking parameters using the controller CLI, follow these steps:

Step 1 Enable or disable RFID tag tracking by entering this command:

config rfid status {**enable** | **disable**}

The default value is enabled.

Step 2 Specify a static timeout value (between 60 and 7200 seconds) by entering this command:

config rfid timeout *seconds*

The static timeout value is the amount of time that the controller maintains tags before expiring them. For example, if a tag is configured to beacon every 30 seconds, we recommend that you set the timeout value to 90 seconds (approximately three times the beacon value). The default value is 1200 seconds.

Step 3 Enable or disable RFID tag mobility for specific tags by entering these commands:

- **config rfid mobility** *vendor_name* **enable**—Enables client mobility for a specific vendor's tags. When you enter this command, tags are unable to obtain a DHCP address for client mode when attempting to select and/or download a configuration.
- **config rfid mobility** *vendor_name* **disable**—Disables client mobility for a specific vendor's tags. When you enter this command, tags can obtain a DHCP address. If a tag roams from one subnet to another, it obtains a new address rather than retaining the anchor state.

Note These commands can be used only for Pango tags. Therefore, the only valid entry for *vendor_name* is "pango" in all lowercase letters.

Using the CLI to View RFID Tag Tracking Information

To view RFID tag tracking information using the controller CLI, follow these steps:

Step 1 See the current configuration for RFID tag tracking by entering this command:

show rfid config

Information similar to the following appears:

```
RFID Tag data Collection..................... Enabled
RFID timeout................................. 1200 seconds
RFID mobility.............................. Oui:00:14:7e : Vendor:pango
                                             State:Disabled
```

Step 2 See detailed information for a specific RFID tag by entering this command:

show rfid detail *mac_address*

where *mac_address* is the tag's MAC address.

Information similar to the following appears:

```
RFID address................................. 00:12:b8:00:20:52
Vendor....................................... G2
Last Heard................................... 51 seconds ago
Packets Received............................. 2
Bytes Received............................... 324
Cisco Type...................................

Content Header
==================
Version...................................... 1
Tx Power..................................... 12 dBm
Channel...................................... 1
Reg Class.................................... 12
Burst Length................................. 1

CCX Payload
===========
Last Sequence Control........................ 0
Payload length............................... 127
Payload Data Hex Dump

01 09 00 00 00 00 0b 85 52 52 52 02 07 4b ff ff
7f ff ff ff 03 14 00 12 7b 10 48 53 c1 f7 51 4b
50 ba 5b 97 27 80 00 67 00 01 03 05 01 42 34 00
00 03 05 02 42 5c 00 00 03 05 03 42 82 00 00 03
05 04 42 96 00 00 03 05 05 00 00 00 55 03 05 06
42 be 00 00 03 02 07 05 03 12 08 10 00 01 02 03
04 05 06 07 08 09 0a 0b 0c 0d 0e 0f 03 0d 09 03
08 05 07 a8 02 00 10 00 23 b2 4e 03 02 0a 03

Nearby AP Statistics:
      lap1242-2(slot 0, chan 1) 50 seconds ag.... -76 dBm
      lap1242(slot 0, chan 1) 50 seconds ago..... -65 dBm
```

Step 3 See a list of all RFID tags currently connected to the controller by entering this command:

show rfid summary

Information similar to the following appears:

```
Total Number of RFID   : 24
---------------- -------- ----------------- ------ --------------------
```

```
     RFID ID      VENDOR       Closest AP      RSSI  Time Since Last Heard
----------------- -------- ------------------ ------ ---------------------
00:04:f1:00:00:03 Wherenet HReap               -70      151 seconds ago
00:04:f1:00:00:05 Wherenet HReap               -66      251 seconds ago
00:0c:cc:5b:f8:1e Aerosct  HReap               -40        5 seconds ago
00:0c:cc:5c:05:10 Aerosct  HReap               -68       25 seconds ago
00:0c:cc:5c:06:69 Aerosct  HReap               -54        7 seconds ago
00:0c:cc:5c:06:6b Aerosct  HReap               -68      245 seconds ago
00:0c:cc:5c:06:b5 Aerosct  cisco1242           -67       70 seconds ago
00:0c:cc:5c:5a:2b Aerosct  cisco1242           -68       31 seconds ago
00:0c:cc:5c:87:34 Aerosct  HReap               -40        5 seconds ago
00:14:7e:00:05:4d Pango    cisco1242              -66      298 seconds ago
```

Step 4 See a list of RFID tags that are associated to the controller as clients by entering this command:

show rfid client

When the RFID tag is in client mode, information similar to the following appears:

```
------------------ -------- --------- ----------------- ------ ----------------
                             Heard
   RFID Mac         VENDOR   Sec Ago    Associated AP    Chnl    Client State
------------------ -------- --------- ----------------- ------ ----------------

00:14:7e:00:0b:b1   Pango      35    AP0019.e75c.fef4   1      Probing

When the RFID tag is not in client mode, the above text boxes are blank.
```

Using the CLI to Debug RFID Tag Tracking Issues

If you experience any problems with RFID tag tracking, use these debug commands.

- Configure MAC address debugging by entering this command:

  debug mac addr *mac_address*

  Note We recommend that you perform the debugging on a per-tag basis. If you enable debugging for all of the tags, the console or Telnet screen is inundated with messages.

- Enable or disable debugging for the 802.11 RFID tag module by entering this command:

  debug dot11 rfid {**enable** | **disable**}

- Enable or disable RFID debug options by entering this command:

  debug rfid {**all** | **detail** | **error** | **nmsp** | **receive**} {**enable** | **disable**}

  where

  - **all** configures debugging of all RFID messages.
  - **detail** configures debugging of RFID detailed messages.
  - **error** configures debugging of RFID error messages.
  - **nmsp** configures debugging of RFID NMSP messages.
  - **receive** configures debugging of incoming RFID tag messages.

Configuring and Viewing Location Settings

This section provides instructions for configuring and viewing location settings from the controller CLI.

Note Access points in monitor mode should not be used for location purposes.

Installing the Location Appliance Certificate

A self-signed certificate (SSC) is required on the location appliance. This certificate, which is comprised of the location appliance MAC address and a 20-byte key hash, must be present on the controller. Otherwise, the controller cannot authenticate the location appliance, and they can never establish a connection. WCS usually pushes the certificate to the controller automatically, but you can install the certificate on the controller using the controller CLI if necessary (for example, if the controller is not connected to WCS or if an error or certificate mismatch occurs on WCS).

Note If an error occurs on WCS and prevents the location appliance certificate from being pushed to the controller, make sure that the time zone has been synchronized on the controller and the location appliance before following this procedure. Follow the instructions in the "Viewing Location Settings" section on page 4-116 to do so.

To install the location appliance certificate on the controller using the controller CLI, follow these steps:

Step 1 Obtain the key hash value of the location appliance certificate by entering this command:

debug pm pki enable

Information similar to the following appears:

```
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Calculate SHA1 hash on Public Key Data
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  30820122 300d0609 2a864886
f70d0101
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  01050003 82010f00 3082010a
02820101
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  009a98b5 d2b7c77b 036cdb87
5bd20e5a
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  894c66f4 df1cbcfb fe2fcf01
09b723aa
Thu Oct 11 08:52:26 2007: sshpmGetIssuerHandles: Key Data  5c0917f1 ec1d5061 2d386351
573f2c5e
Thu Oct 11 08:52:30 2007: sshpmGetIssuerHandles: Key Data  b9020301 0001
Thu Oct 11 08:52:30 2007: sshpmGetIssuerHandles: SSC Key Hash is
4869b32638c00ffca88abe9b1a8e0525b9344b8b
```

Step 2 Install the location appliance certificate on the controller by entering this command:

config auth-list add lbs-ssc *lbs_mac lbs_key*

where

- *lbs_mac* is the MAC address of the location appliance.
- *lbs_key* is the 20-byte key hash value of the certificate.

Step 3 Save your changes by entering this command:

save config

Step 4 Verify that the location appliance certificate is installed on the controller by entering this command:

show auth-list

Information similar to the following appears:

```
Authorize APs against AAA ..................... disabled
Allow APs with Self-Signed Certificate (SSC) .... disabled

Mac Addr                  Cert Type    Key Hash
-----------------------   ----------   ------------------------------------------------
00:16:36:91:9a:27         LBS-SSC    593f34e7cb151997a28cc7da2a6cac040b329636
```

Synchronizing the Controller and Location Appliance

For controller software release 4.2 or later releases, if a location appliance (release 3.1 or later releases) is installed on your network, the time zone must be set on the controller to ensure proper synchronization between the two systems. Also, the times must be synchronized on the two devices. We recommend that you set the time even for networks that do not have location appliances. See the "Configuring 802.11 Bands" section on page 4-29 for instructions on setting the time and date on the controller.

Note The time zone can be different for the controller and the location appliance, but the time zone delta must be configured accordingly, based on GMT.

Configuring Location Settings

The controller determines the location of client devices by gathering received signal strength indication (RSSI) measurements from access points all around the client of interest. The controller can obtain location reports from up to 16 access points for clients, RFID tags, and rogue access points.

Improve location accuracy by configuring the path loss measurement (S60) request for normal clients or calibrating clients by entering this command:

config location plm *?*

where *?* is one of the following:

- **client** {**enable** | **disable**} *burst_interval*—Enables or disables the path loss measurement request for normal, noncalibrating clients. The valid range for the *burst_interval* parameter is 1 to 3600 seconds, and the default value is 60 seconds.
- **calibrating** {**enable** | **disable**} {**uniband** | **multiband**}—Enables or disables the path loss measurement request for calibrating clients on the associated 802.11a or 802.11b/g radio or on the associated 802.11a/b/g radio.

If a client does not send probes often or sends them only on a few channels, its location cannot be updated or cannot be updated accurately. The **config location plm** command forces clients to send more packets on all channels. When a CCXv4 (or higher) client associates, the controller sends it a path loss measurement request, which instructs the client to transmit on the bands and channels that the access points are on (typically, channels 1, 6, and 11 for 2.4-GHz-only access points) at a configurable interval (such as 60 seconds) indefinitely.

These four additional location CLI commands are available; however, they are set to optimal default values, so we do not recommend that you use or modify them:

- Configure the RSSI timeout value for various devices by entering this command:

  config location expiry *?*

  where*?* is one of the following:

  - **client** *timeout*—Configures the RSSI timeout value for clients. The valid range for the *timeout* parameter is 5 to 3600 seconds, and the default value is 5 seconds.
  - **calibrating-client** *timeout*—Configures the RSSI timeout value for calibrating clients. The valid range for the *timeout* parameter is 0 to 3600 seconds, and the default value is 5 seconds.
  - **tags** *timeout*—Configures the RSSI timeout value for RFID tags. The valid range for the *timeout* parameter is 5 to 300 seconds, and the default value is 5 seconds.
  - **rogue-aps** *timeout*—Configures the RSSI timeout value for rogue access points. The valid range for the *timeout* parameter is 5 to 3600 seconds, and the default value is 5 seconds.

  Ensuring that recent, strong RSSIs are retained by the CPU is critical to location accuracy. The **config location expiry** command enables you to specify the length of time after which old RSSI averages expire.

  Note We recommend that you do not use or modify the **config location expiry** command.

- Configure the RSSI half life for various devices by entering this command:

  config location rssi-half-life *?*

  where *?* is one of the following:

  - **client** *half_life*—Configures the RSSI half life for clients. The valid range for the *half_life* parameter is 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.
  - **calibrating-client** *half_life*—Configures the RSSI half life for calibrating clients. The valid range for the *half_life* parameter is 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.
  - **tags** *half_life*—Configures the RSSI half life for RFID tags. The valid range for the *half_life* parameter is 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.
  - **rogue-aps** *half_life*—Configures the RSSI half life for rogue access points. The valid range for the *half_life* parameter is 0, 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, or 300 seconds, and the default value is 0 seconds.

  Some client devices transmit at reduced power immediately after changing channels, and RF is variable, so RSSI values might vary considerably from packet to packet. The **config location rssi-half-life** command increases accuracy by averaging nonuniformly arriving data using a configurable forget period (or half life).

  Note We recommend that you do not use or modify the **config location rssi-half-life** command.

- Configure the NMSP notification threshold for RSSI measurements by entering this command:

  config location notify-threshold *?*

  where *?* is one of the following:

  - **client** *threshold*—Configures the NMSP notification threshold (in dB) for clients and rogue clients. The valid range for the *threshold* parameter is 0 to 10 dB, and the default value is 0 dB.

  - **tags** *threshold*—Configures the NMSP notification threshold (in dB) for RFID tags. The valid range for the *threshold* parameter is 0 to 10 dB, and the default value is 0 dB.
  - **rogue-aps** *threshold*—Configures the NMSP notification threshold (in dB) for rogue access points. The valid range for the *threshold* parameter is 0 to 10 dB, and the default value is 0 dB.

Note We recommend that you do not use or modify the **config location notify-threshold** command.

- Configure the algorithm used to average RSSI and signal-to-noise ratio (SNR) values by entering this command:

  config location algorithm *?*

  where *?* is one of the following:

  - **simple**—Specifies a faster algorithm that requires low CPU overhead but provides less accuracy.
  - **rssi-average**—Specifies a more accurate algorithm but requires more CPU overhead.

Note We recommend that you do not use or modify the **config location algorithm** command.

Viewing Location Settings

To view location information, use these CLI commands:

- View the current location configuration values by entering this command:

  show location summary

  Information similar to the following appears:

```
Location Summary

Algorithm used:                         Average
Client
       RSSI expiry timeout:              5 sec
       Half life:                        0 sec
       Notify Threshold:                 0 db
Calibrating Client
       RSSI expiry timeout:              5 sec
       Half life:                        0 sec
Rogue AP
       RSSI expiry timeout:              5 sec
       Half life:                        0 sec
       Notify Threshold:                 0 db
RFID Tag
       RSSI expiry timeout:              5 sec
       Half life:                        0 sec
       Notify Threshold:                 0 db
```

- See the RSSI table for a particular client by entering this command:

  show location detail *client_mac_addr*

  Information similar to the following appears:

```
...
[11] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A 0) (antenna-B 0), snr 0, acceptable 0
[12] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A 0) (antenna-B 0), snr 0, acceptable 0
[13] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A -1) (antenna-B 0), snr 0, acceptable 0
[14] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A 0) (antenna-B 0), snr 0, acceptable 0
[15] AP 00:00:00:00:00:00 :  Slot 0 inUse 0, expired 0, Timestamp (antenna-A 0)
(antenna-B 0), band 0  rssi (antenna-A 0) (antenna-B 0), snr 0, acceptable 0
```

- See the location-based RFID statistics by entering this command:

  show location statistics rfid

  Information similar to the following appears:

```
RFID Statistics

Database Full :          0        Failed Delete:          0
Null Bufhandle:          0        Bad Packet:             0
Bad LWAPP Data:          0        Bad LWAPP Encap:        0
Off Channel:             0        Bad CCX Version:        0
Bad AP Info :            0
Above Max RSSI:          0        Below Max RSSI:         0
Invalid RSSI:            0        Add RSSI Failed:        0
Oldest Expired RSSI:  0         Smallest Overwrite:  0
```

- Clear the location-based RFID statistics by entering this command:

  clear location statistics rfid

- Clear a specific RFID tag or all of the RFID tags in the entire database by entering this command:

  clear location rfid {*mac_address* | **all**}

- See whether location presence (S69) is supported on a client by entering this command:

  show client detail *client_mac*

  When location presence is supported by a client and enabled on a location appliance, the location appliance can provide the client with its location upon request. Location presence is enabled automatically on CCXv5 clients.

  Information similar to the following appears:

```
Client MAC Address.............................. 00:40:96:b2:a3:44
Client Username ................................ N/A
AP MAC Address.................................. 00:18:74:c7:c0:90
Client State.................................... Associated
Wireless LAN Id................................. 1
BSSID........................................... 00:18:74:c7:c0:9f
Channel......................................... 56
IP Address...................................... 192.168.10.28
Association Id.................................. 1
Authentication Algorithm........................ Open System
Reason Code..................................... 0
Status Code..................................... 0
Session Timeout................................. 0
Client CCX version.............................. 5
Client E2E version.............................. No E2E support
Diagnostics Capability.......................... Supported
S69 Capability.................................. Supported
Mirroring....................................... Disabled
QoS Level....................................... Silver
...
```

Note See the *Cisco Wireless Control System Configuration Guide* or the *Cisco Location Appliance Configuration Guide* for instructions on enabling location presence on a location appliance.

Modifying the NMSP Notification Interval for Clients, RFID Tags, and Rogues

The Network Mobility Services Protocol (NMSP) manages communication between the location appliance and the controller for incoming and outgoing traffic. If your application requires more frequent location updates, you can modify the NMSP notification interval (to a value between 1 and 180 seconds) for clients, active RFID tags, and rogue access points and clients.

Note The TCP port (16113) that the controller and location appliance communicate over must be open (not blocked) on any firewall that exists between the controller and the location appliance for NMSP to function.

To modify the NMSP notification interval value on the controller using the controller CLI, follow these steps:

Step 1 Set the NMSP notification interval value for clients, RFID tags, and rogue clients and access points by entering these commands, where *interval* is a value between 1 and 180 seconds:

- **config nmsp notification interval rssi clients** *interval*
- **config nmsp notification interval rssi rfid** *interval*
- **config nmsp notification interval rssi rogues** *interval*

Step 2 See the NMSP notification intervals by entering this command:

show nmsp notification interval

Information similar to the following appears:

```
NMSP Notification Interval Summary

RSSI Interval:
 Client.......................................... 2 sec
 RFID............................................ 0 sec
 Rogue AP........................................ 2 sec
 Rogue Client.................................... 2 sec
```

Viewing NMSP Settings

To view NMSP information, use these CLI commands:

- See the status of active NMSP connections by entering this command:

  show nmsp status

  Information similar to the following appears:

```
MSE IP Address    Tx Echo Resp    Rx Echo Req    Tx Data    Rx Data
--------------    ------------    -----------    -------    -------
171.71.132.107      39046           39046        103742         1
```

- See the NMSP capabilities by entering this command:

  show nmsp capability

  Information similar to the following appears:

```
Service                  Subservice
-------                  ----------
RSSI                     Mobile Station, Tags, Rogue,
Info                     Mobile Station, Rogue,
Statistics               Mobile Station, Tags,
IDS Services            WIPS
```

- See the NMSP counters by entering this command:

  show nmsp statistics {**summary** | **connection**}

  where

  – **summary** shows the common NMSP counters.

  – **connection** shows the connection-specific NMSP counters.

  Information similar to the following appears for the **show nmsp statistics summary** command:

```
NMSP Global Counters

Client Measure Send Fail..........................  0
Send RSSI with no entry...........................  0
APP msg too big...................................  0
Failed Select on Accept Socket....................  0
Failed SSL write..................................  0
Partial SSL write.................................  0
SSL write returned zero...........................  0
SSL write attempts to want read...................  0
SSL write attempts to want write..................  0
SSL write got default error.......................  0
SSL write max data length sent....................  0
SSL write max attempts to write in loop..........  0
SSL read returned zero............................  0
SSL read attempts to want read....................  0
SSL read attempts to want write...................  0
SSL read got default error........................  0
Failed SSL read - Con Rx buf freed................  0
Failed SSL read - Con/SSL freed...................  0
Max records read before exiting SSL read.........  0
Normal Prio Tx Q full.............................  0
Highest Prio Tx Q count...........................  0
Normal Prio Tx Q count............................  0
Messages sent by APPs to Highest Prio TxQ........  0
Max Measure Notify Msg............................  0
Max Info Notify Msg...............................  0
Max Highest Prio Tx Q Size........................  0
Max Normal Prio Tx Q Size.........................  0
Max Rx Size.......................................  1
Max Info Notify Q Size............................  0
Max Client Info Notify Delay......................  0
Max Rogue AP Info Notify Delay....................  0
Max Rogue Client Info Notify Delay................  0
Max Client Measure Notify Delay...................  0
Max Tag Measure Notify Delay......................  0
Max Rogue AP Measure Notify Delay.................  0
```

```
Max Rogue Client Measure Notify Delay..... 0
Max Client Stats Notify Delay..... 0
Max Client Stats Notify Delay..... 0
RFID Measurement Periodic..... 0
RFID Measurement Immediate..... 0
SSL Handshake failed..... 0
NMSP Rx detected con failure..... 0
NMSP Tx detected con failure..... 0
NMSP Tx buf size exceeded..... 0
Reconnect Before Conn Timeout..... 0
```

Information similar to the following appears for each active connection when you enter the **show nmsp statistics connection** command:

```
NMSP Connection Counters

MSE IP: 171.71.132.107
 Connection status:     UP
 Tx message count                      Rx message count
 ----------------                      ----------------
 WLC Capability:        1              MSE Capability:          0
 Service Subscr Rsp:    1              Service Subscr Req:      1
 Measure Rsp:           0              Measure Req:             0
 Measure Notify:        0
 Info Rsp:              0              Info Req:                0
 Info Notify:           0
 Stats Rsp:             0              Stats Req:               0
 Stats Notify:          0
 Loc Req:               0              Loc Rsp:                 0
 Loc Subscr Req:        0              Loc Subscr Rsp:          0
                                       Loc Notify:              0
 Loc Unsubscr Req:      0              Loc Unsubscr Rsp:        0
 AP Monitor Rsp:        0              AP Monitor Req:          0
 AP Monitor Notify:     64677
 IDS Get Rsp:           0              IDS Get Req:             0
IDS Notif:             0
 IDS Set Rsp:           0              IDS Set Req:             0
```

- See the mobility services that are active on the controller by entering this command:

  show nmsp subscription {**summary** | **detail** | **detail** *ip_addr*}

  where

  - **summary** shows all of the mobility services to which the controller is subscribed.
  - **detail** shows details for all of the mobility services to which the controller is subscribed.
  - **detail** *ip_addr* shows details only for the mobility services subscribed to by a specific IP address.

  Information similar to the following appears for the **show nmsp subscription summary** command:

```
Mobility Services Subscribed:

 Server IP               Services
 ---------               --------
 1.4.93.31               RSSI, Info, Statistics
```

  Information similar to the following appears for the **show nmsp subscription detail** *ip_addr* command:

```
Mobility Services Subscribed by 1.4.93.31

Services                Sub-services
--------                ------------
```

```
RSSI                     Mobile Station, Tags,
Info                     Mobile Station,
Statistics              Mobile Station, Tags,
```

- Clear all NMSP statistics by entering this command:

  clear nmsp statistics

Debugging NMSP Issues

Use these CLI commands if you experience any problems with NMSP:

- Configure NMSP debug options by entering this command:

  debug nmsp *?*

  where *?* is one of the following:

  - **all** {**enable** | **disable**}—Enables or disables debugging for all NMSP messages.
  - **connection** {**enable** | **disable**}—Enables or disables debugging for NMSP connection events.
  - **detail** {**enable** | **disable**}—Enables or disables debugging for NMSP detailed events.
  - **error** {**enable** | **disable**}—Enables or disables debugging for NMSP error messages.
  - **event** {**enable** | **disable**}—Enables or disables debugging for NMSP events.
  - **message** {**tx** | **rx**} {**enable** | **disable**}—Enables or disables debugging for NMSP transmit or receive messages.
  - **packet** {**enable** | **disable**}—Enables or disables debugging for NMSP packet events.
- Enable or disable debugging for NMSP interface events by entering this command:

  debug dot11 nmsp {**enable** | **disable**}
- Enable or disable debugging for IAPP NMSP events by entering this command:

  debug iapp nmsp {**enable** | **disable**}
- Enable or disable debugging for RFID NMSP messages by entering this command:

  debug rfid nmsp {**enable** | **disable**}
- Enable or disable debugging for access point monitor NMSP events by entering this command:

  debug service ap-monitor nmsp {**enable** | **disable**}
- Enable or disable debugging for wIPS NMSP events by entering this command:

  debug wips nmsp {**enable** | **disable**}

Configuring the Supervisor 720 to Support the WiSM

When you install a WiSM in a Cisco Catalyst 6500 series switch or a Cisco 7600 series router, you must configure the Supervisor 720 to support the WiSM. When the supervisor detects the WiSM, the supervisor creates ten Gigabit Ethernet interfaces, ranging from Gig*slot*/1 to Gig*slot*/8. For example, if the WiSM is in slot 9, the supervisor creates interfaces Gig9/1 through Gig9/8. The first eight Gigabit Ethernet interfaces must be organized into two EtherChannel bundles of four interfaces each. The remaining two Gigabit Ethernet interfaces are used as service-port interfaces, one for each controller on the WiSM. You must manually create VLANs to communicate with the ports on the WiSM.

Note The WiSM is supported on Cisco 7600 series routers running only Cisco IOS Release 12.2(18)SXF5.

General WiSM Guidelines

Follow these guidelines when you add a WiSM to your network:

- The switch or router ports leading to the controller service port are automatically configured and cannot be manually configured.
- The switch or router ports leading to the controller data ports should be configured as edge ports to avoid sending unnecessary BPDUs.
- The switch or router ports leading to the controller data ports should not be configured with any additional settings (such as port channel or SPAN destination) other than settings necessary for carrying data traffic to and from the controllers.

Note See Chapter 3, "Configuring Ports and Interfaces," for information on configuring the WiSM's ports and interfaces.

Configuring the Supervisor

Note You must log into the switch or router CLI and begin in privileged EXEC mode.

To configure the supervisor to support the WiSM, follow these steps:

	Command	Purpose
Step 1	**configure terminal**	Enters global configuration mode.
Step 2	**interface** *vlan*	Creates a VLAN to communicate with the data ports on the WiSM and enters interface configuration mode.
Step 3	**ip address** *ip-address gateway*	Assigns an IP address and gateway to the VLAN.
Step 4	**ip helper-address** *ip-address*	Assigns a helper address to the VLAN.
Step 5	**end**	Returns to global configuration mode.
Step 6	**wism module** *module_number* **controller** {**1** | **2**} **allowed-vlan** *vlan_number*	Creates Gigabit port-channel interfaces automatically for the specified WiSM controller and configure the port-channel interfaces as trunk ports. Also, specifies the VLAN that you created earlier as the allowed VLAN on the port-channel trunk. VLAN traffic is carried on the trunk between the WiSM controller and the supervisor. **Note** Services might be temporarily interrupted (for approximately two pings) after you enter this command.
Step 7	**wism module** *module_number* **controller** {**1** | **2**} **native-vlan** *vlan_number*	For the native VLAN on the ports, specifies the VLAN that you created earlier to communicate with the WiSM data ports.

	Command	Purpose
Step 8	**interface** *vlan*	Creates a VLAN to communicate with the service ports on the WiSM.
Step 9	**ip address** *ip_address gateway*	Assigns an IP address and gateway to the VLAN.
Step 10	**end**	Returns to global configuration mode.
Step 11	**wism service-vlan** *vlan*	Configures the VLAN that you created in Steps 8 through Step 10 to communicate with the WiSM service ports.
Step 12	**end**	Returns to global configuration mode.
Step 13	**show wism status**	Verifies that the WiSM is operational

Note The commands used for communication between the Cisco WiSM, the Supervisor 720, and the 4404 controllers are documented in *Configuring a Cisco Wireless Services Module and Wireless Control System* at this URL: http://www.cisco.com/en/US/docs/wireless/technology/wism/technical/reference/appnote.html#wp39498

Using the Wireless LAN Controller Network Module

Follow these guidelines when using a wireless LAN controller network module (CNM) installed in a Cisco Integrated Services Router:

- The CNM does not support IPsec. To use IPsec with the CNM, configure IPsec on the router in which the CNM is installed. Click this link to browse to IPsec configuration instructions for routers:

  http://www.cisco.com/en/US/tech/tk583/tk372/tech_configuration_guides_list.html

- The CNM does not have a battery and cannot save a time setting. It must receive a time setting from an external NTP server when it powers up. When you install the module, the configuration wizard prompts you for NTP server information.
- To access the CNM bootloader, we recommend that you reset the CNM from the router. If you reset the CNM from a CNM user interface, the router might reset the CNM while you are using the bootloader.

  When you reset the CNM from a CNM interface, you have 17 minutes to use the bootloader before the router automatically resets the CNM. The CNM bootloader does not run the Router Blade Configuration Protocol (RBCP), so the RBCP heartbeat running on the router times out after 17 minutes, triggering a reset of the CNM.

  If you reset the CNM from the router, the router stops the RBCP heartbeat exchange and does not restart it until the CNM boots up. To reset the CNM from the router, enter one of these commands on the router CLI:

  service-module wlan-controller 1/0 reset (for Fast Ethernet CNM versions)

  service-module integrated-service-engine 1/0 reset (for Gigabit Ethernet CNM versions)

- Gigabit Ethernet versions of the Controller Network Module are supported on Cisco 28/37/38xx Series Integrated Services Routers running Cisco IOS Release 12.4(11)T2 or later.

Resetting the Controller to Default Settings

If you want to return the controller to its original configuration, you can use the controller GUI or CLI to reset the controller to factory-default settings.

Using the GUI to Reset the Controller to Default Settings

To return the controller to factory-default setting using the controller GUI, follow these steps:

Step 1 Open your Internet browser.

Step 2 Enter the controller IP address in the browser address line and press **Enter**. An Enter Network Password dialog box appears.

Step 3 Enter your username in the User Name text box. The default username is *admin*.

Step 4 Enter the wireless device password in the Password text box and press **Enter**. The default password is *admin*.

Step 5 Choose **Commands** > **Reset to Factory Default**.

Step 6 Click **Reset**.

Step 7 When prompted, confirm the reset.

Step 8 Reboot the controller without saving the configuration.

Step 9 Use the configuration wizard to enter configuration settings. See the "Using the Configuration Wizard" section on page 2-1 for instructions.

Using the CLI to Reset the Controller to Default Settings

To return the controller to factory default settings using the controller CLI, follow these steps:

Step 1 Enter the **reset system** command. At the prompt that asks whether you need to save changes to the configuration, enter **N**. The unit reboots.

Step 2 When you are prompted for a username, enter the **recover-config** command to restore the factory-default configuration. The controller reboots and displays this message:

```
Welcome to the Cisco WLAN Solution Wizard Configuration Tool
```

Step 3 Use the configuration wizard to enter configuration settings. See the "Using the Configuration Wizard" section on page 2-1 for instructions.

CHAPTER 5

Configuring VideoStream

This chapter describes how to configure Cisco VideoStream functionality on the controller. It contains these sections:

Overview of the VideoStream

The IEEE 802.11 wireless multicast delivery mechanism does not provide a reliable way to acknowledge lost or corrupted packets. As a result, if any multicast packet is lost in the air, it is not sent again which may cause an IP multicast stream unviewable.

The VideoStream feature makes the IP multicast stream delivery reliable over the air, by converting the broadcast frame over the air to a unicast frame. Each VideoStream client acknowledges receiving a video IP multicast stream.

Guidelines for Configuring VideoStream on the Controller

Follow these guidelines when configuring VideoStream on the controller:

- The AP1100 and AP1200 do not support the reliable multicast feature.
- Make sure that the multicast feature is enabled. We recommend configuring IP multicast on the controller with multicast-multicast mode.
- Check for the IP address on the client machine. The machine should have an IP address from the respective VLAN.
- If there is a mismatch in the version of code on your controller, upgrade the controller code to 7.0.98.0 or later.
- Verify that the access points have joined the controllers.
- Make sure that the clients are able to associate to the configured WLAN at 802.11n speed.
- VideoStream is supported on the following access points: Cisco Aironet 3500, 1260, 1250, 1240AG, 1140, 1130AG, and 1040.

Configuring VideoStream

This section describes how to configure VideoStream on the controller. This section contains the following topics:

Using the GUI to Configure the VideoStream on the Controller

To configure the VideoStream on the controller using the controller GUI, follow these steps:

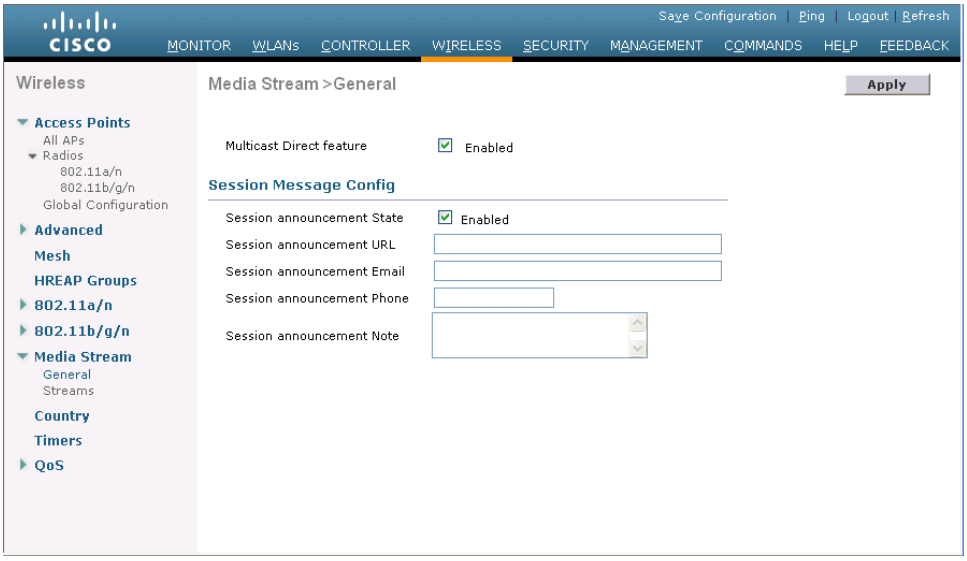
Note To enable the multicast feature using the controller GUI, perform Step 1 through Step 8.

Step 1 Choose **WIRELESS > Media Stream > General** to open the **Media Stream > General** page (see Figure 5-1).

Step 2 Select the **Multicast Direct Feature** check box to enable the multicast direct feature. The default value is disabled.

Note Enabling the Multicast Direct feature does not automatically reset the existing client state. The wireless clients must rejoin the multicast stream after enabling the Multicast Direct feature on the controller.

Figure 5-1 Media Stream > General Page



Step 3 Under the Session Message Config, select **Session announcement State** to enable the session announcement mechanism. If this feature is enabled, clients are informed each time a controller is not able to serve the multicast direct data to the client.

Step 4 In the Session announcement URL text box, enter the URL where the client can find more information when an error occurs during the multicast media stream transmission.

Step 5 In the Session announcement e-mail text box, enter the e-mail address of the person who can be contacted.

Step 6 In the Session announcement Phone text box, enter the phone number of the person who can be contacted.

Step 7 In the Session announcement Note text box, enter a reason as to why a particular client cannot be served with a multicast media.

Step 8 Click **Apply** to commit your changes.

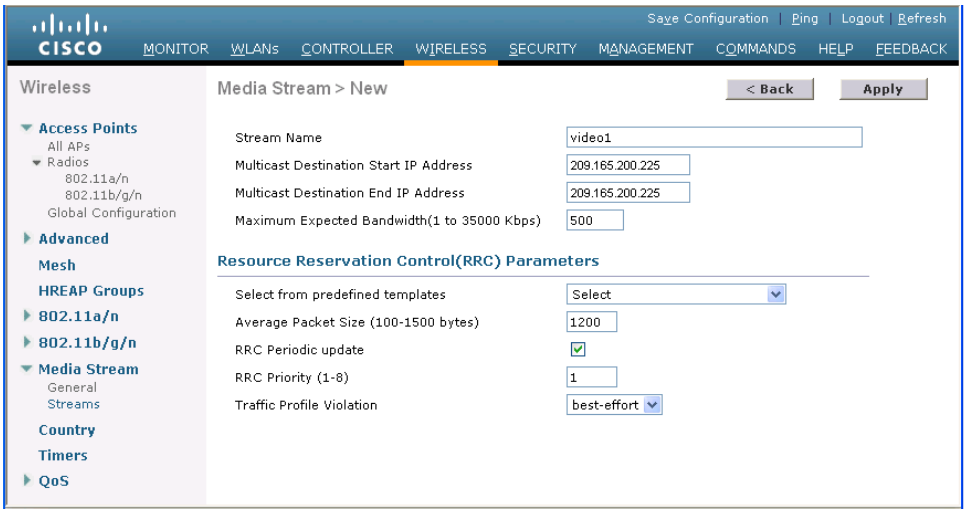
Note **To add a media stream using the controller GUI, perform Step 9 through Step 16.**

Step 9 Choose **WIRELESS > Media Stream > Streams** to open the Media Stream page (see Figure 5-2).

Figure 5-2 Media Streams Page

Step 10 Click **Add New** to configure a new media stream. The Media Stream > New page (see Figure 5-3) appears.

Figure 5-3 Media Stream > New Page



Note The Stream Name, Multicast Destination Start IP Address, and Multicast Destination End IP Address text boxes are mandatory. You must enter information in these text boxes.

Step 11 In the Stream Name text box, enter the media stream name. The stream name can be up to 64 characters.

Step 12 In the Multicast Destination Start IP Address text box, enter the start IP address of the multicast media stream.

Step 13 In the Multicast Destination End IP Address text box, enter the end IP address of the multicast media stream.

Step 14 In the Maximum Expected Bandwidth text box, enter the maximum expected bandwidth that you want to assign to the media stream. The values can range between 1 to 35000 kbps.

Note We recommend that you use a template to add a media stream to the controller.

Step 15 From the Select from Predefined Templates drop-down list under Resource Reservation Control (RRC) Parameters, choose one of the following options to specify the details about the resource reservation control:

- **Very Coarse** (below 300 kbps)
- **Coarse** (below 500 kbps)
- **Ordinary** (below 750 kbps)
- **Low** (below 1 Mbps)
- **Medium** (below 3 Mbps)
- **High** (below 5 Mbps)

Note When you select a predefined template from the drop-down list, the following text boxes under the Resource Reservation Control (RRC) Parameters list their default values that are assigned with the template.

- **Average Packet Size** (100-1500 bytes)—Specifies the average packet size. The value can be in the range of 100 to 1500 bytes. The default value is 1200.
- **RRC Periodic update**—Enables the RRC (Resource Reservation Control Check) Periodic update. By default, this option is enabled. RRC periodically updates the admission decision on the admitted stream according to the correct channel load. As a result, it may deny certain low priority admitted stream requests.
- **RRC Priority** (1-8)—Specifies the priority bit set in the media stream. The priority can be any number between 1 and 8. The larger the value means the higher the priority is. For example, a priority of 1 is the lowest value and a value of 8 is the highest value. The default priority is 4. The low priority stream may be denied in the RRC periodic update.
- **Traffic Profile Violation**—Specifies the action to perform in case of a violation after a re-RRC. Choose an action from the drop-down list. The possible values are as follows:
  - Drop —Specifies that a stream is dropped on periodic revaluation.
  - Fallback—Specifies that a stream is demoted to BestEffort class on periodic reevaluation.

The default value is drop.

Step 16 Click **Apply** to save the configuration changes.

Note To enable the media stream using the controller GUI, perform Step 17 through Step 20.

Note The media stream added needs to be enabled for multicast-direct.

Step 17 Choose **WLANs > WLAN ID** to open the WLANs > Edit page.

Step 18 Choose the **QoS** tab and select **Gold (Video)** from the Quality of Service (QoS) drop-down list.

Step 19 Enable **Multicast Direct**.

Step 20 Click **Apply** to save the configuration changes.

Note To set the EDCA parameters to voice and video optimized using the controller GUI, perform Step 21 through Step 23.

Note Setting the EDCA parameters to voice and video optimized is an optional procedure.

Step 21 Choose **WIRELESS > 802.11a/n** or **802.11b/g/n > EDCA Parameters**.

Step 22 From the EDCA Profile drop-down list, choose **Voice and Video Optimized** option.

Step 23 Click **Apply** to save the changes made.

Note To enable the admission control on desired band for video using the controller GUI, perform Step 24 through Step 27.

Note Enabling the admission control on the desired band for video is optional.

Note Keep the voice bandwidth allocation to a minimum for better performance.

Step 24 Choose **WIRELESS > 802.11a/n** or **802.11b/g/n > Media** to open the 802.11a/n (5 GHZ) or 802.11b/g/n > Media page.

Step 25 Choose the **Video** tab.

Step 26 Select the **Admission Control (ACM)** check box to enable bandwidth-based CAC for this radio band. The default value is disabled.

Step 27 Click **Apply** to save the configuration changes.

Note To configure the video bandwidth using the controller GUI, perform Step 28 through Step 33.

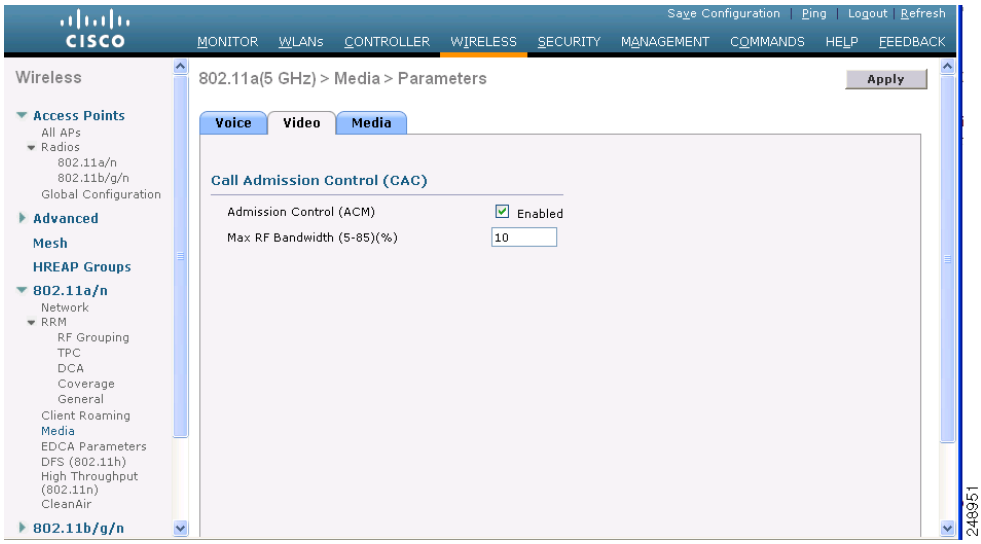
Note The template bandwidth that is configured for a media stream should be more than the bandwidth for the source media stream.

Note sThe voice configuration is optional. Keep the voice bandwidth allocation to a minimum for better performance.

Step 28 Choose **WIRELESS > 802.11a/n** or **802.11b/g/n > Media** to open the 802.11a/n (5 GHZ) or 802.11b/g/n > Media page.

Step 29 Choose the **Video** tab (see Figure 5-4).

Figure 5-4 802.11 a/n Video



Step 30 Select the **Admission Control (ACM)** check box to enable the video CAC for this radio band. The default value is disabled.

Step 31 In the Max RF Bandwidth field, enter the percentage of the maximum bandwidth allocated to clients for video applications on this radio band. Once the client reaches the value specified, the access point rejects new requests on this radio band.

The range is 5 to 85%.

The default value is 9%.

Step 32 Click **Apply** to commit your changes.

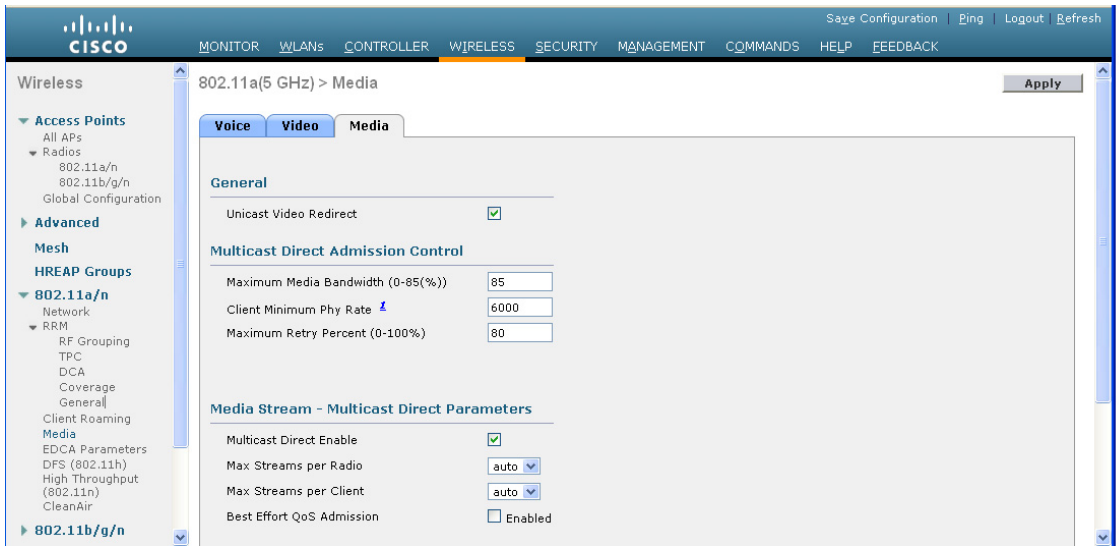
Step 33 Reenable all WMM WLANs and click **Apply**.

Note **To configure the media bandwidth using the controller GUI, perform Step 34 through Step 44.**

Step 34 Choose **Wireless > 802.11a/n** or **802.11b/g/n > Media** to open the 802.11a (or 802.11b) > Media > Parameters page.

Step 35 Choose the **Media** tab to open the Media page (see Figure 5-5).

Figure 5-5 Media Streams Page



Step 36 Select the **Unicast Video Redirect** check box to enable Unicast Video Redirect. The default value is disabled.

Step 37 In the Maximum Media Bandwidth (0-85%) text box, enter the percentage of the maximum bandwidth to be allocated for media applications on this radio band. Once the client reaches a specified value, the access point rejects new calls on this radio band.

The default value is 85%; valid values are from 0 to 85%.

Step 38 In the Client Phy Rate field, enter the minimum transmission data rate to the client. If the transmission data rate is below the phy rate, either the video will not start or the client may be classified as a bad client. The bad client video can be demoted for better effort QoS or subject to denial.

Step 39 In the Maximum Retry Percent (0-100%) field, enter the percentage of maximum retries that are allowed. The default value is 80. If it exceeds 80, either the video will not start or client may be classified as a bad client. The bad client video can be demoted for better effort QoS or subject to denial.

Step 40 Select the **Multicast Direct Enable** check box to enable the Multicast Direct Enable field. The default value is enabled.

Step 41 From the Max Streams per Radio drop-down list, choose the maximum number of streams allowed per radio from the range 0 to 20. The default value is set to auto. If you choose auto, there is no limit set for the number of client subscriptions.

Step 42 From the Max Streams per Client drop-down list, choose the maximum number of streams allowed per client from the range 0 to 20. The default value is set to auto. If you choose auto, there is no limit set for the number of client subscriptions.

Step 43 Select the Best Effort QoS Admission check box to enable best-effort QoS admission.

Step 44 Click **Apply** to save the configuration changes

Note To enable WLANs using the controller GUI, perform Step 45 through Step 48.

Step 45 Choose **WLANS > WLAN ID**. The WLANs > Edit page appears.

Step 46 Enable the VideoStream feature for the WLAN.

Step 47 Select the **Status** check box to enable the WLAN.

Step 48 Click **Apply** to commit your changes.

Note To enable the 802.11 a/n or 802.11 b/g/n network using the controller GUI, perform Step 49 through Step 51.

Step 49 Choose **WIRELESS > Wireless > 802.11a/n** or **802.11b/g/n > Network**.

Step 50 Select the **802.11a** or **802.11b/g Network Status** check box to enable the network status.

Step 51 Click **Apply** to commit your changes.

Note To verify if the clients are associated with the multicast groups and group-ides using the controller GUI, perform Step 52 through Step 56.

Step 52 Choose **MONITOR > Clients**. The Clients page appears.

Step 53 Check if the 802.11a or 802.11b/g network clients have the associated access points.

Step 54 Choose **Monitor > Multicast**. The Multicast Groups page appears.

Step 55 Select the **MGID** check box for the VideoStream to the clients.

Step 56 Click **MGID.** The Multicast Group Detail page appears. Check the Multicast Status details.

Using the CLI to Configure the VideoStream to the Controller

To configure the VideoStream to the controller using the controller GUI, follow these steps:

Step 1 Configure multicast-direct feature on WLANs media stream by entering this command:

config wlan media-stream multicast-direct {*wlan_id* | **all**} {**enable** | **disable**}

Step 2 Enable or disable the multicast feature by entering this command:

config media-stream multicast-direct {**enable** | **disable**}

Step 3 Configure various message configuration parameters by entering this command:

config media-stream message {state [enable | disable] | url *url* **| email** *email* **| phone** *phone _number* **| note** *note***}**

Step 4 Save your changes by entering this command:

save config

Step 5 Configure various global media-stream configurations by entering this commands:

config media-stream add multicast-direct stream-name *media_stream_name start_IP end_IP* [**template** {**very-coarse | coarse | ordinary | low-resolution | med-resolution | high-resolution**} | **detail** {**Max_bandwidth** *bandwidth* **| packet size** *packet_size* **| Re-evaluation** *re-evaluation* {*periodic* | *initial*}} **video** *video* **priority {drop | fallback}**

Note
- The Resource Reservation Control (RRC) parameters are assigned with the predefined values based on the values assigned to the template.
- The following templates are used to assign RRC parameters to the media stream:
  - Very Coarse (below 3000 kbps)
  - Coarse (below 500 kbps)
  - Ordinary (below 750 kbps)
  - Low Resolution (below 1 mbps)
  - Medium Resolution (below 3 mbps)
  - High Resolution (below 5 mbps)

Step 6 Delete a media stream by entering this command:

config media-stream delete *media_stream_name*

Step 7 Enable a specific enhanced distributed channel access (EDC) profile by entering this command:

config advanced {**801.11a | 802.11b**} **edca-parameters optimized-video-voice**

Step 8 Enable the admission control on desired bandwidth by entering the following commands:

- Enable bandwidth-based voice CAC for 802.11a or 802.11b/g network by entering this command:

  config {**802.11a | 802.11b**} **cac voice acm enable**

- Set the percentage of the maximum bandwidth allocated to clients for voice applications on the 802.11a or 802.11b/g network by entering this command:

  config {**802.11a | 802.11b**} **cac voice max-bandwidth** *bandwidth*

- Configure the percentage of the maximum allocated bandwidth reserved for roaming voice clients on the 802.11a or 802.11b/g network by entering this command:

  config {**802.11a | 802.11b**} **cac voice roam-bandwidth** *bandwidth*

Step 9 Set the maximum number of streams per radio and/or per client by entering the following commands:

- Set the maximum limit to the number multicast streams per radio by entering this command:

  config {802.11a | 802.11b} media-stream multicast-direct radio-maximum [value | 'no-limit']

- Set the maximum number of multicast streams per client by entering this command:

  config {802.11a | 802.11b} media-stream multicast-direct client-maximum [value | 'no-limit']

Step 10 Save your changes by entering this command:

save config

Use the following commands to view or debug media streams functionality:

- See the configured media streams by entering this command:

  show wlan *wlan_id*
- See the details of the media stream name by entering this command:

  show 802.11{a | b | h} media-stream *media-stream_name*
- See the clients for a media stream by entering this command:

  show 802.11a media-stream client *media-stream-name*
- See a summary of the media stream and client information by entering this command:

  show media-stream group summary
- See details about a particular media stream group by entering this command:

  show media-stream group detail *media_stream_name*
- See details of the 802.11a or 802.11b media resource reservation configuration by entering this command:

  show {802.11a | 802.11b} media-stream rrc
- Enable debugging of media stream history by entering this command:

  debug media-stream history {enable | disable}

CHAPTER 6

Configuring Security Solutions

This chapter describes security solutions for wireless LANs. It contains these sections:

Cisco UWN Solution Security

Cisco UWN solution security includes the following sections:

Security Overview

The Cisco UWN security solution bundles potentially complicated Layer 1, Layer 2, and Layer 3 802.11 Access Point security components into a simple policy manager that customizes system-wide security policies on a per-WLAN basis. The Cisco UWN security solution provides simple, unified, and systematic security management tools.

One of the biggest hurdles to WLAN deployment in the enterprise is WEP encryption, which is a weak standalone encryption method. A newer problem is the availability of low-cost access points, which can be connected to the enterprise network and used to mount man-in-the-middle and denial-of-service attacks.

Layer 1 Solutions

The Cisco UWN security solution ensures that all clients gain access within a user-set number of attempts. If a client fails to gain access within that limit, it is automatically excluded (blocked from access) until the user-set timer expires. The operating system can also disable SSID broadcasts on a per-WLAN basis.

Layer 2 Solutions

If a higher level of security and encryption is required, you can also implement industry-standard security solutions such as Extensible Authentication Protocol (EAP), Wi-Fi protected access (WPA), and WPA2. The Cisco UWN solution WPA implementation includes AES (advanced encryption standard), TKIP and Michael (temporal key integrity protocol and message integrity code checksum) dynamic keys, or WEP (Wired Equivalent Privacy) static keys. Disabling is also used to automatically block Layer 2 access after a user-set number of failed authentication attempts.

Regardless of the wireless security solution selected, all Layer 2 wired communications between controllers and lightweight access points are secured by passing data through CAPWAP tunnels.

Note With WPA/WPA2, CCKM as Auth Key management, and a latency between controller and AP set as 2 seconds, Cisco Aironet client adapter of version 4.2 does not authenticate.

Layer 3 Solutions

The WEP problem can be further solved using industry-standard Layer 3 security solutions such as passthrough VPNs (virtual private networks).

The Cisco UWN solution supports local and RADIUS MAC (media access control) filtering. This filtering is best suited to smaller client groups with a known list of 802.11 access card MAC addresses.

The Cisco UWN solution supports local and RADIUS user/password authentication. This authentication is best suited to small to medium client groups.

Integrated Security Solutions

The integrated security solutions are as follows:

- Cisco UWN solution operating system security is built around a 802.1X AAA (authorization, authentication and accounting) engine, which allows users to rapidly configure and enforce a variety of security policies across the Cisco UWN solution.
- The controllers and lightweight access points are equipped with system-wide authentication and authorization protocols across all ports and interfaces, maximizing system security.
- Operating system security policies are assigned to individual WLANs, and lightweight access points simultaneously broadcast all (up to 16) configured WLANs, which can eliminate the need for additional access points, which can increase interference and degrade system throughput.
- Operating system security uses the RRM function to continually monitor the air space for interference and security breaches and to notify the user when they are detected.
- Operating system security works with industry-standard authorization, authentication, and accounting (AAA) servers.

Configuring RADIUS

Remote Authentication Dial-In User Service (RADIUS) is a client/server protocol that provides centralized security for users attempting to gain management access to a network. It serves as a backend database similar to local and TACACS+ and provides authentication and accounting services:

- Authentication—The process of verifying users when they attempt to log into the controller.

  Users must enter a valid username and password in order for the controller to authenticate users to the RADIUS server.

  Note When multiple databases are configured, you can use the controller GUI or CLI to specify the sequence in which the backend databases should be tried.

- Accounting—The process of recording user actions and changes.

  Whenever a user successfully executes an action, the RADIUS accounting server logs the changed attributes, the user ID of the person who made the change, the remote host where the user is logged in, the date and time when the command was executed, the authorization level of the user, and a description of the action performed and the values provided. If the RADIUS accounting server becomes unreachable, users are able to continue their sessions uninterrupted.

RADIUS uses User Datagram Protocol (UDP) for its transport. It maintains a database and listens on UDP port 1812 for incoming authentication requests and UDP port 1813 for incoming accounting requests. The controller, which requires access control, acts as the client and requests AAA services from the server. The traffic between the controller and the server is encrypted by an algorithm defined in the protocol and a shared secret key configured on both devices.

You can configure up to 17 RADIUS authentication and accounting servers each. For example, you may want to have one central RADIUS authentication server but several RADIUS accounting servers in different regions. If you configure multiple servers of the same type and the first one fails or becomes unreachable, the controller automatically tries the second one, then the third one if necessary, and so on.

Note If multiple RADIUS servers are configured for redundancy, the user database must be identical in all the servers for the backup to work properly.

The primary RADIUS server (the server with the lowest server index) is assumed to be the most preferable server for the controller. If the primary server becomes unresponsive, the controller switches to the next active backup server (the server with the next lowest server index). The controller continues to use this backup server forever, unless you configure the controller to fall back to the primary RADIUS server when it recovers and becomes responsive or to a more preferable server from the available backup servers.

You must configure RADIUS on both your CiscoSecure Access Control Server (ACS) and your controller. You can configure the controller through either the GUI or the CLI.

Configuring RADIUS on the ACS

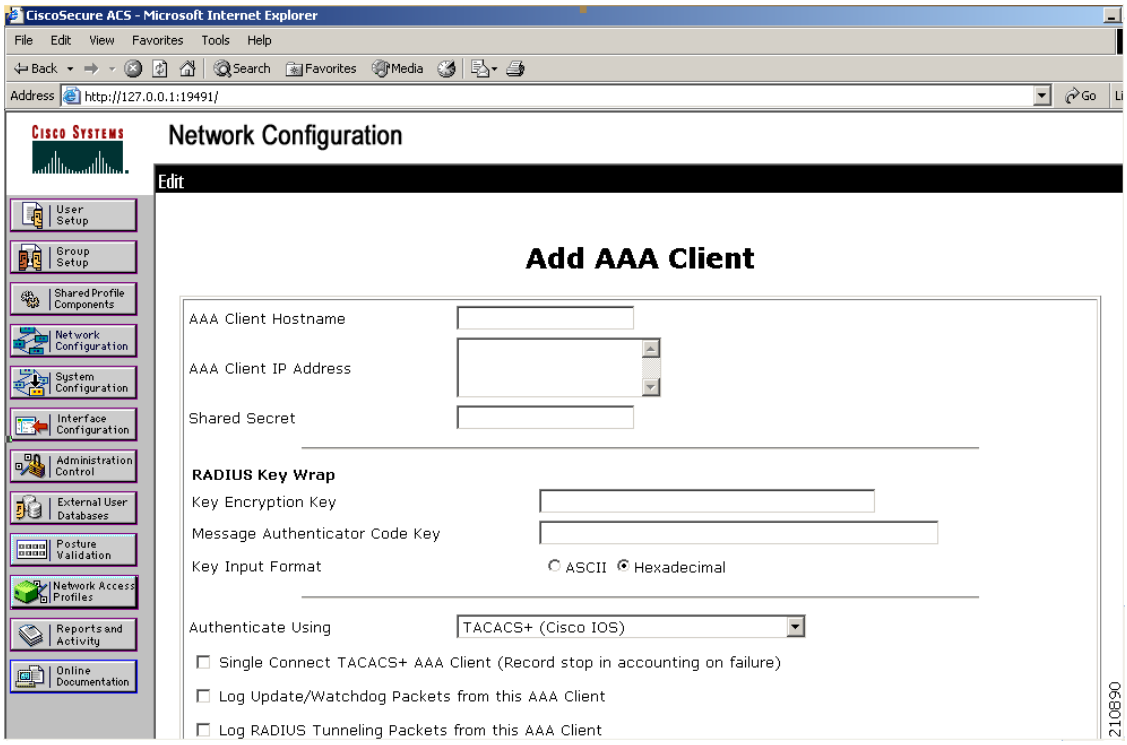
To configure RADIUS on the ACS, follow these steps:

Note RADIUS is supported on CiscoSecure ACS version 3.2 and later releases. The figures and instructions in this section pertain to ACS version 4.1 and may vary for other versions. See the *CiscoSecure ACS* documentation for the version that you are running.

Step 1 Choose **Network Configuration** on the ACS main page.

Step 2 Choose **Add Entry** under AAA Clients to add your controller to the server. The Add AAA Client page appears (see Figure 6-1).

Figure 6-1 Add AAA Client Page on CiscoSecure ACS



Step 3 In the AAA Client Hostname text box, enter the name of your controller.

Step 4 In the AAA Client IP Address text box, enter the IP address of your controller.

Step 5 In the Shared Secret text box, enter the shared secret key to be used for authentication between the server and the controller.

Note The shared secret key must be the same on both the server and the controller.

Step 6 From the Authenticate Using drop-down list, choose **RADIUS (Cisco Aironet)**.

Step 7 Click **Submit + Apply** to save your changes.

Step 8 Choose **Interface Configuration** on the ACS main page.

Step 9 Choose **RADIUS (Cisco Aironet)**. The RADIUS (Cisco Aironet) page appears.

Step 10 Under User Group, select the **Cisco-Aironet-Session-Timeout** check box.

Step 11 Click **Submit** to save your changes.

Step 12 On the ACS main page, from the left navigation pane, choose **System Configuration.**

Step 13 Choose **Logging**.

Step 14 When the Logging Configuration page appears, enable all of the events that you want to be logged and save your changes.

Step 15 On the ACS main page, from the left navigation pane, choose **Group Setup**.

Step 16 Choose a previously created group from the Group drop-down list.

Note This step assumes that you have already assigned users to groups on the ACS according to the roles to which they will be assigned.

Step 17 Click **Edit Settings**. The Group Setup page appears.

Step 18 Under Cisco Aironet Attributes, select the **Cisco-Aironet-Session-Timeout** check box and enter a session timeout value in the edit box.

Step 19 Specify read-only or read-write access to controllers through RADIUS authentication, by setting the Service-Type attribute (006) to **Callback NAS Prompt** for read-only access or to **Administrative** for read-write privileges. If you do not set this attribute, the authentication process completes successfully (without an authorization error on the controller), but you might be prompted to authenticate again.

Note If you set the Service-Type attribute on the ACS, make sure to select the **Management** check box on the RADIUS Authentication Servers page of the controller GUI. See Step 17 in the next section for more information.

Note The "RADIUS Authentication Attributes Sent by the Access Point" section on page 6-15 lists the RADIUS attributes that are sent by a lightweight access point to a client in access-request and access-accept packets.

Step 20 Click **Submit** to save your changes.

Using the GUI to Configure RADIUS

To configure RADIUS using the controller GUI, follow these steps:

Step 1 Choose **Security** > **AAA** > **RADIUS**.

Step 2 Perform one of the following:

- If you want to configure a RADIUS server for authentication, choose **Authentication**.
- If you want to configure a RADIUS server for accounting, choose **Accounting**.

Note The pages used to configure authentication and accounting contain mostly the same text boxes. Therefore, these instructions walk through the configuration only once, using the Authentication pages as examples. You would follow the same steps to configure multiple services and/or multiple servers.

The RADIUS Authentication (or Accounting) Servers page appears (see Figure 6-2).

Figure 6-2 RADIUS Authentication Servers Page

This page lists any RADIUS servers that have already been configured.

- If you want to delete an existing server, hover your cursor over the blue drop-down arrow for that server and choose **Remove**.
- If you want to make sure that the controller can reach a particular server, hover your cursor over the blue drop-down arrow for that server and choose **Ping**.

Step 3 From the Call Station ID Type drop-down list, choose **IP Address**, **System MAC Address**, or **AP MAC Address** to specify whether the IP address, system MAC address, or AP MAC address of the originator will be sent to the RADIUS server in the Access-Request message.

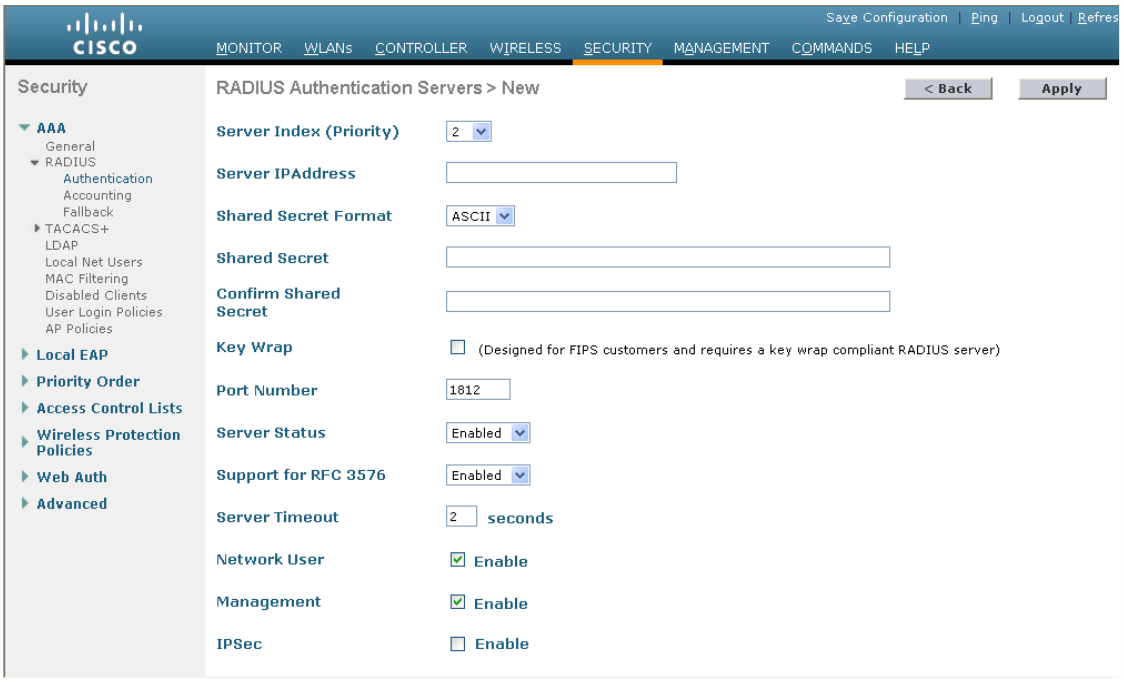
Step 4 Enable RADIUS-to-controller key transport using AES key wrap protection by selecting the **Use AES Key Wrap** check box. The default value is unselected. This feature is required for FIPS customers.

Step 5 Click **Apply** to commit your changes.

Step 6 Perform one of the following:

- To edit an existing RADIUS server, click the server index number for that server. The RADIUS Authentication (or Accounting) Servers > Edit page appears.
- To add a RADIUS server, click **New**. The RADIUS Authentication (or Accounting) Servers > New page appears (see Figure 6-3).

Figure 6-3 RADIUS Authentication Servers > New Page



Step 7 If you are adding a new server, choose a number from the Server Index (Priority) drop-down list to specify the priority order of this server in relation to any other configured RADIUS servers providing the same service. You can configure up to 17 servers. If the controller cannot reach the first server, it tries the second one in the list, then the third one if necessary, and so on.

Step 8 If you are adding a new server, enter the IP address of the RADIUS server in the Server IP Address text box.

Step 9 From the Shared Secret Format drop-down list, choose **ASCII** or **Hex** to specify the format of the shared secret key to be used between the controller and the RADIUS server. The default value is ASCII.

Step 10 In the Shared Secret and Confirm Shared Secret text boxes, enter the shared secret key to be used for authentication between the controller and the server.

Note The shared secret key must be the same on both the server and the controller.

Step 11 If you are configuring a new RADIUS authentication server and want to enable AES key wrap, which makes the shared secret between the controller and the RADIUS server more secure, follow these steps:

Note AES key wrap is designed for Federal Information Processing Standards (FIPS) customers and requires a key-wrap compliant RADIUS authentication server.

a. Select the **Key Wrap** check box.

b. From the Key Wrap Format drop-down list, choose **ASCII** or **HEX** to specify the format of the AES key wrap keys: Key Encryption Key (KEK) and Message Authentication Code Key (MACK).

c. In the Key Encryption Key (KEK) text box, enter the 16-byte KEK.

d. In the Message Authentication Code Key (MACK) text box, enter the 20-byte KEK.

Step 12 If you are adding a new server, enter the RADIUS server's UDP port number for the interface protocols in the Port Number text box. The valid range is 1 to 65535, and the default value is 1812 for authentication and 1813 for accounting.

Step 13 From the Server Status text box, choose **Enabled** to enable this RADIUS server or choose **Disabled** to disable it. The default value is Enabled.

Step 14 If you are configuring a new RADIUS authentication server, choose **Enabled** from the Support for RFC 3576 drop-down list to enable RFC 3576, which is an extension to the RADIUS protocol that allows dynamic changes to a user session, or choose **Disabled** to disable this feature. The default value is Enabled. RFC 3576 includes support for disconnecting users and changing authorizations applicable to a user session and supports disconnect and change-of-authorization (CoA) messages. Disconnect messages cause a user session to be terminated immediately where CoA messages modify session authorization attributes such as data filters.

Step 15 In the Server Timeout text box, enter the number of seconds between retransmissions. The valid range is 2 to 30 seconds, and the default value is 2 seconds.

Note We recommend that you increase the timeout value if you experience repeated reauthentication attempts or the controller falls back to the backup server when the primary server is active and reachable.

Step 16 Select the **Network User** check box to enable network user authentication (or accounting), or unselect it to disable this feature. The default value is selected. If you enable this feature, this entry is considered the RADIUS authentication (or accounting) server for network users. If you did not configure a RADIUS server entry on the WLAN, you must enable this option for network users.

Step 17 If you are configuring a RADIUS authentication server, select the **Management** check box to enable management authentication, or unselect it to disable this feature. The default value is selected. If you enable this feature, this entry is considered the RADIUS authentication server for management users, and authentication requests go to the RADIUS server.

Step 18 Select the **IPSec** check box to enable the IP security mechanism, or unselect it to disable this feature. The default value is unselected.

Note The IPsec option appears only if a crypto card is installed in the controller.

Step 19 If you enabled IPsec in Step 18, follow these steps to configure additional IPsec parameters:

a. From the IPSec drop-down list, choose one of the following options as the authentication protocol to be used for IP security: **HMAC MD5** or **HMAC SHA1**. The default value is HMAC SHA1.

A message authentication code (MAC) is used between two parties that share a secret key to validate information transmitted between them. HMAC (Hash MAC) is based on cryptographic hash functions. It can be used in combination with any iterated cryptographic hash function. HMAC MD5 and HMAC SHA1 are two constructs of the HMAC using the MD5 hash function and the SHA1 hash function. HMAC also uses a secret key for calculation and verification of the message authentication values.

b. From the IPSec Encryption drop-down list, choose one of the following options to specify the IP security encryption mechanism:

- **DES**—Data Encryption Standard that is a method of data encryption using a private (secret) key. DES applies a 56-bit key to each 64-bit block of data.
- **3DES**—Data Encryption Standard that applies three keys in succession. This is the default value.

- **AES CBS**—Advanced Encryption Standard that uses keys with a length of 128, 192, or 256 bits to encrypt data blocks with a length of 128, 192, or 256 bits. AES 128 CBC uses a 128-bit data path in Cipher Clock Chaining (CBC) mode.

c. From the IKE Phase 1 drop-down list, choose one of the following options to specify the Internet Key Exchange (IKE) protocol: **Aggressive** or **Main**. The default value is Aggressive.

IKE Phase 1 is used to negotiate how IKE should be protected. Aggressive mode passes more information in fewer packets with the benefit of slightly faster connection establishment at the cost of transmitting the identities of the security gateways in the clear.

d. In the Lifetime text box, enter a value (in seconds) to specify the timeout interval for the session. The valid range is 1800 to 57600 seconds, and the default value is 1800 seconds.

e. From the IKE Diffie Hellman Group drop-down list, choose one of the following options to specify the IKE Diffie Hellman group: **Group 1 (768 bits)**, **Group 2 (1024 bits)**, or **Group 5 (1536 bits)**. The default value is Group 1 (768 bits).

Diffie-Hellman techniques are used by two devices to generate a symmetric key through which they can publicly exchange values and generate the same symmetric key. Although all three groups provide security from conventional attacks, Group 5 is considered more secure because of its larger key size. However, computations involving Group 1 and Group 2 based keys might occur slightly faster because of their smaller prime number size.

Step 20 Click **Apply** to commit your changes.

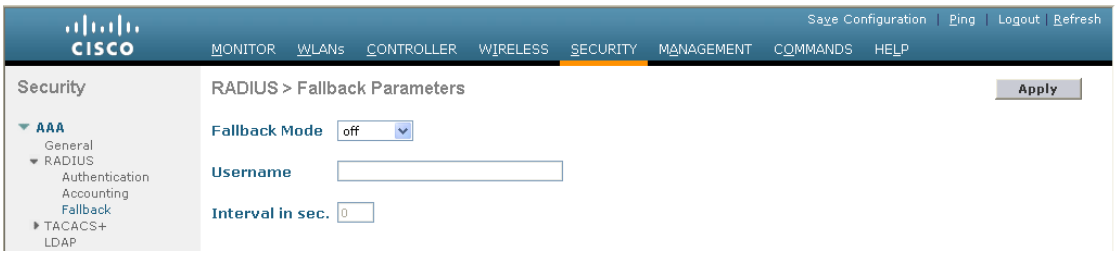
Step 21 Click **Save Configuration** to save your changes.

Step 22 Repeat the previous steps if you want to configure any additional services on the same server or any additional RADIUS servers.

Step 23 Specify the RADIUS server fallback behavior, as follows:

a. Choose **Security** > **AAA** > **RADIUS** > **Fallback** to open the RADIUS > Fallback Parameters page (see Figure 6-4).

Figure 6-4 RADIUS > Fallback Parameters Page



b. From the Fallback Mode drop-down list, choose one of the following options:

- **Off**—Disables RADIUS server fallback. This is the default value.
- **Passive**—Causes the controller to revert to a server with a lower priority from the available backup servers without using extraneous probe messages. The controller ignores all inactive servers for a time period and retries later when a RADIUS message needs to be sent.
- **Active**—Causes the controller to revert to a server with a lower priority from the available backup servers by using RADIUS probe messages to proactively determine whether a server that has been marked inactive is back online. The controller ignores all inactive servers for all

active RADIUS requests. Once the primary server receives a response from the recovered ACS server, the active fallback RADIUS server no longer sends probe messages to the server requesting the active probe authentication.

c. If you enabled Active fallback mode in Step b, enter the name to be sent in the inactive server probes in the Username text box. You can enter up to 16 alphanumeric characters. The default value is "cisco-probe."

d. If you enabled Active fallback mode in Step b, enter the probe interval value (in seconds) in the Interval in Sec text box. The interval serves as inactive time in passive mode and probe interval in active mode. The valid range is 180 to 3600 seconds, and the default value is 300 seconds.

Step 24 Specify the order of authentication when multiple databases are configured by choosing **Security** > **Priority Order** > **Management User**. The Priority Order > Management User page appears (see Figure 6-5).

Figure 6-5 Priority Order > Management User Page

Step 25 In the Order Used for Authentication text box, specify which servers have priority when the controller attempts to authenticate management users. Use the **>** and **<** buttons to move servers between the Not Used and Order Used for Authentication text boxes. After the desired servers appear in the Order Used for Authentication text box, use the **Up** and **Down** buttons to move the priority server to the top of the list.

By default, the local database is always queried first. If the username is not found, the controller switches to the RADIUS server if configured for RADIUS or to the TACACS+ server if configured for TACACS+. The default setting is local and then RADIUS.

Step 26 Click **Apply** to commit your changes.

Step 27 Click **Save Configuration** to save your changes.

Using the CLI to Configure RADIUS

To configure RADIUS using the controller CLI, follow these steps:

Note See the "Using the GUI to Configure RADIUS" section on page 6-6 for the valid ranges and default values of the parameters used in the CLI commands.

Step 1 Specify whether the IP address, system MAC address, or AP MAC address of the originator will be sent to the RADIUS server in the Access-Request message by entering this command:

config radius callStationIdType {*ip_address*, *mac_address*, *ap_mac_address*, *ap_macaddr_ssid*}

Step 2 Specify the delimiter to be used in the MAC addresses that are sent to the RADIUS authentication or accounting server in Access-Request messages by entering this command:

config radius {**auth** | **acct**} **mac-delimiter {colon | hyphen | single-hyphen | none**}

where

- **colon** sets the delimiter to a colon (the format is xx:xx:xx:xx:xx:xx).
- **hyphen** sets the delimiter to a hyphen (the format is xx-xx-xx-xx-xx-xx). This is the default value.
- **single-hyphen** sets the delimiter to a single hyphen (the format is xxxxxx-xxxxxx).
- **none** disables delimiters (the format is xxxxxxxxxxxx).

Step 3 Configure a RADIUS authentication server by entering these commands:

- **config radius auth add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a RADIUS authentication server.
- **config radius auth keywrap** {**enable** | **disable}**—Enables AES key wrap, which makes the shared secret between the controller and the RADIUS server more secure. AES key wrap is designed for Federal Information Processing Standards (FIPS) customers and requires a key-wrap compliant RADIUS authentication server.
- **config radius auth keywrap add {ascii | hex**} *kek mack index*—Configures the AES key wrap attributes

  where

  - *kek* specifies the 16-byte Key Encryption Key (KEK).
  - *mack* specifies the 20-byte Message Authentication Code Key (MACK).
  - *index* specifies the index of the RADIUS authentication server on which to configure the AES key wrap.
- **config radius auth rfc3576 {enable | disable**} *index*—Enables or disables RFC 3576, which is an extension to the RADIUS protocol that allows dynamic changes to a user session. RFC 3576 includes support for disconnecting users and changing authorizations applicable to a user session and supports disconnect and change-of-authorization (CoA) messages. Disconnect messages cause a user session to be terminated immediately where CoA messages modify session authorization attributes such as data filters.
- **config radius auth retransmit-timeout** *index timeout*—Configures the retransmission timeout value for a RADIUS authentication server.
- **config radius auth network** *index* {**enable** | **disable}**—Enables or disables network user authentication. If you enable this feature, this entry is considered the RADIUS authentication server for network users. If you did not configure a RADIUS server entry on the WLAN, you must enable this option for network users.
- **config radius auth management** *index* **{enable | disable**}—Enables or disables management authentication. If you enable this feature, this entry is considered the RADIUS authentication server for management users, and authentication requests go to the RADIUS server.
- **config radius auth ipsec** {**enable** | **disable**} *index*—Enables or disables the IP security mechanism.
- **config radius auth ipsec authentication** {**hmac-md5** | **hmac-sha1**} *index*—Configures the authentication protocol to be used for IP security.

- **config radius auth ipsec encryption** {**3des** | **aes** | **des** | **none**} *index*—Configures the IP security encryption mechanism.
- **config radius auth ipsec ike dh-group** {**group-1** | **group-2** | **group-5**} *index*—Configures the IKE Diffie Hellman group.
- **config radius auth ipsec ike lifetime** *interval index*—Configures the timeout interval for the session.
- **config radius auth ipsec ike phase1**{**aggressive** | **main**} *index*—Configures the Internet Key Exchange (IKE) protocol.
- **config radius auth** {**enable** | **disable**} *index*—Enables or disables a RADIUS authentication server.
- **config radius auth delete** *index*—Deletes a previously added RADIUS authentication server.

Step 4 Configure a RADIUS accounting server by entering these commands:

- **config radius acct add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a RADIUS accounting server.
- **config radius acct server-timeout** *index timeout*—Configures the retransmission timeout value for a RADIUS accounting server.
- **config radius acct network** *index* **{enable** | **disable**}—Enables or disables network user accounting. If you enable this feature, this entry is considered the RADIUS accounting server for network users. If you did not configure a RADIUS server entry on the WLAN, you must enable this option for network users.
- **config radius acct ipsec** {**enable** | **disable**} *index*—Enables or disables the IP security mechanism.
- **config radius acct ipsec authentication** {**hmac-md5** | **hmac-sha1**} *index*—Configures the authentication protocol to be used for IP security.
- **config radius acct ipsec encryption** {**3des** | **aes** | **des** | **none**} *index*—Configures the IP security encryption mechanism.
- **config radius acct ipsec ike dh-group** {**group-1** | **group-2** | **group-5**} *index*—Configures the IKE Diffie Hellman group.
- **config radius acct ipsec ike lifetime** *interval index*—Configures the timeout interval for the session.
- **config radius acct ipsec ike phase1**{**aggressive** | **main**} *index*—Configures the Internet Key Exchange (IKE) protocol.
- **config radius acct** {**enable** | **disable**} *index*—Enables or disables a RADIUS accounting server.
- **config radius acct delete** *index*—Deletes a previously added RADIUS accounting server.

Step 5 Configure the RADIUS server fallback behavior by entering this command:

config radius fallback-test mode {**off** | **passive** | **active**}

where

- **off** disables RADIUS server fallback.
- **passive** causes the controller to revert to a server with a lower priority from the available backup servers without using extraneous probe messages. The controller simply ignores all inactive servers for a time period and retries later when a RADIUS message needs to be sent.
- **active** causes the controller to revert to a server with a lower priority from the available backup servers by using RADIUS probe messages to proactively determine whether a server that has been marked inactive is back online. The controller simply ignores all inactive servers for all active

RADIUS requests. Once the primary server receives a response from the recovered ACS server, the active fallback RADIUS server no longer sends probe messages to the server requesting the active probe authentication.

Step 6 If you enabled Active mode in Step 5, enter these commands to configure additional fallback parameters:

- **config radius fallback-test username** *username*—Specifies the name to be sent in the inactive server probes. You can enter up to 16 alphanumeric characters for the *username* parameter.
- **config radius fallback-test interval** *interval*—Specifies the probe interval value (in seconds).

Step 7 Save your changes by entering this command:

save config

Step 8 Configure the order of authentication when multiple databases are configured by entering this command:

config aaa auth mgmt *AAA_server_type AAA_server_type*

where *AAA_server_type is* **local**, **radius**, or **tacacs**.

To see the current management authentication server order, enter this command:

show aaa auth

Information similar to the following appears:

```
Management authentication server order:
   1..................................... local
   2..................................... radius
```

Step 9 See RADIUS statistics by entering these commands:

- **show radius summary**—Shows a summary of RADIUS servers and statistics.
- **show radius auth statistics**—Shows the RADIUS authentication server statistics.
- **show radius acct statistics**—Shows the RADIUS accounting server statistics.
- **show radius rfc3576 statistics**—Shows a summary of the RADIUS RFC-3576 server.

Information similar to the following appears for the **show radius auth statistics** command:

```
Authentication Servers:

Server Index..................................... 1
Server Address................................... 10.91.104.76
Msg Round Trip Time.............................. 0 (msec)
First Requests................................... 1
Retry Requests................................... 0
Accept Responses................................. 0
Reject Responses................................. 0
Challenge Responses.............................. 0
Malformed Msgs................................... 0
Bad Authenticator Msgs........................... 0
Pending Requests................................. 0
Timeout Requests................................. 0
Unknowntype Msgs................................. 0
Other Drops...................................... 0
```

Information similar to the following appears for the **show radius acct statistics** command:

```
Accounting Servers:

Server Index..................................... 1
Server Address................................... 10.10.10.1
Msg Round Trip Time.............................. 0 (msec)
First Requests................................... 1
Retry Requests................................... 0
```

```
Accounting Responses.............................. 0
Malformed Msgs.................................... 0
Bad Authenticator Msgs............................ 0
Pending Requests.................................. 0
Timeout Requests.................................. 0
Unknowntype Msgs.................................. 0
Other Drops....................................... 0
```

Information similar to the following appears for the **show radius rfc3576 statistics** command:

```
RFC-3576 Servers:

Server Index...................................... 1
Server Address.................................... 10.91.104.76
Disconnect-Requests............................... 0
COA-Requests...................................... 0
Retransmitted Requests............................ 0
Malformed Requests................................ 0
Bad Authenticator Requests........................ 0
Other Drops....................................... 0
Sent Disconnect-Ack............................... 0
Sent Disconnect-Nak............................... 0
Sent CoA-Ack...................................... 0
Sent CoA-Nak.................................... 0
```

Step 10 See active security associations by entering these commands:

- **show ike** {**brief** | **detailed**} *ip_or_mac_addr*—Shows a brief or detailed summary of active IKE security associations.
- **show ipsec** {**brief** | **detailed**} *ip_or_mac_addr*—Shows a brief or detailed summary of active IPSec security associations.

Step 11 Clear the statistics for one or more RADIUS servers by entering this command:

clear stats radius {**auth** | **acct**} {*index* | **all**}

Step 12 Make sure that the controller can reach the RADIUS server by entering this command:

ping *server_ip_address*

RADIUS Authentication Attributes Sent by the Access Point

Table 6-1 through Table 6-5 identify the RADIUS authentication attributes sent by a lightweight access point to a client in access-request and access-accept packets.

Table 6-1 Authentication Attributes Sent in Access-Request Packets

Attribute ID	Description
1	User-Name
2	Password
3	CHAP-Password
4	NAS-IP-Address
5	NAS-Port
6	Service-Type[1]

Table 6-1 Authentication Attributes Sent in Access-Request Packets

Attribute ID	Description
12	Framed-MTU
30	Called-Station-ID (MAC address)
31	Calling-Station-ID (MAC address)
32	NAS-Identifier
33	Proxy-State
60	CHAP-Challenge
61	NAS-Port-Type
79	EAP-Message
243	TPLUS-Role

1. To specify read-only or read-write access to controllers through RADIUS authentication, you must set the Service-Type attribute (6) on the RADIUS server to **Callback NAS Prompt** for read-only access or to **Administrative** for read-write privileges. See Step 19 in the "Configuring RADIUS on the ACS" section for more information.

Table 6-2 Authentication Attributes Honored in Access-Accept Packets (Cisco)

Attribute ID	Description
1	Cisco-LEAP-Session-Key
2	Cisco-Keywrap-Msg-Auth-Code
3	Cisco-Keywrap-NonCE
4	Cisco-Keywrap-Key
5	Cisco-URL-Redirect
6	Cisco-URL-Redirect-ACL

Note These Cisco-specific attributes are not supported: Auth-Algo-Type and SSID.

Table 6-3 Authentication Attributes Honored in Access-Accept Packets (Standard)

Attribute ID	Description
6	Service-Type[1]
8	Framed-IP-Address
25	Class
26	Vendor-Specific
27	Timeout
29	Termination-Action
40	Acct-Status-Type
64	Tunnel-Type
79	EAP-Message
81	Tunnel-Group-ID

1. To specify read-only or read-write access to controllers through RADIUS authentication, you must set the Service-Type attribute (6) on the RADIUS server to **Callback NAS Prompt** for read-only access or to **Administrative** for read-write privileges. See Step 19 in the "Configuring RADIUS on the ACS" section for more information.

Note Message authentication is not supported.

Table 6-4 Authentication Attributes Honored in Access-Accept Packets (Microsoft)

Attribute ID	Description
11	MS-CHAP-Challenge
16	MS-MPPE-Send-Key
17	MS-MPPE-Receive-Key
25	MS-MSCHAP2-Response
26	MS-MSCHAP2-Success

Table 6-5 Authentication Attributes Honored in Access-Accept Packets (Airespace)

Attribute ID	Description
1	VAP-ID
2	QoS-Level
3	DSCP
4	8021P-Type
5	VLAN-Interface-Name
6	ACL-Name
7	Data-Bandwidth-Average-Contract
8	Real-Time-Bandwidth-Average-Contract
9	Data-Bandwidth-Burst-Contract
10	Real-Time-Bandwidth-Burst-Contract
11	Guest-Role-Name

RADIUS Accounting Attributes

Table 6-6 identifies the RADIUS accounting attributes for accounting requests sent from a controller to the RADIUS server. Table 6-7 lists the different values for the Accounting-Status-Type attribute (40).

Table 6-6 Accounting Attributes for Accounting Requests

Attribute ID	Description
1	User-Name
4	NAS-IP-Address
5	NAS-Port
8	Framed-IP-Address
25	Class
30	Called-Station-ID (MAC address)
31	Calling-Station-ID (MAC address)
32	NAS-Identifier
40	Accounting-Status-Type
41	Accounting-Delay-Time (Stop and interim messages only)
42	Accounting-Input-Octets (Stop and interim messages only)
43	Accounting-Output-Octets (Stop and interim messages only)
44	Accounting-Session-ID
45	Accounting-Authentic
46	Accounting-Session-Time (Stop and interim messages only)
47	Accounting-Input-Packets (Stop and interim messages only)
48	Accounting-Output-Packets (Stop and interim messages only)
49	Accounting-Terminate-Cause (Stop messages only)

Table 6-6 Accounting Attributes for Accounting Requests (continued)

Attribute ID	Description
64	Tunnel-Type
65	Tunnel-Medium-Type
81	Tunnel-Group-ID

Table 6-7 Accounting-Status-Type Attribute Values

Attribute ID	Description
1	Start
2	Stop
3	Interim-Update
7	Accounting-On
8	Accounting-Off
9-14	Reserved for Tunneling Accounting
15	Reserved for Failed

Configuring TACACS+

Terminal Access Controller Access Control System Plus (TACACS+) is a client/server protocol that provides centralized security for users attempting to gain management access to a controller. It serves as a backend database similar to local and RADIUS. However, local and RADIUS provide only authentication support and limited authorization support while TACACS+ provides three services:

- Authentication—The process of verifying users when they attempt to log into the controller.

  Users must enter a valid username and password in order for the controller to authenticate users to the TACACS+ server. The authentication and authorization services are tied to one another. For example, if authentication is performed using the local or RADIUS database, then authorization would use the permissions associated with the user in the local or RADIUS database (which are read-only, read-write, and lobby-admin) and not use TACACS+. Similarly, when authentication is performed using TACACS+, authorization is tied to TACACS+.

  Note When multiple databases are configured, you can use the controller GUI or CLI to specify the sequence in which the backend databases should be tried.

- Authorization—The process of determining the actions that users are allowed to take on the controller based on their level of access.

  For TACACS+, authorization is based on privilege (or role) rather than specific actions. The available roles correspond to the seven menu options on the controller GUI: MONITOR, WLAN, CONTROLLER, WIRELESS, SECURITY, MANAGEMENT, and COMMANDS. An additional role, LOBBY, is available for users who require only lobby ambassador privileges. The roles to which users are assigned are configured on the TACACS+ server. Users can be authorized for one or more roles. The minimum authorization is MONITOR only, and the maximum is ALL, which authorizes the user to execute the functionality associated with all seven menu options. For example, a user who is assigned the role of SECURITY can make changes to any items appearing on the

Security menu (or designated as security commands in the case of the CLI). If users are not authorized for a particular role (such as WLAN), they can still access that menu option in read-only mode (or the associated CLI **show** commands). If the TACACS+ authorization server becomes unreachable or unable to authorize, users are unable to log into the controller.

Note If users attempt to make changes on a controller GUI page that are not permitted for their assigned role, a message appears indicating that they do not have sufficient privilege. If users enter a controller CLI command that is not permitted for their assigned role, a message may appear indicating that the command was successfully executed although it was not. In this case, the following additional message appears to inform users that they lack sufficient privileges to successfully execute the command: "Insufficient Privilege! Cannot execute command!"

- Accounting—The process of recording user actions and changes.

  Whenever a user successfully executes an action, the TACACS+ accounting server logs the changed attributes, the user ID of the person who made the change, the remote host where the user is logged in, the date and time when the command was executed, the authorization level of the user, and a description of the action performed and the values provided. If the TACACS+ accounting server becomes unreachable, users are able to continue their sessions uninterrupted.

TACACS+ uses Transmission Control Protocol (TCP) for its transport, unlike RADIUS which uses User Datagram Protocol (UDP). It maintains a database and listens on TCP port 49 for incoming requests. The controller, which requires access control, acts as the client and requests AAA services from the server. The traffic between the controller and the server is encrypted by an algorithm defined in the protocol and a shared secret key configured on both devices.

You can configure up to three TACACS+ authentication, authorization, and accounting servers each. For example, you may want to have one central TACACS+ authentication server but several TACACS+ authorization servers in different regions. If you configure multiple servers of the same type and the first one fails or becomes unreachable, the controller automatically tries the second one and then the third one if necessary.

Note If multiple TACACS+ servers are configured for redundancy, the user database must be identical in all the servers for the backup to work properly.

You must configure TACACS+ on both your CiscoSecure Access Control Server (ACS) and your controller. You can configure the controller through either the GUI or the CLI.

Configuring TACACS+ on the ACS

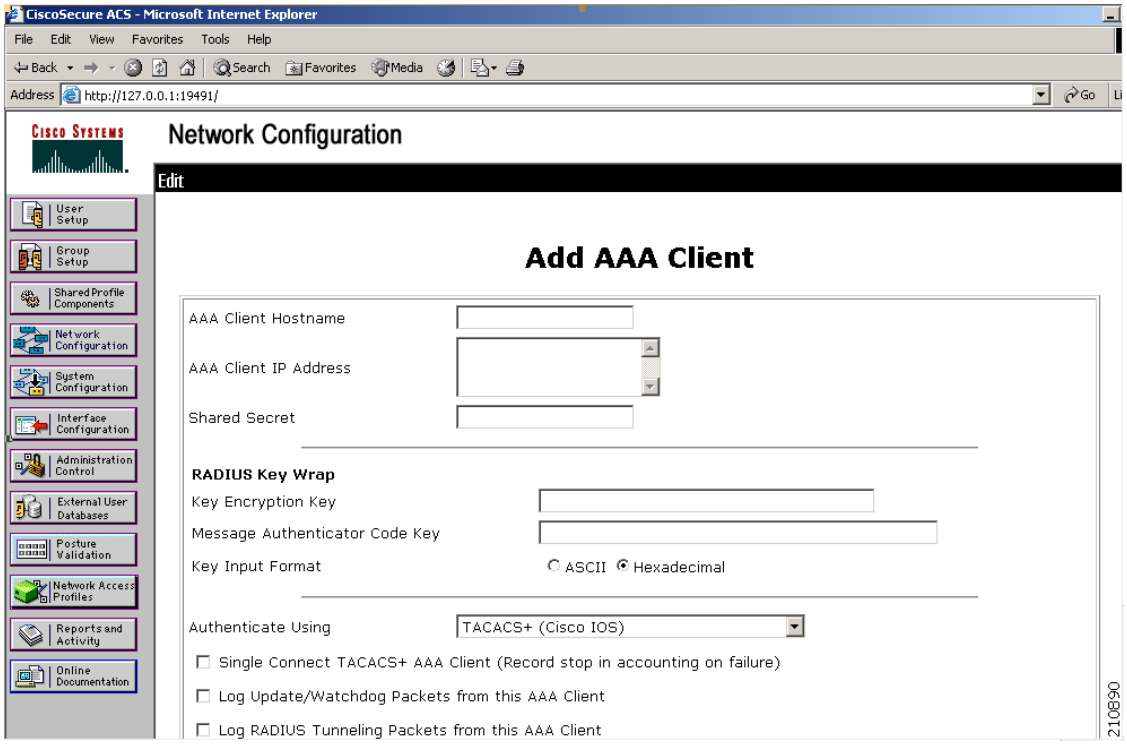
To configure TACACS+ on the ACS, follow these steps:

Note TACACS+ is supported on CiscoSecure ACS version 3.2 and later releases. The figures and instructions in this section pertain to ACS version 4.1 and may vary for other versions. See the *CiscoSecure ACS* documentation for the version that you are running.

Step 1 Choose **Network Configuration** on the ACS main page.

Step 2 Choose **Add Entry** under AAA Clients to add your controller to the server. The Add AAA Client page appears (see Figure 6-6).

Figure 6-6 Add AAA Client Page on CiscoSecure ACS



Step 3 In the AAA Client Hostname text box, enter the name of your controller.

Step 4 In the AAA Client IP Address text box, enter the IP address of your controller.

Step 5 In the Shared Secret text box, enter the shared secret key to be used for authentication between the server and the controller.

Note The shared secret key must be the same on both the server and the controller.

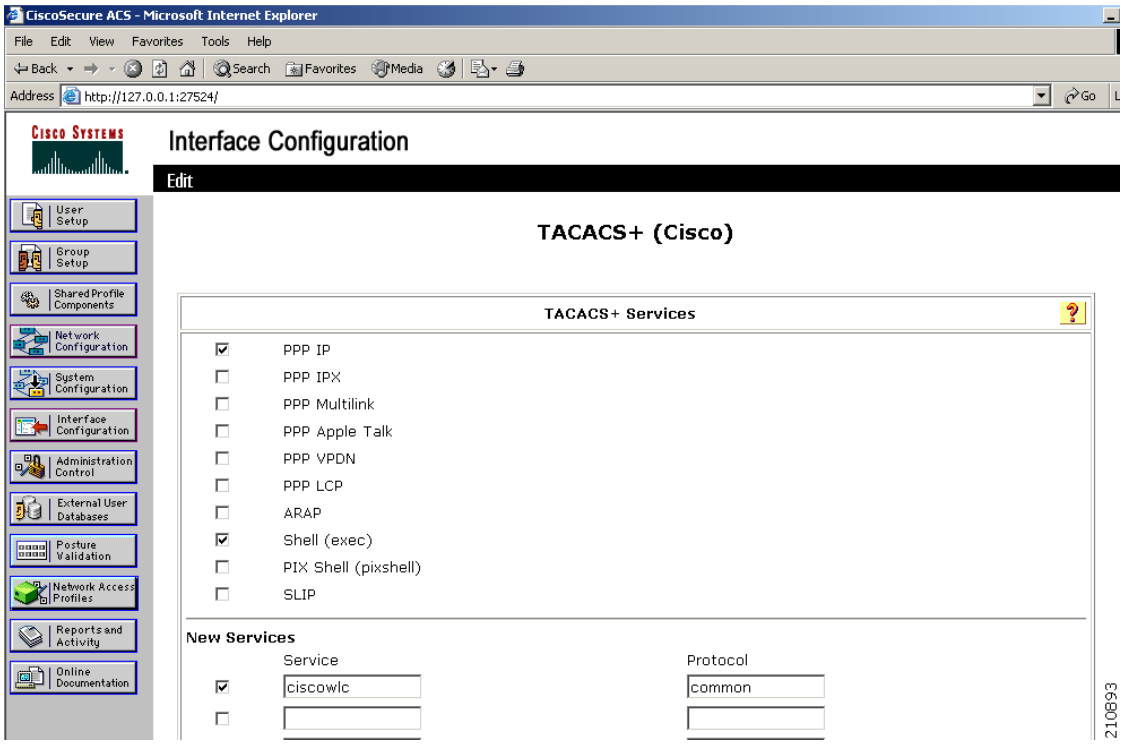
Step 6 From the Authenticate Using drop-down list, choose **TACACS+ (Cisco IOS)**.

Step 7 Click **Submit + Apply** to save your changes.

Step 8 On the ACS main page, in the left navigation pane, choose **Interface Configuration**.

Step 9 Choose **TACACS+ (Cisco IOS)**. The TACACS+ (Cisco) page appears (see Figure 6-7).

Figure 6-7 TACACS+ (Cisco) Page on CiscoSecure ACS



Step 10 Under TACACS+ Services, select the **Shell (exec)** check box.

Step 11 Under New Services, select the first check box and enter **ciscowlc** in the Service text box and **common** in the Protocol text box.

Step 12 Under Advanced Configuration Options, select the **Advanced TACACS+ Features** check box.

Step 13 Click **Submit** to save your changes.

Step 14 On the ACS main page, in the left navigation pane, choose **System Configuration**.

Step 15 Choose **Logging**.

Step 16 When the Logging Configuration page appears, enable all of the events that you want to be logged and save your changes.

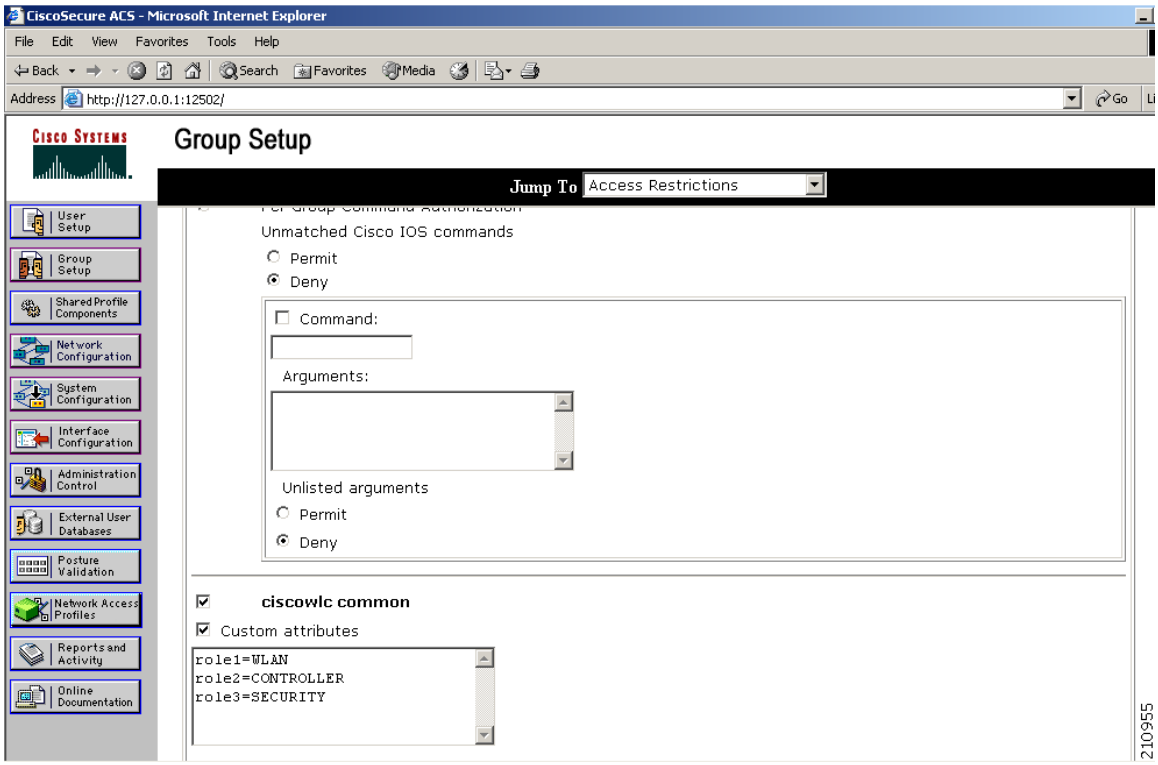
Step 17 On the ACS main page, in the left navigation pane, choose **Group Setup.**

Step 18 From the Group drop-down list, choose a previously created group.

Note This step assumes that you have already assigned users to groups on the ACS according to the roles to which they will be assigned.

Step 19 Click **Edit Settings**. The Group Setup page appears (see Figure 6-8).

Figure 6-8 Group Setup Page on CiscoSecure ACS



Step 20 Under **TACACS+ Settings**, select the **ciscowlc common** check box.

Step 21 Select the **Custom Attributes** check box.

Step 22 In the text box below Custom Attributes, specify the roles that you want to assign to this group. The available roles are MONITOR, WLAN, CONTROLLER, WIRELESS, SECURITY, MANAGEMENT, COMMANDS, ALL, and LOBBY. The first seven correspond to the menu options on the controller GUI and allow access to those particular controller features. You can enter one or multiple roles, depending on the group's needs. Use ALL to specify all seven roles or LOBBY to specify the lobby ambassador role. Enter the roles using this format:

role*x*=*ROLE*

For example, to specify the WLAN, CONTROLLER, and SECURITY roles for a particular user group, you would enter the following text:

```
role1=WLAN
role2=CONTROLLER
role3=SECURITY
```

To give a user group access to all seven roles, you would enter the following text:

```
role1=ALL
```

Note Make sure to enter the roles using the format shown above. The roles must be in all uppercase letters, and there can be no spaces within the text.

Note You should not combine the MONITOR role or the LOBBY role with any other roles. If you specify one of these two roles in the Custom Attributes text box, users will have MONITOR or LOBBY privileges only, even if additional roles are specified.

Step 23 Click **Submit** to save your changes.

Using the GUI to Configure TACACS+

To configure TACACS+ using the controller GUI, follow these steps:

Step 1 Choose **Security** > **AAA** > **TACACS+**.

Step 2 Perform one of the following:

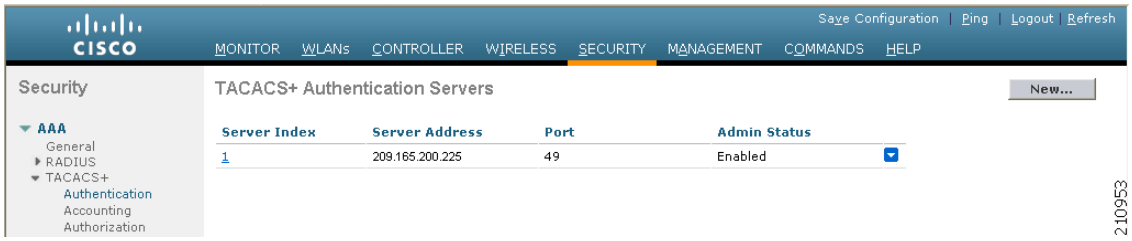
- If you want to configure a TACACS+ server for authentication, choose **Authentication**.
- If you want to configure a TACACS+ server for authorization, choose **Authorization**.
- If you want to configure a TACACS+ server for accounting, choose **Accounting**.

Note The pages used to configure authentication, authorization, and accounting all contain the same text boxes. Therefore, these instructions walk through the configuration only once, using the Authentication pages as examples. You would follow the same steps to configure multiple services and/or multiple servers.

Note For basic management authentication via TACACS+ to succeed, it is required to configure authentication and authorization servers on the WLC. Accounting configuration is optional.

The TACACS+ (Authentication, Authorization, or Accounting) Servers page appears (see Figure 6-9).

Figure 6-9 TACACS+ Authentication Servers Page



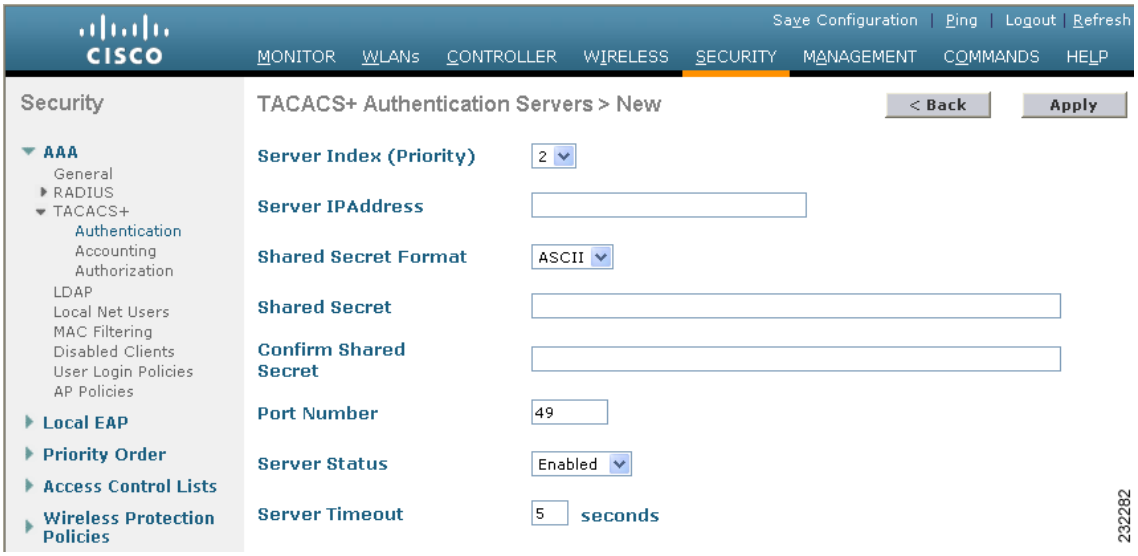
This page lists any TACACS+ servers that have already been configured.

- If you want to delete an existing server, hover your cursor over the blue drop-down arrow for that server and choose **Remove**.
- If you want to make sure that the controller can reach a particular server, hover your cursor over the blue drop-down arrow for that server and choose **Ping**.

Step 3 Perform one of the following:

- To edit an existing TACACS+ server, click the server index number for that server. The TACACS+ (Authentication, Authorization, or Accounting) Servers > Edit page appears.
- To add a TACACS+ server, click **New**. The TACACS+ (Authentication, Authorization, or Accounting) Servers > New page appears (see Figure 6-10).

Figure 6-10 TACACS+ Authentication Servers > New Page



Step 4 If you are adding a new server, choose a number from the Server Index (Priority) drop-down list to specify the priority order of this server in relation to any other configured TACACS+ servers providing the same service. You can configure up to three servers. If the controller cannot reach the first server, it tries the second one in the list and then the third if necessary.

Step 5 If you are adding a new server, enter the IP address of the TACACS+ server in the Server IP Address text box.

Step 6 From the Shared Secret Format drop-down list, choose **ASCII** or **Hex** to specify the format of the shared secret key to be used between the controller and the TACACS+ server. The default value is ASCII.

Step 7 In the Shared Secret and Confirm Shared Secret text boxes, enter the shared secret key to be used for authentication between the controller and the server.

Note The shared secret key must be the same on both the server and the controller.

Step 8 If you are adding a new server, enter the TACACS+ server's TCP port number for the interface protocols in the Port Number text box. The valid range is 1 to 65535, and the default value is 49.

Step 9 In the Server Status text box, choose **Enabled** to enable this TACACS+ server or choose **Disabled** to disable it. The default value is Enabled.

Step 10 In the Server Timeout text box, enter the number of seconds between retransmissions. The valid range is 5 to 30 seconds, and the default value is 5 seconds.

Note We recommend that you increase the timeout value if you experience repeated reauthentication attempts or the controller falls back to the backup server when the primary server is active and reachable.

Step 11 Click **Apply** to commit your changes.

Step 12 Click **Save Configuration** to save your changes.

Step 13 Repeat the previous steps if you want to configure any additional services on the same server or any additional TACACS+ servers.

Step 14 Specify the order of authentication when multiple databases are configured by choosing **Security** > **Priority Order** > **Management User**. The Priority Order > Management User page appears (see Figure 6-11).

Figure 6-11 Priority Order > Management User Page

Step 15 In the Order Used for Authentication text box, specify which servers have priority when the controller attempts to authenticate management users. Use the **>** and **<** buttons to move servers between the Not Used and Order Used for Authentication text boxes. After the desired servers appear in the Order Used for Authentication text box, use the **Up** and **Down** buttons to move the priority server to the top of the list.

By default, the local database is always queried first. If the username is not found, the controller switches to the RADIUS server if configured for RADIUS or to the TACACS+ server if configured for TACACS+. The default setting is local and then RADIUS.

Step 16 Click **Apply** to commit your changes.

Step 17 Click **Save Configuration** to save your changes.

Using the CLI to Configure TACACS+

To configure TACACS+ using the controller CLI, use these commands:

Note See the "Using the GUI to Configure TACACS+" section on page 6-24 for the valid ranges and default values of the parameters used in the CLI commands.

- Configure a TACACS+ authentication server by entering these commands:
  - **config tacacs auth add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a TACACS+ authentication server.
  - **config tacacs auth delete** *index*—Deletes a previously added TACACS+ authentication server.
  - **config tacacs auth** {**enable** | **disable**} *index*—Enables or disables a TACACS+ authentication server.
  - **config tacacs auth server-timeout** *index timeout*—Configures the retransmission timeout value for a TACACS+ authentication server.
- Configure a TACACS+ authorization server by entering these commands:
  - **config tacacs athr add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a TACACS+ authorization server.
  - **config tacacs athr delete** *index*—Deletes a previously added TACACS+ authorization server.
  - **config tacacs athr** {**enable** | **disable**} *index*—Enables or disables a TACACS+ authorization server.
  - **config tacacs athr server-timeout** *index timeout*—Configures the retransmission timeout value for a TACACS+ authorization server.
- Configure a TACACS+ accounting server by entering these commands:
  - **config tacacs acct add** *index server_ip_address port#* {**ascii** | **hex**} *shared_secret*—Adds a TACACS+ accounting server.
  - **config tacacs acct delete** *index*—Deletes a previously added TACACS+ accounting server.
  - **config tacacs acct** {**enable** | **disable**} *index*—Enables or disables a TACACS+ accounting server.
  - **config tacacs acct server-timeout** *index timeout*—Configures the retransmission timeout value for a TACACS+ accounting server.
- See TACACS+ statistics by entering these commands:
  - **show tacacs summary**—Shows a summary of TACACS+ servers and statistics.
  - **show tacacs auth stats**—Shows the TACACS+ authentication server statistics.
  - **show tacacs athr stats**—Shows the TACACS+ authorization server statistics.
  - **show tacacs acct stats**—Shows the TACACS+ accounting server statistics.

  Information similar to the following appears when you enter the **show tacacs summary** command:

```
Authentication Servers

Idx  Server Address    Port    State     Tout
---  ----------------  ------  --------  ----
1    11.11.12.2        49      Enabled   5
2    11.11.13.2        49      Enabled   5
3    11.11.14.2        49      Enabled   5

Authorization Servers

Idx  Server Address    Port    State     Tout
---  ----------------  ------  --------  ----
```

```
1    11.11.12.2        49      Enabled   5
2    11.11.13.2        49      Enabled   5
3    11.11.14.2        49      Enabled   5

Accounting Servers

Idx  Server Address    Port    State     Tout
---  ----------------  ------  --------  ----
1    11.11.12.2        49      Enabled   5
2    11.11.13.2        49      Enabled   5
3    11.11.14.2        49      Enabled   5
```

Information similar to the following appears when you enter the **show tacacs auth stats** command:

```
Server Index..................................... 1
Server Address................................... 10.10.10.10
Msg Round Trip Time.............................. 0 (msec)
First Requests................................... 0
Retry Requests................................... 0
Accept Responses................................. 0
Reject Responses................................. 0
Error Responses.................................. 0
Restart Responses................................ 0
Follow Responses................................. 0
GetData Responses................................ 0
Encrypt no secret Responses...................... 0
Challenge Responses.............................. 0
Malformed Msgs................................... 0
Bad Authenticator Msgs........................... 0
Pending Requests................................. 0
Timeout Requests................................. 0
Unknowntype Msgs................................. 0
Other Drops.....................................0
```

- Clear the statistics for one or more TACACS+ servers by entering this command:

  clear stats tacacs [**auth** | **athr** | **acct**] {*index* | **all**}

- Configure the order of authentication when multiple databases are configured by entering this command. The default setting is **local** and then **radius**.

  config aaa auth mgmt [**radius** | **tacacs**]

  See the current management authentication server order by entering this command:

  show aaa auth

  Information similar to the following appears:

  ```
  Management authentication server order:
     1..................................... local
     2..................................... tacacs
  ```

- Make sure the controller can reach the TACACS+ server by entering this command:

  ping *server_ip_address*

- Enable or disable TACACS+ debugging by entering this command:

  debug aaa tacacs {**enable** | **disable**}

- Save your changes by entering this command:

  save config

Viewing the TACACS+ Administration Server Logs

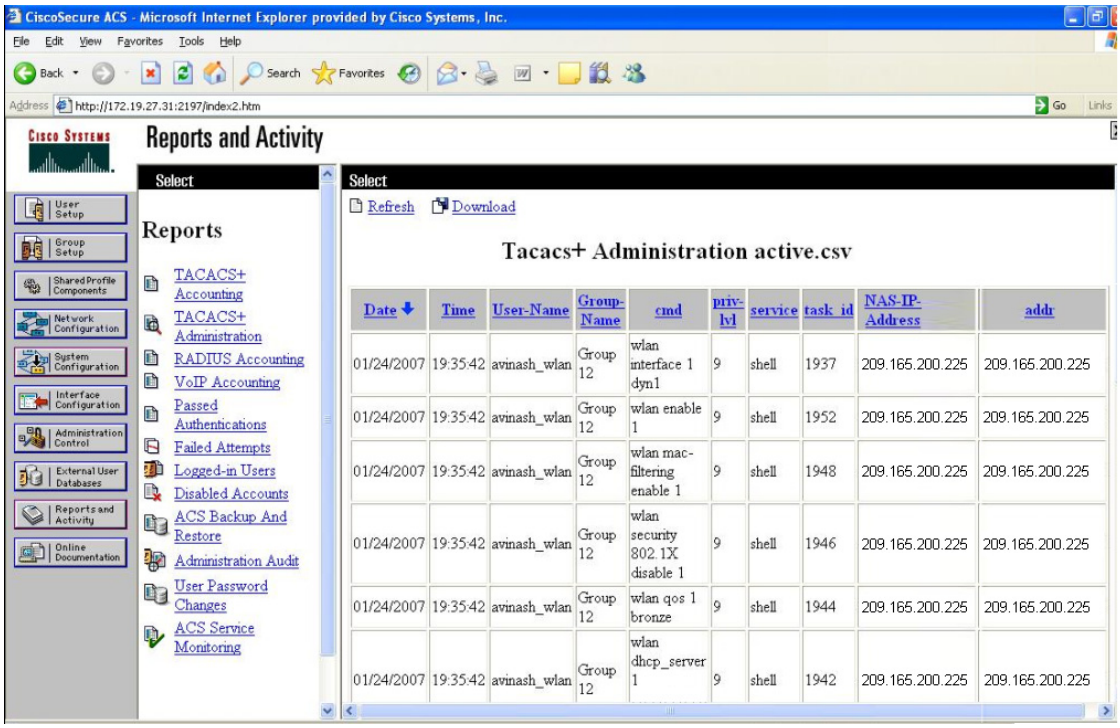
To view the TACACS+ administration server logs, if you have a TACACS+ accounting server configured on the controller, follow these steps:

Step 1 On the ACS main page, in the left navigation pane, choose **Reports and Activity**.

Step 2 Under Reports, choose **TACACS+ Administration**.

Step 3 Click the .csv file corresponding to the date of the logs you want to view. The TACACS+ Administration .csv page appears (see Figure 6-12).

Figure 6-12 TACACS+ Administration .csv Page on CiscoSecure ACS

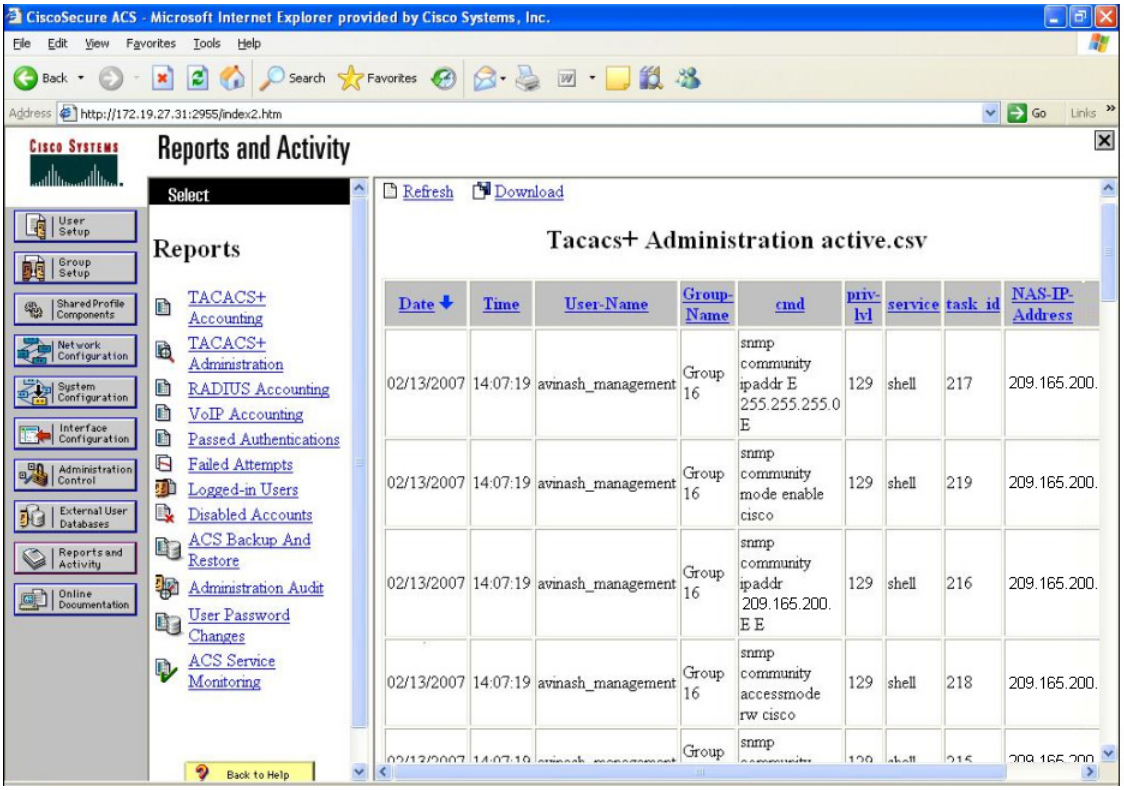


This page provides the following information:

- The date and time the action was taken
- The name and assigned role of the user who took the action
- The group to which the user belongs
- The specific action that the user took
- The privilege level of the user who executed the action
- The IP address of the controller
- The IP address of the laptop or workstation from which the action was executed

Sometimes a single action (or command) is logged multiple times, once for each parameter in the command. For example, if you enter the **snmp community ipaddr** *ip_address subnet_mask community_name* command, the IP address may be logged on one line while the subnet mask and community name are logged as "E." On another line, the subnet mask maybe logged while the IP address and community name are logged as "E." See the first and third lines in the example in Figure 6-13.

Figure 6-13 TACACS+ Administration .csv Page on CiscoSecure ACS



Note You can click **Refresh** at any time to refresh this page.

TACACS+ VSA

The Internet Engineering Task Force (IETF) draft standard specifies a method for communicating vendor-specific attributes (VSAs) between the network access server and the TACACS+ server. The IETF uses attribute 26. VSAs allow vendors to support their own extended attributes that are not suitable for general use.

The Cisco TACACS+ implementation supports one vendor-specific option using the format recommended in the IETF specification. The Cisco vendor ID is 9, and the supported option is vendor type 1, which is named cisco-av-pair. The value is a string with the following format:

```
protocol : attribute separator value *
```

The protocol is a Cisco attribute for a particular type of authorization, the separator is = (equal sign) for mandatory attributes, and * (asterisk) indicates optional attributes.

Configuring Maximum Local Database Entries

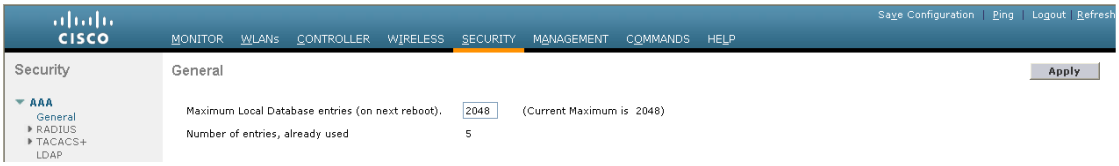
You can use the controller GUI or CLI to specify the maximum number of local database entries used for storing user authentication information. The database entries include local management users (including lobby ambassadors), local network users (including guest users), MAC filter entries, exclusion list entries, and access point authorization list entries. Together they cannot exceed the configured maximum value.

Using the GUI to Configure Maximum Local Database Entries

To configure the maximum number of local database entries using the controller GUI, follow these steps:

Step 1 Choose **Security** > **AAA** > **General** to open the General page (see Figure 6-14).

Figure 6-14 General Page



Step 2 In the Maximum Local Database Entries text box, enter a value for the maximum number of entries that can be added to the local database the next time the controller reboots. The currently configured value appears in parentheses to the right of the text box. The valid range is 512 to 2048, and the default setting is 2048.

The Number of Entries, Already Used text box shows the number of entries currently in the database.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your settings.

Using the CLI to Configure Maximum Local Database Entries

To configure the maximum number of local database entries using the controller CLI, follow these steps:

Step 1 Specify the maximum number of entries that can be added to the local database the next time the controller reboots by entering this command:

config database size *max_entries*

Step 2 Save your changes by entering this command:

save config

Step 3 View the maximum number of database entries and the current database contents by entering this command:

show database summary

Information similar to the following appears:

```
Maximum Database Entries..................... 2048
Maximum Database Entries On Next Reboot...... 2048
Database Contents
    MAC Filter Entries..................... 2
    Exclusion List Entries................. 0
    AP Authorization List Entries.......... 1
    Management Users....................... 1
    Local Network Users.................... 1
        Local Users........................ 1
        Guest Users........................ 0
    Total.................................. 5
```

Configuring Local Network Users

This section explains how to add local network users to the local user database on the controller. The local user database stores the credentials (username and password) of all the local network users. These credentials are then used to authenticate the users. For example, local EAP may use the local user database as its backend database to retrieve user credentials. See the "Configuring Local EAP" section on page 6-42 for more information.

Note The controller passes client information to the RADIUS authentication server first. If the client information does not match a RADIUS database entry, the local user database is polled. Clients located in this database are granted access to network services if the RADIUS authentication fails or does not exist.

You can configure local network users through either the GUI or the CLI.

Using the GUI to Configure Local Network Users

To configure local network users using the controller GUI, follow these steps:

Step 1 Choose **Security > AAA > Local Net Users** to open the Local Net Users page (see Figure 6-15).

Figure 6-15 Local Net Users Page

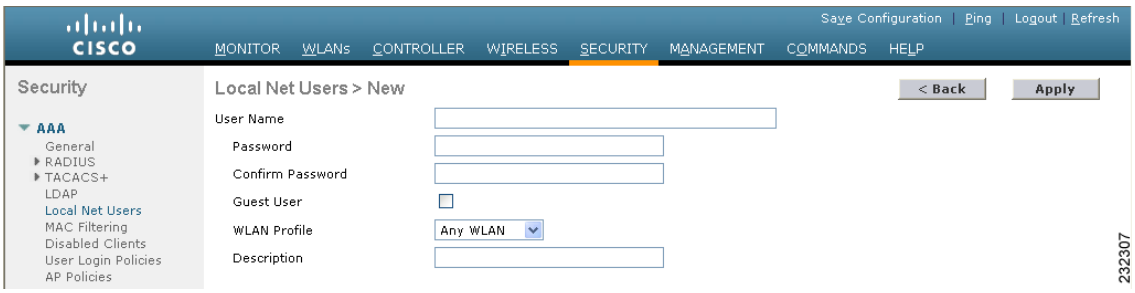
This page lists any local network users that have already been configured. It also specifies any guest users and the QoS role to which they are assigned (if applicable). See the"Configuring Quality of Service" section on page 4-68 for information on configuring QoS roles.

Note If you want to delete an existing user, hover your cursor over the blue drop-down arrow for that user and choose **Remove**.

Step 2 Perform one of the following:

- To edit an existing local network user, click the username for that user. The Local Net Users > Edit page appears.
- To add a local network user, click **New**. The Local Net Users > New page appears (see Figure 6-16).

Figure 6-16 Local Net Users > New Page



Step 3 If you are adding a new user, enter a username for the local user in the User Name text box. You can enter up to 24 alphanumeric characters.

Note Local network usernames must be unique because they are all stored in the same database.

Step 4 In the Password and Confirm Password text boxes, enter a password for the local user. You can enter up to 24 alphanumeric characters.

Step 5 If you are adding a new user, select the **Guest User** check box if you want to limit the amount of time that the user has access to the local network. The default setting is unselected.

Step 6 If you are adding a new user and you selected the Guest User check box, enter the amount of time (in seconds) that the guest user account is to remain active in the Lifetime text box. The valid range is 60 to 2,592,000 seconds (30 days) inclusive, and the default setting is 86,400 seconds.

Step 7 If you are adding a new user, you selected the Guest User check box, and you want to assign a QoS role to this guest user, select the **Guest User Role** check box. The default setting is unselected.

Note If you do not assign a QoS role to a guest user, the bandwidth contracts for this user are defined in the QoS profile for the WLAN.

Step 8 If you are adding a new user and you selected the Guest User Role check box, choose the QoS role that you want to assign to this guest user from the Role drop-down list.

Note If you want to create a new QoS role, see the "Configuring Quality of Service" section on page 4-68 for instructions.

Step 9 From the WLAN Profile drop-down list, choose the name of the WLAN that is to be accessed by the local user. If you choose **Any WLAN**, which is the default setting, the user can access any of the configured WLANs.

Step 10 In the Description text box, enter a descriptive title for the local user (such as "User 1").

Step 11 Click **Apply** to commit your changes.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure Local Network Users

To configure local network users using the controller CLI, use these commands:

Note See the "Using the GUI to Configure Local Network Users" section on page 6-32 for the valid ranges and default values of the parameters used in the CLI commands.

- Configure a local network user by entering these commands:
  - **config netuser add** *username password* **wlan** *wlan_id* **userType permanent description** *description*—Adds a permanent user to the local user database on the controller.
  - **config netuser add** *username password* {**wlan** | **guestlan**} {*wlan_id* | *guest_lan_id*} **userType guest lifetime** *seconds* **description** *description*—Adds a guest user on a WLAN or wired guest LAN to the local user database on the controller.

    Note Instead of adding a permanent user or a guest user to the local user database from the controller, you can choose to create an entry on the RADIUS server for the user and enable RADIUS authentication for the WLAN on which web authentication is performed.

  - **config netuser delete** *username*—Deletes a user from the local user database on the controller.

    Note Local network usernames must be unique because they are all stored in the same database.

- See information related to the local network users configured on the controller by entering these commands:
  - **show netuser detail** *username*—Shows the configuration of a particular user in the local user database.
  - **show netuser summary**—Lists all the users in the local user database.

  For example, information similar to the following appears for the **show netuser detail** *username* command:

```
User Name.............................. abc
WLAN Id................................ Any
Lifetime............................... Permanent
```

```
Description..................... test user
```

- Save your changes by entering this command:

  save config

Configuring Password Policies

The password policies allows you to enforce strong password checks on newly created passwords for additional management users of controller and access point. The following are the requirements enforced on the new password:

Note When the controller is upgraded from old version, all the old passwords are maintained as it is, even though the passwords are weak. After the system upgrade, if strong password checks are enabled, the same is enforced from that time and the strength of previously added passwords will not be checked or altered.

Note Depending on the settings done in the Password Policy page, the local management and access point user configuration is affected.

You can configure Password Policies either through the GUI or the CLI.

Using the GUI to Configure Password Policies

To configure Password Policies using the controller GUI, follow these steps:

Step 1 Choose **Security > AAA > Password Policies** to open the Password Policies page.

Step 2 Select the Password must contain characters from at least 3 different classes check box if you want your password to contain characters from at least three of the following classes: lower case letters, upper case letters, digits, and special characters.

Step 3 Select No character can be repeated more than 3 times consecutively check box if you do not want character in the new password to repeat more than three times consecutively.

Step 4 Select Password cannot be the default words like cisco, admin check box if you do not want the password to contain words such as Cisco, ocsic, admin, nimda, or any variant obtained by changing the capitalization of letters or by substituting 1, |, or ! or substituting 0 for o or substituting $ for s.

Step 5 Select Password cannot contain username or reverse of username check box if you do not want the password to contain a username or the reverse letters of a username.

Step 6 Click Apply to commit your changes.

Step 7 Click Save Configuration to save your changes.

Using the CLI to Configure Password Policies

To configure Password Policies using the controller CLI, follow these steps:

Step 1 Enable or disable strong password check for AP and WLC by entering the following command:

config switchconfig strong-pwd {case-check | consecutive-check | default-check | username-check | all-check} {enable | disable}

where

- case-check—checks the occurrence of same character thrice consecutively
- consecutive-check—checks the default values or its variants are being used.
- default-check—checks either username or its reverse is being used.
- all-checks—enables/disables all the strong password checks.

Step 2 See the configured options for strong password check using the following command:

show switchconfig

Information similar to the following appears:

```
802.3x Flow Control Mode..................... Disabled
FIPS prerequisite features................... Disabled
secret obfuscation........................... Enabled
Strong Password Check Features:

         case-check ...........Enabled
         consecutive-check ....Enabled
         default-check .......Enabled
         username-check ......Enabled
```

Configuring LDAP

This section explains how to configure a Lightweight Directory Access Protocol (LDAP) server as a backend database, similar to a RADIUS or local user database. An LDAP backend database allows the controller to query an LDAP server for the credentials (username and password) of a particular user. These credentials are then used to authenticate the user. For example, local EAP may use an LDAP server as its backend database to retrieve user credentials. See the "Configuring Local EAP" section on page 6-42 for more information.

Note The LDAP backend database supports these local EAP methods: EAP-TLS, EAP-FAST/GTC, and PEAPv1/GTC. LEAP, EAP-FAST/MSCHAPv2, and PEAPv0/MSCHAPv2 are also supported but only if the LDAP server is set up to return a clear-text password.

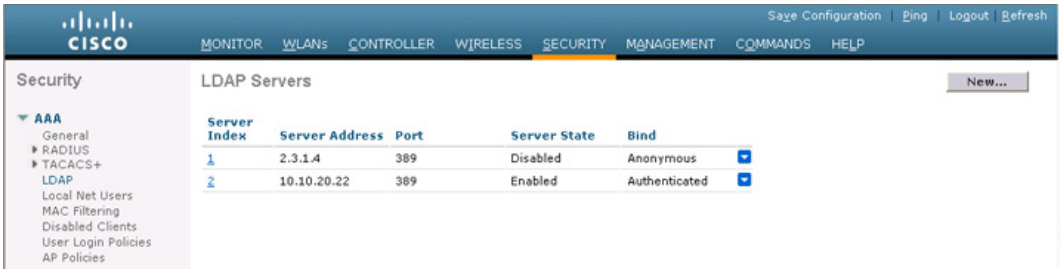
Note Cisco wireless LAN controllers support Local EAP authentication against external LDAP databases such as Microsoft Active Directory and Novell's eDirectory. For more information about configuring the controller for Local EAP authentication against Novell's eDirectory, see the *Configure Unified Wireless Network for Authentication Against Novell's eDirectory Database* whitepaper at http://www.cisco.com/en/US/products/ps6366/products_white_paper09186a0080b4cd24.shtml.

Using the GUI to Configure LDAP

To configure LDAP using the controller GUI, follow these steps:

Step 1 Choose **Security** > **AAA** > **LDAP** to open the LDAP Servers page (see Figure 6-17).

Figure 6-17 LDAP Servers Page



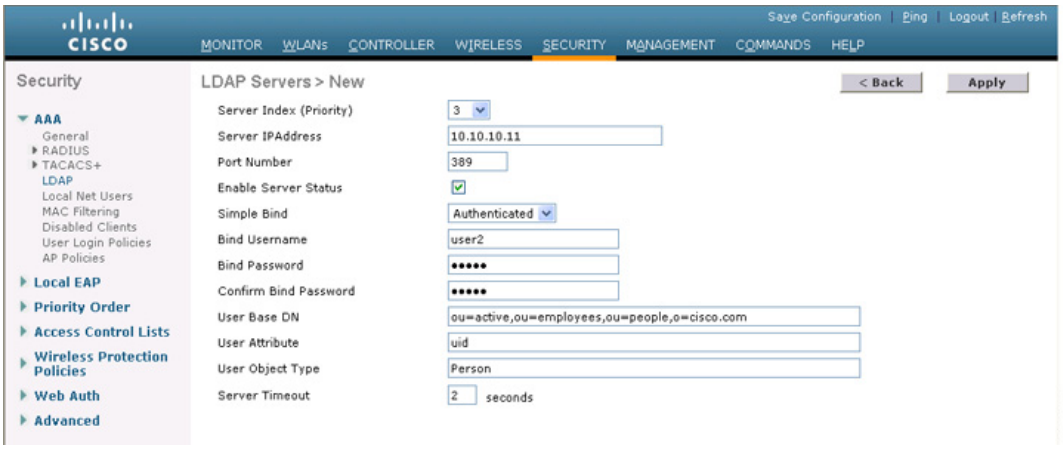
This page lists any LDAP servers that have already been configured.

- If you want to delete an existing LDAP server, hover your cursor over the blue drop-down arrow for that server and choose **Remove**.
- If you want to make sure that the controller can reach a particular server, hover your cursor over the blue drop-down arrow for that server and choose **Ping**.

Step 2 Perform one of the following:

- To edit an existing LDAP server, click the index number for that server. The LDAP Servers > Edit page appears.
- To add an LDAP server, click **New**. The LDAP Servers > New page appears (see Figure 6-18).

Figure 6-18 LDAP Servers > New Page



Step 3 If you are adding a new server, choose a number from the Server Index (Priority) drop-down list to specify the priority order of this server in relation to any other configured LDAP servers. You can configure up to 17 servers. If the controller cannot reach the first server, it tries the second one in the list and so on.

Step 4 If you are adding a new server, enter the IP address of the LDAP server in the Server IP Address text box.

Step 5 If you are adding a new server, enter the LDAP server's TCP port number in the Port Number text box. The valid range is 1 to 65535, and the default value is 389.

Step 6 Select the **Enable Server Status** check box to enable this LDAP server or unselect it to disable it. The default value is disabled.

Step 7 From the Simple Bind drop-down list, choose **Anonymous** or **Authenticated** to specify the local authentication bind method for the LDAP server. The Anonymous method allows anonymous access to the LDAP server. The Authenticated method requires that a username and password be entered to secure access. The default value is **Anonymous**.

Step 8 If you chose Authenticated in Step 7, follow these steps:

a. In the Bind Username text box, enter a username to be used for local authentication to the LDAP server. The username can contain up to 80 characters.

Note If the username starts with "cn=" (in lowercase letters), the controller assumes that the username includes the entire LDAP database path and does not append the user base DN. This designation allows the authenticated bind user to be outside the user base DN.

b. In the Bind Password and Confirm Bind Password text boxes, enter a password to be used for local authentication to the LDAP server. The password can contain up to 32 characters.

Step 9 In the User Base DN text box, enter the distinguished name (DN) of the subtree in the LDAP server that contains a list of all the users. For example, ou=organizational unit, .ou=next organizational unit, and o=corporation.com. If the tree containing users is the base DN, type **o=***corporation***.com** or **dc=***corporation***,dc=com**.

Step 10 In the User Attribute text box, enter the name of the attribute in the user record that contains the username. You can obtain this attribute from your directory server.

Step 11 In the User Object Type text box, enter the value of the LDAP objectType attribute that identifies the record as a user. Often, user records have several values for the objectType attribute, some of which are unique to the user and some of which are shared with other object types.

Step 12 In the Server Timeout text box, enter the number of seconds between retransmissions. The valid range is 2 to 30 seconds, and the default value is 2 seconds.

Step 13 Click **Apply** to commit your changes.

Step 14 Click **Save Configuration** to save your changes.

Step 15 Specify LDAP as the priority backend database server for local EAP authentication as follows:

a. Choose **Security > Local EAP > Authentication Priority** to open the Priority Order > Local-Auth page (see Figure 6-19).

Figure 6-19 Priority Order > Local-Auth Page

b. Highlight **LOCAL** and click **<** to move it to the left User Credentials box.

c. Highlight **LDAP** and click **>** to move it to the right User Credentials box. The database that appears at the top of the right User Credentials box is used when retrieving user credentials.

Note If both LDAP and LOCAL appear in the right User Credentials box with LDAP on the top and LOCAL on the bottom, local EAP attempts to authenticate clients using the LDAP backend database and fails over to the local user database if the LDAP servers are not reachable. If the user is not found, the authentication attempt is rejected. If LOCAL is on the top, local EAP attempts to authenticate using only the local user database. It does not fail over to the LDAP backend database.

d. Click **Apply** to commit your changes.

e. Click **Save Configuration** to save your changes.

Step 16 (Optional) Assign specific LDAP servers to a WLAN as follows:

a. Choose **WLANs** to open the WLANs page.

b. Click the ID number of the desired WLAN.

c. When the WLANs > Edit page appears, choose the **Security** > **AAA Servers** tabs to open the WLANs > Edit (Security > AAA Servers) page (see Figure 6-20).

Figure 6-20 WLANs > Edit (Security > AAA Servers) Page

d. From the LDAP Servers drop-down lists, choose the LDAP server(s) that you want to use with this WLAN. You can choose up to three LDAP servers, which are tried in priority order.

Note These LDAP servers apply only to WLANs with web authentication enabled. They are not used by local EAP.

e. Click **Apply** to commit your changes.

f. Click **Save Configuration** to save your changes.

Using the CLI to Configure LDAP

To configure LDAP using the controller CLI, use these commands:

Note See the "Using the GUI to Configure LDAP" section on page 6-36 for the valid ranges and default values of the parameters used in the CLI commands.

- Configure an LDAP server by entering these commands:
  - **config ldap add** *index server_ip_address port# user_base user_attr user_type*—Adds an LDAP server.
  - **config ldap delete** *index*—Deletes a previously added LDAP server.
  - **config ldap** {**enable** | **disable**} *index*—Enables or disables an LDAP server.
  - **config ldap simple-bind** {**anonymous** *index* | **authenticated** *index* **username** *username* **password** *password*}—Specifies the local authentication bind method for the LDAP server. The anonymous method allows anonymous access to the LDAP server whereas the authenticated method requires that a username and password be entered to secure access. The default value is **anonymous**.

    Note The username can contain up to 80 characters.

    Note If the username starts with "cn=" (in lowercase letters), the controller assumes that the username includes the entire LDAP database path and does not append the user base DN. This designation allows the authenticated bind user to be outside the user base DN.

  - **config ldap retransmit-timeout** *index timeout*—Configures the number of seconds between retransmissions for an LDAP server.
- Specify LDAP as the priority backend database server by entering this command:

  config local-auth user-credentials ldap

  Note If you enter the **config local-auth user-credentials ldap local** command, local EAP attempts to authenticate clients using the LDAP backend database and fails over to the local user database if the LDAP servers are not reachable. If the user is not found, the authentication attempt is rejected. If you enter the **config local-auth user-credentials local ldap** command, local EAP attempts to authenticate using only the local user database. It does not fail over to the LDAP backend database.

- (Optional) Assign specific LDAP servers to a WLAN by entering these commands:
  - **config wlan ldap add** *wlan_id server_index*—Links a configured LDAP server to a WLAN.

    Note The LDAP servers specified in this command apply only to WLANs with web authentication enabled. They are not used by local EAP.

  - **config wlan ldap delete** *wlan_id* {**all** | *index*}—Deletes a specific or all configured LDAP server(s) from a WLAN.

- View information pertaining to configured LDAP servers by entering these commands:
  - **show ldap summary**—Shows a summary of the configured LDAP servers.
  - **show ldap** *index*—Shows detailed LDAP server information.
  - **show ldap statistics**—Shows LDAP server statistics.
  - show wlan *wlan_id*—Shows the LDAP servers that are applied to a WLAN.

  Information similar to the following appears when you enter the **show ldap** *index* command:

```
Server Index..................................... 2
Address.......................................... 10.10.20.22
Port............................................. 389
Enabled.......................................... Yes
User DN.......................................... ou=active,ou=employees,ou=people,
                                                  o=cisco.com
User Attribute................................... uid
User Type........................................ Person
Retransmit Timeout............................... 2 seconds
Bind Method ..................................... Authenticated
Bind Username.................................... user1
```

  Information similar to the following appears when you enter the **show ldap summary** command:

```
Idx  Server Address   Port  Enabled
---  ---------------  ----  -------
1    2.3.1.4          389   No
2    10.10.20.22      389   Yes
```

  Information similar to the following appears when you enter the **show ldap statistics** command:

```
Server Index..................................... 1
Server statistics:
  Initialized OK................................. 0
  Initialization failed.......................... 0
  Initialization retries......................... 0
  Closed OK...................................... 0
Request statistics:
  Received....................................... 0
  Sent........................................... 0
  OK............................................. 0
  Success........................................ 0
  Authentication failed.......................... 0
  Server not found............................... 0
  No received attributes......................... 0
  No passed username............................. 0
  Not connected to server........................ 0
  Internal error................................. 0
  Retries........................................ 0

Server Index..................................... 2
...
```

- Make sure the controller can reach the LDAP server by entering this command:

  ping *server_ip_address*
- Save your changes by entering this command:

  save config
- Enable or disable debugging for LDAP by entering this command:

  debug aaa ldap {**enable** | **disable**}

Configuring Local EAP

Local EAP is an authentication method that allows users and wireless clients to be authenticated locally. It is designed for use in remote offices that want to maintain connectivity to wireless clients when the backend system becomes disrupted or the external authentication server goes down. When you enable local EAP, the controller serves as the authentication server and the local user database, which removes dependence on an external authentication server. Local EAP retrieves user credentials from the local user database or the LDAP backend database to authenticate users. Local EAP supports LEAP, EAP-FAST, EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC authentication between the controller and wireless clients.

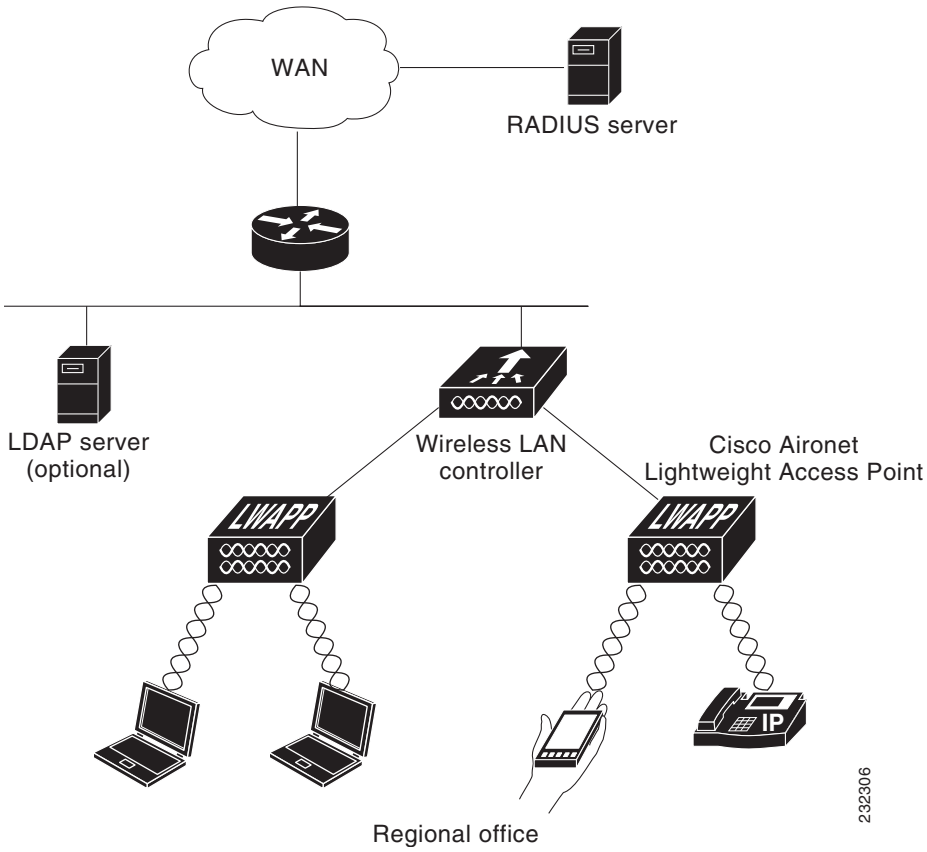
Note The LDAP backend database supports these local EAP methods: EAP-TLS, EAP-FAST/GTC, and PEAPv1/GTC. LEAP, EAP-FAST/MSCHAPv2, and PEAPv0/MSCHAPv2 are also supported but only if the LDAP server is set up to return a clear-text password.

Note Cisco wireless LAN controllers support Local EAP authentication against external LDAP databases such as Microsoft Active Directory and Novell's eDirectory. For more information about configuring the controller for Local EAP authentication on Novell's eDirectory, see the *Configure Unified Wireless Network for Authentication Against Novell's eDirectory Database* whitepaper at http://www.cisco.com/en/US/products/ps6366/products_white_paper09186a0080b4cd24.shtml.

Note If any RADIUS servers are configured on the controller, the controller tries to authenticate the wireless clients using the RADIUS servers first. Local EAP is attempted only if no RADIUS servers are found, either because the RADIUS servers timed out or no RADIUS servers were configured. If four RADIUS servers are configured, the controller attempts to authenticate the client with the first RADIUS server, then the second RADIUS server, and then local EAP. If the client attempts to then reauthenticate manually, the controller tries the third RADIUS server, then the fourth RADIUS server, and then local EAP. If you never want the controller to try to authenticate clients using an external RADIUS server, enter these CLI commands in this order:
config wlan disable *wlan_id*
config wlan radius_server auth disable *wlan_id*
config wlan enable *wlan_id*

Figure 6-21 provides an example of a remote office using local EAP.

Figure 6-21 Local EAP Example



You can configure local EAP through either the GUI or the CLI.

Using the GUI to Configure Local EAP

To configure local EAP using the controller GUI, follow these steps:

Note EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC use certificates for authentication, and EAP-FAST uses either certificates or PACs. The controller is shipped with Cisco-installed device and Certificate Authority (CA) certificates. However, if you want to use your own vendor-specific certificates, they must be imported on the controller.

Step 1 If you are configuring local EAP to use one of the EAP types listed in the note above, make sure that the appropriate certificates and PACs (if you will use manual PAC provisioning) have been imported on the controller. See Chapter 10, "Managing Controller Software and Configurations," for instructions on importing certificates and PACs.

Step 2 If you want the controller to retrieve user credentials from the local user database, make sure that you have properly configured the local network users on the controller. See the "Configuring Local Network Users" section on page 6-32 for instructions.

Step 3 If you want the controller to retrieve user credentials from an LDAP backend database, make sure that you have properly configured an LDAP server on the controller. See the "Configuring LDAP" section on page 6-36 for instructions.

Step 4 Specify the order in which user credentials are retrieved from the backend database servers as follows:

a. Choose **Security > Local EAP > Authentication Priority** to open the Priority Order > Local-Auth page (see Figure 6-22).

Figure 6-22 Priority Order > Local-Auth Page

b. Determine the priority order in which user credentials are to be retrieved from the local and/or LDAP databases. For example, you may want the LDAP database to be given priority over the local user database, or you may not want the LDAP database to be considered at all.

c. When you have decided on a priority order, highlight the desired database. Then use the left and right arrows and the Up and Down buttons to move the desired database to the top of the right User Credentials box.

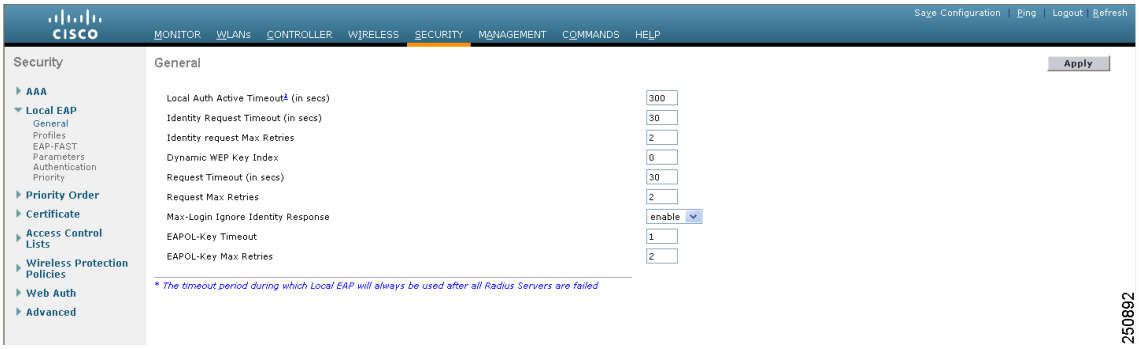
Note If both LDAP and LOCAL appear in the right User Credentials box with LDAP on the top and LOCAL on the bottom, local EAP attempts to authenticate clients using the LDAP backend database and fails over to the local user database if the LDAP servers are not reachable. If the user is not found, the authentication attempt is rejected. If LOCAL is on the top, local EAP attempts to authenticate using only the local user database. It does not fail over to the LDAP backend database.

d. Click **Apply** to commit your changes.

Step 5 Specify values for the local EAP timers as follows:

a. Choose **Security > Local EAP > General** to open the General page (see Figure 6-23).

Figure 6-23 General Page



b. In the Local Auth Active Timeout text box, enter the amount of time (in seconds) in which the controller attempts to authenticate wireless clients using local EAP after any pair of configured RADIUS servers fails. The valid range is 1 to 3600 seconds, and the default setting is 100 seconds.

c. In the Identity Request Timeout text box, enter the amount of time (in seconds) in which the controller attempts to send an EAP identity request to wireless clients using local EAP. The valid range is 1 to 120 seconds, and the default setting is 30 seconds.

d. In the Identity Request Max Retries text box, enter the maximum number of times that the controller attempts to retransmit the EAP identity request to wireless clients using local EAP. The valid range is 1 to 20 retries, and the default setting is 20 retries.

e. In the Dynamic WEP Key Index text box, enter the key index used for dynamic wired equivalent privacy (WEP). The default value is 0, which corresponds to a key index of 1; the valid values are 0 to 3 (key index of 1 to 4).

f. In the Request Timeout text box, enter the amount of time (in seconds) in which the controller attempts to send an EAP request to wireless clients using local EAP. The valid range is 1 to 120 seconds, and the default setting is 30 seconds.

g. In the Request Max Retries text box, enter the maximum number of times that the controller attempts to retransmit the EAP request to wireless clients using local EAP. The valid range is 1 to 120 retries, and the default setting is 20 retries.

h. From the Max-Login Ignore Identity Response drop-down list, choose **Enable** to limit the number of devices that can be connected to the controller with the same username. You can log in up to eight times from different devices (PDA, laptop, IP phone, and so on) on the same controller. The default value is enabled.

i. In the EAPOL-Key Timeout text box, enter the amount of time (in seconds) in which the controller attempts to send an EAP key over the LAN to wireless clients using local EAP. The valid range is 1 to 5 seconds, and the default setting is 1 second.

Note If the controller and access point are separated by a WAN link, the default timeout of 1 second may not be sufficient.

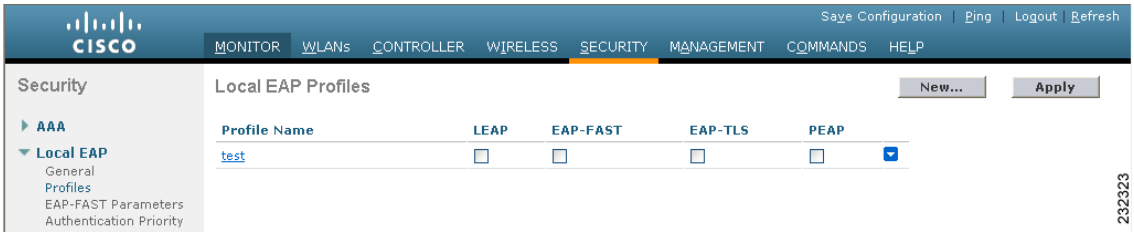
j. In the EAPOL-Key Max Retries text box, enter the maximum number of times that the controller attempts to send an EAP key over the LAN to wireless clients using local EAP. The valid range is 0 to 4 retries, and the default setting is 2 retries.

k. Click **Apply** to commit your changes.

Step 6 Create a local EAP profile, which specifies the EAP authentication types that are supported on the wireless clients as follows:

a. Choose **Security > Local EAP > Profiles** to open the Local EAP Profiles page (see Figure 6-24).

Figure 6-24 Local EAP Profiles Page



This page lists any local EAP profiles that have already been configured and specifies their EAP types. You can create up to 16 local EAP profiles.

Note If you want to delete an existing profile, hover your cursor over the blue drop-down arrow for that profile and choose **Remove**.

Note Local EAP Profiles are not supported on AP602 OEAP.

b. Click **New** to open the Local EAP Profiles > New page.

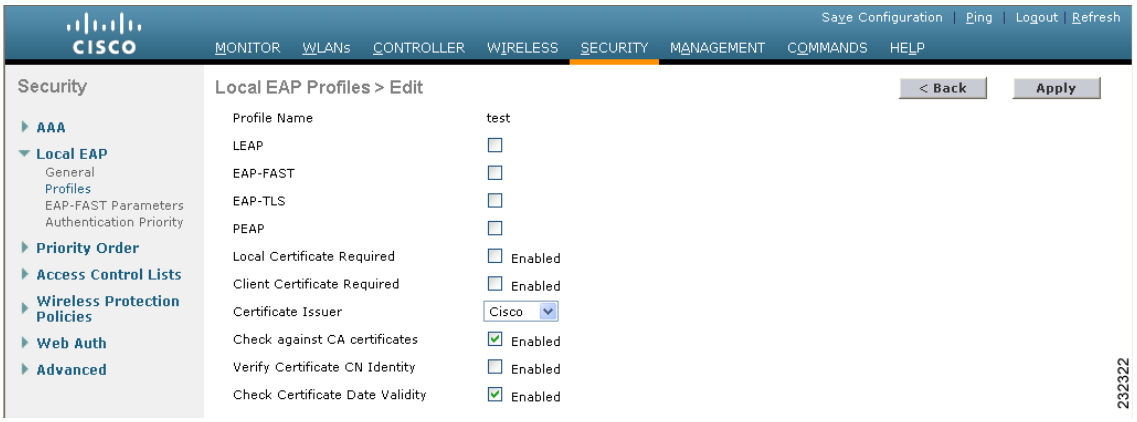
c. In the Profile Name text box, enter a name for your new profile and then click **Apply**.

Note You can enter up to 63 alphanumeric characters for the profile name. Make sure not to include spaces.

d. When the Local EAP Profiles page reappears, click the name of your new profile. The Local EAP Profiles > Edit page appears (see Figure 6-25).

Note Local EAP Profiles are not supported on AP602 OEAP.

Figure 6-25 Local EAP Profiles > Edit Page



e. Select the **LEAP**, **EAP-FAST**, **EAP-TLS**, and/or **PEAP** check boxes to specify the EAP type that can be used for local authentication.

Note You can specify more than one EAP type per profile. However, if you choose multiple EAP types that use certificates (such as EAP-FAST with certificates, EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC), all of the EAP types must use the same certificate (from either Cisco or another vendor).

Note If you select the PEAP check box, both PEAPv0/MSCHAPv2 or PEAPv1/GTC are enabled on the controller.

f. If you chose EAP-FAST and want the device certificate on the controller to be used for authentication, select the **Local Certificate Required** check box. If you want to use EAP-FAST with PACs instead of certificates, leave this check box unselected, which is the default setting.

Note This option applies only to EAP-FAST because device certificates are not used with LEAP and are mandatory for EAP-TLS and PEAP.

g. If you chose EAP-FAST and want the wireless clients to send their device certificates to the controller in order to authenticate, select the **Client Certificate Required** check box. If you want to use EAP-FAST with PACs instead of certificates, leave this check box unselected, which is the default setting.

Note This option applies only to EAP-FAST because client certificates are not used with LEAP or PEAP and are mandatory for EAP-TLS.

h. If you chose EAP-FAST with certificates, EAP-TLS, or PEAP, choose which certificates will be sent to the client, the ones from **Cisco** or the ones from another **Vendor**, from the Certificate Issuer drop-down list. The default setting is Cisco.

i. If you chose EAP-FAST with certificates or EAP-TLS and want the incoming certificate from the client to be validated against the CA certificates on the controller, select the **Check against CA certificates** check box. The default setting is enabled.

j. If you chose EAP-FAST with certificates or EAP-TLS and want the common name (CN) in the incoming certificate to be validated against the CA certificates' CN on the controller, select the **Verify Certificate CN Identity** check box. The default setting is disabled.

k. If you chose EAP-FAST with certificates or EAP-TLS and want the controller to verify that the incoming device certificate is still valid and has not expired, select the **Check Certificate Date Validity** check box. The default setting is enabled.

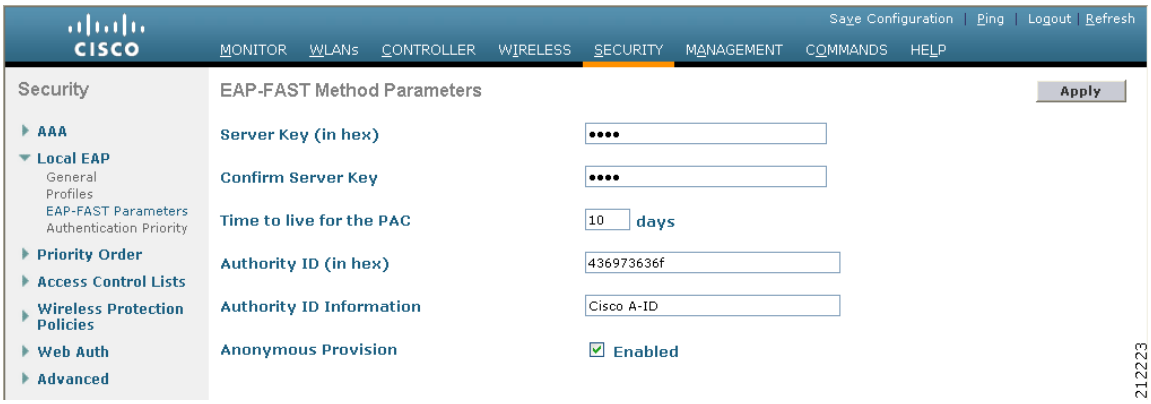
Note Certificate date validity is checked against the current UTC (GMT) time that is configured on the controller. Timezone offset will be ignored.

l. Click **Apply** to commit your changes.

Step 7 If you created an EAP-FAST profile, follow these steps to configure the EAP-FAST parameters:

a. Choose **Security > Local EAP > EAP-FAST Parameters** to open the EAP-FAST Method Parameters page (see Figure 6-26).

Figure 6-26 EAP-FAST Method Parameters Page



b. In the Server Key and Confirm Server Key text boxes, enter the key (in hexadecimal characters) used to encrypt and decrypt PACs.

c. In the Time to Live for the PAC text box, enter the number of days for the PAC to remain viable. The valid range is 1 to 1000 days, and the default setting is 10 days.

d. In the Authority ID text box, enter the authority identifier of the local EAP-FAST server in hexadecimal characters. You can enter up to 32 hexadecimal characters, but you must enter an even number of characters.

e. In the Authority ID Information text box, enter the authority identifier of the local EAP-FAST server in text format.

f. If you want to enable anonymous provisioning, select the **Anonymous Provision** check box. This feature allows PACs to be sent automatically to clients that do not have one during PAC provisioning. If you disable this feature, PACS must be manually provisioned. The default setting is enabled.

Note If the local and/or client certificates are required and you want to force all EAP-FAST clients to use certificates, unselect the **Anonymous Provision** check box.

g. Click **Apply** to commit your changes.

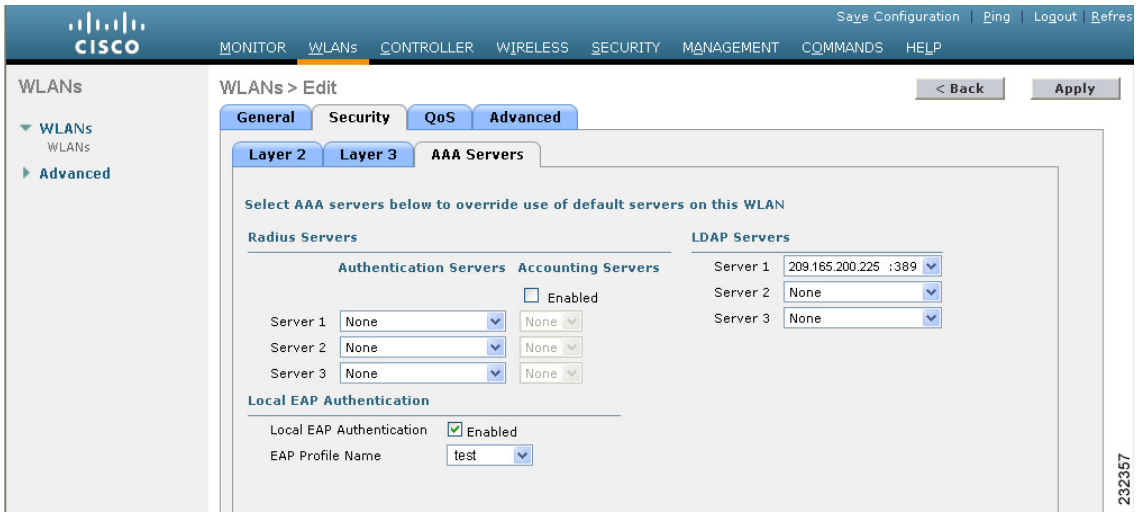
Step 8 Enable local EAP on a WLAN as follows:

a. Choose **WLANs** to open the WLANs page.

b. Click the ID number of the desired WLAN.

c. When the WLANs > Edit page appears, choose the **Security** > **AAA Servers** tabs to open the WLANs > Edit (Security > AAA Servers) page (see Figure 6-27).

Figure 6-27 WLANs > Edit (Security > AAA Servers) Page



d. Select the **Local EAP Authentication** check box to enable local EAP for this WLAN.

e. From the EAP Profile Name drop-down list, choose the EAP profile that you want to use for this WLAN.

f. If desired, choose the LDAP server that you want to use with local EAP on this WLAN from the LDAP Servers drop-down lists.

g. Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure Local EAP

To configure local EAP using the controller CLI, follow these steps:

Note See the "Using the GUI to Configure Local EAP" section on page 6-43 for the valid ranges and default values of the parameters used in the CLI commands.

Note EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC use certificates for authentication, and EAP-FAST uses either certificates or PACs. The controller is shipped with Cisco-installed device and Certificate Authority (CA) certificates. However, if you want to use your own vendor-specific certificates, they must be imported on the controller.

Step 1 If you are configuring local EAP to use one of the EAP types listed in the note above, make sure that the appropriate certificates and PACs (if you will use manual PAC provisioning) have been imported on the controller. See Chapter 10, "Managing Controller Software and Configurations," for instructions on importing certificates and PACs.

Step 2 If you want the controller to retrieve user credentials from the local user database, make sure that you have properly configured the local network users on the controller. See the "Configuring Local Network Users" section on page 6-32 for instructions.

Step 3 If you want the controller to retrieve user credentials from an LDAP backend database, make sure that you have properly configured an LDAP server on the controller. See the "Configuring LDAP" section on page 6-36 for instructions.

Step 4 Specify the order in which user credentials are retrieved from the local and/or LDAP databases by entering this command:

config local-auth user-credentials {**local** | **ldap**}

Note If you enter the **config local-auth user-credentials ldap local** command, local EAP attempts to authenticate clients using the LDAP backend database and fails over to the local user database if the LDAP servers are not reachable. If the user is not found, the authentication attempt is rejected. If you enter the **config local-auth user-credentials local ldap** command, local EAP attempts to authenticate using only the local user database. It does not fail over to the LDAP backend database.

Step 5 Specify values for the local EAP timers by entering these commands:

- **config local-auth active-timeout** *timeout*—Specifies the amount of time (in seconds) in which the controller attempts to authenticate wireless clients using local EAP after any pair of configured RADIUS servers fails. The valid range is 1 to 3600 seconds, and the default setting is 100 seconds.
- **config advanced eap identity-request-timeout** *timeout*—Specifies the amount of time (in seconds) in which the controller attempts to send an EAP identity request to wireless clients using local EAP. The valid range is 1 to 120 seconds, and the default setting is 30 seconds.
- **config advanced eap identity-request-retries** *retries*—Specifies the maximum number of times that the controller attempts to retransmit the EAP identity request to wireless clients using local EAP. The valid range is 1 to 20 retries, and the default setting is 20 retries.
- **config advanced eap key-index** *index*—Specifies the key index used for dynamic wired equivalent privacy (WEP). The default value is 0, which corresponds to a key index of 1; the valid values are 0 to 3 (key index of 1 to 4).
- **config advanced eap request-timeout** *timeout*—Specifies the amount of time (in seconds) in which the controller attempts to send an EAP request to wireless clients using local EAP. The valid range is 1 to 120 seconds, and the default setting is 30 seconds.
- **config advanced eap request-retries** *retries*—Specifies the maximum number of times that the controller attempts to retransmit the EAP request to wireless clients using local EAP. The valid range is 1 to 120 retries, and the default setting is 20 retries.
- **config advanced eap eapol-key-timeout** *timeout*—Specifies the amount of time (in seconds) in which the controller attempts to send an EAP key over the LAN to wireless clients using local EAP. The valid range is 1 to 5 seconds, and the default setting is 1 second.

Note If the controller and access point are separated by a WAN link, the default timeout of 1 second may not be sufficient.

- **config advanced eap eapol-key-retries** *retries*—Specifies the maximum number of times that the controller attempts to send an EAP key over the LAN to wireless clients using local EAP. The valid range is 0 to 4 retries, and the default setting is 2 retries.

- **config advanced eap max-login-ignore-identity-response** {**enable** | **disable**}—When enabled, this command limits the number of devices that can be connected to the controller with the same username. You can log in up to eight times from different devices (PDA, laptop, IP phone, and so on) on the same controller. The default value is enabled.

Step 6 Create a local EAP profile by entering this command:

config local-auth eap-profile add *profile_name*

Note Do not include spaces within the profile name.

Note To delete a local EAP profile, enter the **config local-auth eap-profile delete** *profile_name* command.

Step 7 Add an EAP method to a local EAP profile by entering this command:

config local-auth eap-profile method add *method profile_name*

The supported methods are leap, fast, tls, and peap.

Note If you choose peap, both PEAPv0/MSCHAPv2 or PEAPv1/GTC are enabled on the controller.

Note You can specify more than one EAP type per profile. However, if you create a profile with multiple EAP types that use certificates (such as EAP-FAST with certificates, EAP-TLS, PEAPv0/MSCHAPv2, and PEAPv1/GTC), all of the EAP types must use the same certificate (from either Cisco or another vendor).

Note To delete an EAP method from a local EAP profile, enter the **config local-auth eap-profile method delete** *method profile_name* command:

Step 8 Configure EAP-FAST parameters if you created an EAP-FAST profile by entering this command:

config local-auth method fast *?*

where *?* is one of the following:

- **anon-prov** {**enable** | **disable**}—Configures the controller to allow anonymous provisioning, which allows PACs to be sent automatically to clients that do not have one during PAC provisioning.
- **authority-id** *auth_id*—Specifies the authority identifier of the local EAP-FAST server.
- **pac-ttl** *days*—Specifies the number of days for the PAC to remain viable.
- **server-key** *key*—Specifies the server key used to encrypt and decrypt PACs.

Step 9 Configure certificate parameters per profile by entering these commands:

- **config local-auth eap-profile method fast local-cert** {**enable** | **disable**} *profile_name*—Specifies whether the device certificate on the controller is required for authentication.

Note This command applies only to EAP-FAST because device certificates are not used with LEAP and are mandatory for EAP-TLS and PEAP.

- **config local-auth eap-profile method fast client-cert** {**enable** | **disable**} *profile_name*—Specifies whether wireless clients are required to send their device certificates to the controller in order to authenticate.

  Note This command applies only to EAP-FAST because client certificates are not used with LEAP or PEAP and are mandatory for EAP-TLS.

- **config local-auth eap-profile cert-issuer {cisco | vendor}** *profile_name*—If you specified EAP-FAST with certificates, EAP-TLS, or PEAP, specifies whether the certificates that will be sent to the client are from Cisco or another vendor.
- **config local-auth eap-profile cert-verify ca-issuer** {**enable** | **disable**} *profile_name*—If you chose EAP-FAST with certificates or EAP-TLS, specifies whether the incoming certificate from the client is to be validated against the CA certificates on the controller.
- **config local-auth eap-profile cert-verify cn-verify** {**enable** | **disable**} *profile_name*—If you chose EAP-FAST with certificates or EAP-TLS, specifies whether the common name (CN) in the incoming certificate is to be validated against the CA certificates' CN on the controller.
- **config local-auth eap-profile cert-verify date-valid** {**enable** | **disable**} *profile_name*—If you chose EAP-FAST with certificates or EAP-TLS, specifies whether the controller is to verify that the incoming device certificate is still valid and has not expired.

Step 10 Enable local EAP and attach an EAP profile to a WLAN by entering this command:

config wlan local-auth enable *profile_name wlan_id*

Note To disable local EAP for a WLAN, enter the **config wlan local-auth disable** *wlan_id* command.

Step 11 Save your changes by entering this command:

save config

Step 12 View information pertaining to local EAP by entering these commands:

- **show local-auth config**—Shows the local EAP configuration on the controller.

  Information similar to the following appears when you enter the **show local-auth config** command:

```
User credentials database search order:
   Primary ..................................... Local DB

Timer:
    Active timeout ............................. 300

Configured EAP profiles:
   Name ........................................ fast-cert
     Certificate issuer ........................ vendor
     Peer verification options:
       Check against CA certificates ........... Enabled
       Verify certificate CN identity .......... Disabled
       Check certificate date validity ......... Enabled
     EAP-FAST configuration:
       Local certificate required .............. Yes
       Client certificate required ............. Yes
     Enabled methods ........................... fast
     Configured on WLANs ....................... 1

   Name ........................................ tls
     Certificate issuer ........................ vendor
```

```
      Peer verification options:
        Check against CA certificates ........... Enabled
        Verify certificate CN identity .......... Disabled
        Check certificate date validity ......... Enabled
      EAP-FAST configuration:
        Local certificate required .............. No
        Client certificate required ............. No
      Enabled methods ......................... tls
      Configured on WLANs ..................... 2

EAP Method configuration:
   EAP-FAST:
     Server key .............................. <hidden>
     TTL for the PAC ......................... 10
     Anonymous provision allowed ............. Yes
     Accept client on auth prov .............. No
     Authority ID ............................ 436973636f000000000000000000000000
     Authority Information ................... Cisco A-ID
```

- **show local-auth statistics**—Shows the local EAP statistics.
- **show local-auth certificates**—Shows the certificates available for local EAP.
- **show local-auth user-credentials**—Shows the priority order that the controller uses when retrieving user credentials from the local and/or LDAP databases.
- **show advanced eap**—Shows the timer values for local EAP. Information similar to the following appears:

```
EAP-Identity-Request Timeout (seconds)........... 1
EAP-Identity-Request Max Retries................. 20
EAP Key-Index for Dynamic WEP.................... 0
EAP Max-Login Ignore Identity Response........... enable
EAP-Request Timeout (seconds).................... 20
EAP-Request Max Retries.......................... 20
EAPOL-Key Timeout (seconds)...................... 1
EAPOL-Key Max Retries........................ 2
```

- **show ap stats wlan** *Cisco_AP*—Shows the EAP timeout and failure counters for a specific access point for each WLAN. Information similar to the following appears:

```
WLAN      1
   EAP Id Request Msg Timeouts................... 0
   EAP Id Request Msg Timeouts Failures.......... 0
   EAP Request Msg Timeouts...................... 2
   EAP Request Msg Timeouts Failures............. 1
   EAP Key Msg Timeouts.......................... 0
   EAP Key Msg Timeouts Failures................. 0
WLAN      2
   EAP Id Request Msg Timeouts................... 1
   EAP Id Request Msg Timeouts Failures.......... 0
   EAP Request Msg Timeouts...................... 0
   EAP Request Msg Timeouts Failures............. 0
   EAP Key Msg Timeouts.......................... 3
   EAP Key Msg Timeouts Failures.............. 1
```

- **show client detail** *client_mac*—Shows the EAP timeout and failure counters for a specific associated client. These statistics are useful in troubleshooting client association issues. Information similar to the following appears:

```
...
Client Statistics:
      Number of Bytes Received................... 10
      Number of Bytes Sent....................... 10
```

```
        Number of Packets Received..................... 2
        Number of Packets Sent......................... 2
        Number of EAP Id Request Msg Timeouts.......... 0
        Number of EAP Id Request Msg Failures.......... 0
        Number of EAP Request Msg Timeouts............. 2
        Number of EAP Request Msg Failures............. 1
        Number of EAP Key Msg Timeouts................. 0
        Number of EAP Key Msg Failures................. 0
        Number of Policy Errors........................ 0
        Radio Signal Strength Indicator.............. Unavailable
        Signal to Noise Ratio........................ Unavailable
...
```

- **show wlan** *wlan_id*—Shows the status of local EAP on a particular WLAN.

Step 13 (Optional) Troubleshoot local EAP sessions by entering these commands:

- **debug aaa local-auth eap method** {**all** | **errors** | **events** | **packets** | **sm**} {**enable** | **disable**}—Enables or disables debugging of local EAP methods.
- **debug aaa local-auth eap framework** {**all** | **errors** | **events** | **packets** | **sm**} {**enable** | **disable**}—Enables or disables debugging of the local EAP framework.

Note In these two debug commands, **sm** is the state machine.

- **clear stats local-auth**—Clears the local EAP counters.
- **clear stats ap wlan** *Cisco_AP*—Clears the EAP timeout and failure counters for a specific access point for each WLAN.

Configuring the System for SpectraLink NetLink Telephones

For the best integration with the Cisco UWN solution, SpectraLink NetLink Telephones require an extra operating system configuration step: enable long preambles. The radio preamble (sometimes called a header) is a section of data at the head of a packet that contains information that wireless devices need when sending and receiving packets. Short preambles improve throughput performance, so they are enabled by default. However, some wireless devices, such as SpectraLink NetLink phones, require long preambles.

Use one of these methods to enable long preambles:

- Using the GUI to Enable Long Preambles, page 6-54
- Using the CLI to Enable Long Preambles, page 6-55

Using the GUI to Enable Long Preambles

To enable long preambles to optimize the operation of SpectraLink NetLink phones on your wireless LAN using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **802.11b/g/n** > **Network** to open the 802.11b/g Global Parameters page.

Step 2 If the Short Preamble check box is selected, continue with this procedure. However, if the Short Preamble check box is unselected (which means that long preambles are enabled), the controller is already optimized for SpectraLink NetLink phones and you do not need to continue this procedure.

Step 3 Unselect the **Short Preamble** check box to enable long preambles.

Step 4 Click **Apply** to update the controller configuration.

Note If you do not already have an active CLI session to the controller, we recommend that you start a CLI session to reboot the controller and watch the reboot process. A CLI session is also useful because the GUI loses its connection when the controller reboots.

Step 5 Choose **Commands > Reboot > Reboot > Save and Reboot** to reboot the controller. Click **OK** in response to this prompt:

```
Configuration will be saved and the controller will be rebooted. Click ok to confirm.
```

The controller reboots.

Step 6 Log back into the controller GUI to verify that the controller is properly configured.

Step 7 Choose **Wireless > 802.11b/g/n > Network** to open the 802.11b/g Global Parameters page. If the Short Preamble check box is unselected, the controller is optimized for SpectraLink NetLink phones.

Using the CLI to Enable Long Preambles

To enable long preambles to optimize the operation of SpectraLink NetLink phones on your wireless LAN using the controller CLI, follow these steps:

Step 1 Log into the controller CLI.

Step 2 Enter the **show 802.11b** command and select the Short preamble mandatory parameter. If the parameter indicates that short preambles are enabled, continue with this procedure. This example shows that short preambles are enabled:

```
Short Preamble mandatory..................... Enabled
```

However, if the parameter shows that short preambles are disabled (which means that long preambles are enabled), the controller is already optimized for SpectraLink NetLink phones and you do not need to continue this procedure. This example shows that short preambles are disabled:

```
Short Preamble mandatory..................... Disabled
```

Step 3 Disable the 802.11b/g network by entering this command:

config 802.11b disable network

You cannot enable long preambles on the 802.11a network.

Step 4 Enable long preambles by entering this command:

config 802.11b preamble long

Step 5 Reenable the 802.11b/g network by entering this command:

config 802.11b enable network

Step 6 Enter the **reset system** command to reboot the controller. Enter **y** when this prompt appears:

```
The system has unsaved changes. Would you like to save them now? (y/n)
```

The controller reboots.

Step 7 Verify that the controller is properly configured by logging back into the CLI and entering the **show 802.11b** command to view these parameters:

```
802.11b Network.............................. Enabled
Short Preamble mandatory..................... Disabled
```

These parameters show that the 802.11b/g network is enabled and that short preambles are disabled.

Using the CLI to Configure Enhanced Distributed Channel Access

To configure 802.11 enhanced distributed channel access (EDCA) parameters to support SpectraLink phones, use the following CLI commands:

config advanced edca-parameters {**svp-voice** | **wmm-default**}

where

svp-voice enables SpectraLink voice priority (SVP) parameters and **wmm-default** enables wireless multimedia (WMM) default parameters.

Note To propagate this command to all access points connected to the controller, make sure to disable and then reenable the 802.11b/g network after entering this command.

Configuring RADIUS NAC Support

The Cisco Identity Services Engine (ISE) is a next-generation, context-based access control solution that provides the functions of Cisco Secure Access Control System (ACS) and Cisco Network Admission Control (NAC) in one integrated platform.

ISE has been introduced in the 7.0.116.0 release of the Cisco Unified Wireless Network. ISE can be used to provide advanced security for your deployed network. It is an authentication server that you can configure on your controller. When a client associates to the controller on a RADIUS NAC–enabled WLAN, the controller forwards the request to the ISE server.

The ISE server validates the user in the database and on successful authentication, the URL and pre-AUTH ACL are sent to the client. The client then moves to the Posture Required state and is redirected to the URL returned by the ISE server. The NAC agent in the client triggers the posture validation process. On successful posture validation by the ISE server, the client is moved to the run state.

Note Radius NAC functionality does not work if the configured accounting server is different from authentication (ISE) server. You should configure same server as authentication and accounting server in case ISE functionalities are used. If ISE is used only for ACS functionality, then the accounting srever can be flexible.

Note Dot1x authentication must be enabled.

The following restrictions apply:

- RADIUS NAC functionality with VLAN override is not supported after the change of authorization once the client is authorized.
- During slow roaming, the client goes through posture validation.
- Guest tunneling mobility is not supported for ISE NAC–enabled WLANs.
- MAC auth bypass is not supported for RADIUS NAC clients.
- VLAN select is not supported
- Workgroup bridge is not supported.
- The AP Group over NAC is not supported over RADIUS NAC.
- Hybrid REAP local switching is not supported.

Note Do not swap AAA server indexes in a live network. This may result in clients to be disconnected and having to reconnect to the RADIUS server. This may result in log messages to be appended to the ISE server logs.

When clients move from one WLAN to another, the controller retains the client's audit session ID if it returns to the WLAN before the idle timeout occurs. As a result of this, when clients join back the controller before the idle timeout session expires, they are immediately moved to RUN state. The clients are validated if they reassociate with the controller after the session timeout.

Suppose you have two WLANs, where WLAN 1 is configured on a controller (WLC1) and WLAN2 configured on another controller (WLC2) and both are RADIUS NAC enabled. The client first connects to WLC1 and movs to the RUN state after posture validation. Assume that the client now moved to WLC2. If the client connects back to WLC1 before the PMK expires for this client in WLC1, the posture validation is skipped for the client. Effectively, the client directly moves to RUN state bypassing posture validation as the controller retains the old audit session ID for the client which is already known to ISE.

When deploying RADIUS NAC in your wireless network, do not configure a primary and secondary ISE server. Instead, we recommend that you configure HA between the two ISE servers. Having a primary and secondary ISE setup will require a posture validation to happen before the clients move to RUN state. If HA is configured, the client is automatically moved to RUN state in the fallback ISE server.

Controller software configured with RADIUS NAC does not support change of authorization (CoA) on the service port.

Using the CLI to Configure RADIUS NAC Support

To configure RADIUS NAC support, use the following command:

config wlan nac radius {enable | disable} wlan *wlan_id*

Note You must enable AAA override on the WLAN to use RADIUS NAC.

Note WPA and WPA2 or dot1X must be enabled on the WLAN.

Using the GUI to Configure RADIUS NAC Support

To configure ISE on a WLAN using the controller GUI, follow these steps:

Step 1 Choose the WLANs tab.

Step 2 Click the WLAN ID of the WLAN for which you want to enable ISE.

The WLANs > Edit page appears.

Step 3 Click the **Advanced** tab.

Step 4 From the **NAC State** drop-down list, choose **Radius NAC**:

- SNMP NAC—Uses SNMP NAC for the WLAN.
- Radius NAC—Uses Radius NAC for the WLAN

Note AAA override is automatically enabled when you use RADIUS NAC on a WLAN.

Step 5 Click **Apply**.

Using Management over Wireless

The management over wireless feature allows you to monitor and configure local controllers using a wireless client. This feature is supported for all management tasks except uploads to and downloads from (transfers to and from) the controller.

Before you can use management over wireless, you must properly configure the controller using one of these sections:

- Using the GUI to Enable Management over Wireless, page 6-58
- Using the CLI to Enable Management over Wireless, page 6-59

Using the GUI to Enable Management over Wireless

To enable management over wireless using the controller GUI, follow these steps:

Step 1 Choose **Management** > **Mgmt Via Wireless** to open the Management Via Wireless page.

Step 2 Select the **Enable Controller Management to be accessible from Wireless Clients** check box to enable management over wireless for the WLAN or unselect it to disable this feature. The default value is unselected.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 Use a wireless client web browser to connect to the controller management port or distribution system port IP address, and log into the controller GUI to verify that you can manage the WLAN using a wireless client.

Using the CLI to Enable Management over Wireless

To enable management over wireless using the controller CLI, follow these steps:

Step 1 Verify whether the management over wireless interface is enabled or disabled by entering this command:

show network summary

If disabled, continue with Step 2. Otherwise, continue with Step 3.

Step 2 Enable management over wireless by entering this command:

config network mgmt-via-wireless enable

Step 3 Use a wireless client to associate with an access point connected to the controller that you want to manage.

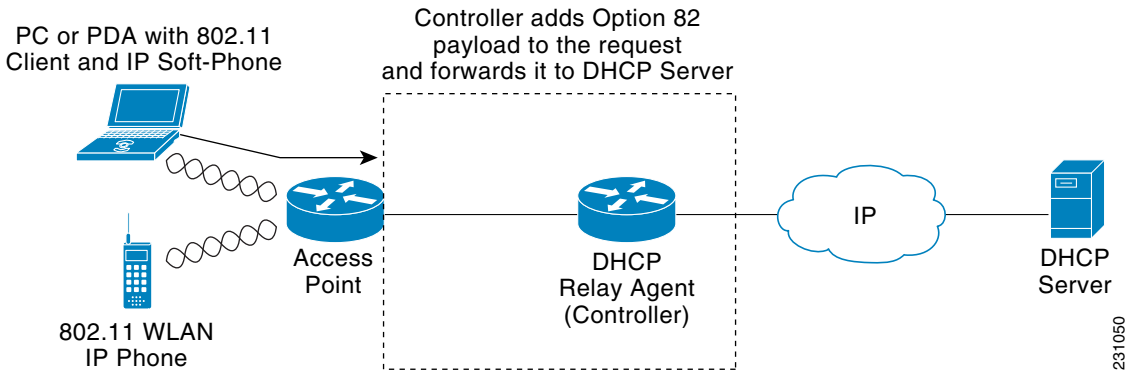
Step 4 Log into the CLI to verify that you can manage the WLAN using a wireless client by entering this command:

telnet controller-ip-address command

Configuring DHCP Option 82

DHCP option 82 provides additional security when DHCP is used to allocate network addresses. Specifically, it enables the controller to act as a DHCP relay agent to prevent DHCP client requests from untrusted sources. The controller can be configured to add option 82 information to DHCP requests from clients before forwarding the requests to the DHCP server. See Figure 6-28 for an illustration of this process.

Figure 6-28 DHCP Option 82



The access point forwards all DHCP requests from a client to the controller. The controller adds the DHCP option 82 payload and forwards the request to the DHCP server. The payload can contain the MAC address or the MAC address and SSID of the access point, depending on how you configure this option. In controller software release 4.0 or later releases, you can configure DHCP option 82 using the controller CLI. In controller software release 6.0 or later releases, you can configure this feature using either the GUI or CLI.

Note In order for DHCP option 82 to operate correctly, DHCP proxy must be enabled. See the "Configuring DHCP Proxy" section on page 4-39 for instructions on configuring DHCP proxy.

Note Any DHCP packets that already include a relay agent option are dropped at the controller.

Note DHCP option 82 is not supported for use with auto-anchor mobility, which is described in Chapter 14, "Configuring Mobility Groups."

Using the GUI to Configure DHCP Option 82

To configure DHCP option 82 using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Advanced** > **DHCP** to open the DHCP Parameters page (see Figure 6-29).

Figure 6-29 DHCP Parameters Page

Step 2 Select the Enable DHCP Proxy check box to enable DHCP proxy.

Step 3 Choose one of the following options from the DHCP Option 82 Remote ID text box Format drop-down list to specify the format of the DHCP option 82 payload:

- **AP-MAC**—Adds the MAC address of the access point to the DHCP option 82 payload. This is the default value.
- **AP-MAC-SSID**—Adds the MAC address and SSID of the access point to the DHCP option 82 payload.
- **AP-ETHMAC—**Adds the Ethernet MAC address of the access point to the DHCP option 82 payload.

Note If the SSID is associated with a dynamic interface, then the DHCP Option 82 that you configure must be enabled on the dynamic interface.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Using the CLI to Configure DHCP Option 82

To configure DHCP option 82 using the controller CLI, use these commands:

- Configure the format of the DHCP option 82 payload by entering one of these commands:
  - **config dhcp opt-82 remote-id** *ap_mac*

    This command adds the MAC address of the access point to the DHCP option 82 payload.
  - **config dhcp opt-82 remote-id** *ap_mac*:s*sid*

    This command adds the MAC address and SSID of the access point to the DHCP option 82 payload.
  - **config dhcp opt-82 remote-id** *ap-ethmac*

    Adds the Ethernet MAC address of the access point to the DHCP option 82 payload.
- Override the global DHCP option 82 setting and disable (or enable) this feature for the AP-manager or management interface on the controller by entering this command:

  config interface dhcp {**ap-manager** | **management**} **option-82** {**disable** | **enable**}
- See the status of DHCP option 82 on the controller by entering this command:

  show interface detailed ap-manager

  Information similar to the following appears:

```
Interface Name................................. ap-manager
MAC Address.................................... 00:0a:88:25:10:c4
IP Address..................................... 10.30.16.13
IP Netmask..................................... 255.255.248.0
IP Gateway..................................... 10.30.16.1
External NAT IP State.......................... Disabled
External NAT IP Address........................ 0.0.0.0
External NAT IP Netmask........................ 0.0.0.0
VLAN........................................... untagged
Active Physical Port........................... LAG (29)
Primary Physical Port.......................... LAG (29)
Backup Physical Port........................... Unconfigured
Primary DHCP Server............................ 10.1.0.10
Secondary DHCP Server.......................... Unconfigured
DHCP Option 82................................. Enabled
ACL............................................ Unconfigured
AP Manager..................................... Yes
Guest Interface................................ No
```

Configuring and Applying Access Control Lists

An access control list (ACL) is a set of rules used to limit access to a particular interface (for example, if you want to restrict a wireless client from pinging the management interface of the controller). After ACLs are configured on the controller, they can be applied to the management interface, the AP-manager interface, any of the dynamic interfaces, or a WLAN to control data traffic to and from wireless clients or to the controller central processing unit (CPU) to control all traffic destined for the CPU.

You may also want to create a preauthentication ACL for web authentication. Such an ACL could be used to allow certain types of traffic before authentication is complete.

Note If you are using an external web server with a Cisco 5500 Series Controller, a Cisco 2100 Series Controller, or a controller network module, you must configure a preauthentication ACL on the WLAN for the external web server.

You can define up to 64 ACLs, each with up to 64 rules (or filters). Each rule has parameters that affect its action. When a packet matches all of the parameters for a rule, the action set for that rule is applied to the packet.

Note All ACLs have an implicit "deny all rule" as the last rule. If a packet does not match any of the rules, it is dropped by the controller.

Note ACLs in your network might need to be modified if CAPWAP uses different ports than LWAPP.

Note Adding an ACL on the Controller results in the degradation of throughput and could even result in packet loss.

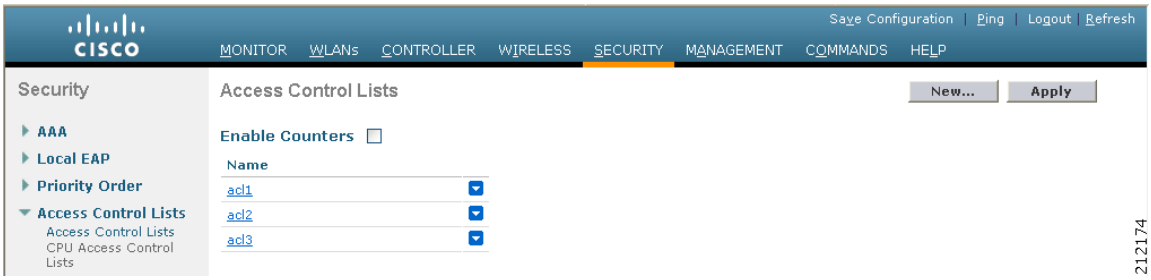
You can configure and apply ACLs through either the GUI or the CLI.

Using the GUI to Configure Access Control Lists

To configure ACLs using the controller GUI, follow these steps:

Step 1 Choose **Security > Access Control Lists > Access Control Lists** to open the Access Control Lists page (see Figure 6-30).

Figure 6-30 Access Control Lists Page



This page lists all of the ACLs that have been configured for this controller.

Note If you want to delete an existing ACL, hover your cursor over the blue drop-down arrow for that ACL and choose **Remove**.

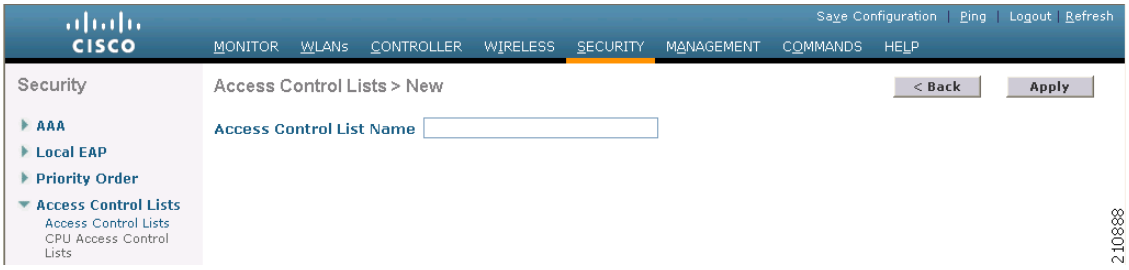
Step 2 If you want to see if packets are hitting any of the ACLs configured on your controller, select the **Enable Counters** check box and click **Apply**. Otherwise, leave the check box unselected, which is the default value. This feature is useful when troubleshooting your system.

Note If you want to clear the counters for an ACL, hover your cursor over the blue drop-down arrow for that ACL and choose **Clear Counters**.

Note ACL counters are available only on the following controllers: 5500 series, 4400 series, Cisco WiSM, and Catalyst 3750G Integrated Wireless LAN Controller Switch.

Step 3 Add a new ACL by clicking **New**. The Access Control Lists > New page appears (see Figure 6-31).

Figure 6-31 Access Control Lists > New Page

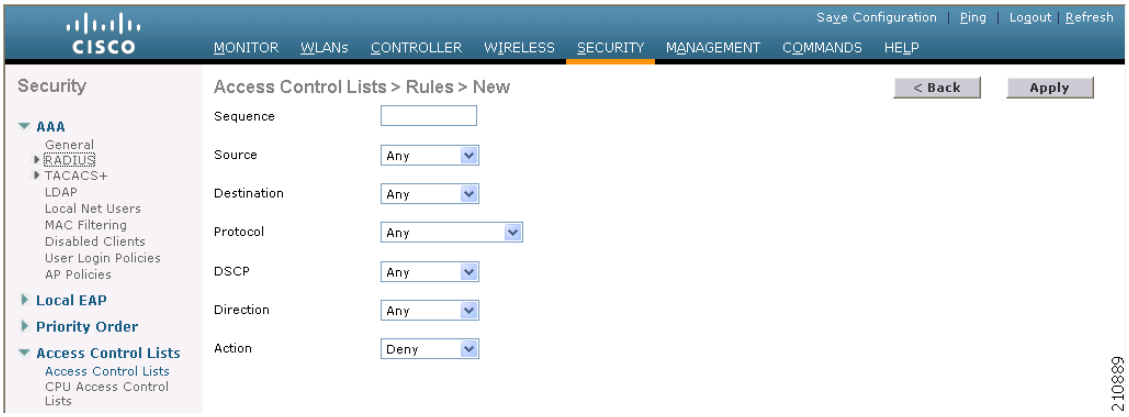


Step 4 In the Access Control List Name text box, enter a name for the new ACL. You can enter up to 32 alphanumeric characters.

Step 5 Click **Apply**. When the Access Control Lists page reappears, click the name of the new ACL.

Step 6 When the Access Control Lists > Edit page appears, click **Add New Rule**. The Access Control Lists > Rules > New page appears (see Figure 6-32).

Figure 6-32 Access Control Lists > Rules > New Page



Step 7 Configure a rule for this ACL as follows:

a. The controller supports up to 64 rules for each ACL. These rules are listed in order from 1 to 64. In the Sequence text box, enter a value (between 1 and 64) to determine the order of this rule in relation to any other rules defined for this ACL.

Note If rules 1 through 4 are already defined and you add rule 29, it is added as rule 5. If you add or change a sequence number for a rule, the sequence numbers for other rules adjust to maintain a contiguous sequence. For instance, if you change a rule's sequence number from 7 to 5, the rules with sequence numbers 5 and 6 are automatically reassigned as 6 and 7, respectively.

b. From the Source drop-down list, choose one of these options to specify the source of the packets to which this ACL applies:

- **Any**—Any source (this is the default value).
- **IP Address**—A specific source. If you choose this option, enter the IP address and netmask of the source in the edit boxes.

c. From the Destination drop-down list, choose one of these options to specify the destination of the packets to which this ACL applies:

- **Any**—Any destination (this is the default value).
- **IP Address**—A specific destination. If you choose this option, enter the IP address and netmask of the destination in the edit boxes.

d. From the Protocol drop-down list, choose the protocol ID of the IP packets to be used for this ACL. These are the protocol options:

- **Any**—Any protocol (this is the default value)
- **TCP**—Transmission Control Protocol
- **UDP**—User Datagram Protocol
- **ICMP**—Internet Control Message Protocol
- **ESP**—IP Encapsulating Security Payload
- **AH**—Authentication Header
- **GRE**—Generic Routing Encapsulation
- **IP in IP**—Internet Protocol (IP) in IP (permits or denies IP-in-IP packets)
- **Eth Over IP**—Ethernet-over-Internet Protocol
- **OSPF**—Open Shortest Path First
- **Other**—Any other Internet Assigned Numbers Authority (IANA) protocol

Note If you choose **Other**, enter the number of the desired protocol in the Protocol text box. You can find the list of available protocols in the INAI wesite.

- The controller can permit or deny only IP packets in an ACL. Other types of packets (such as ARP packets) cannot be specified.

e. If you chose TCP or UDP in the previous step, two additional parameters appear: Source Port and Destination Port. These parameters enable you to choose a specific source port and destination port or port ranges. The port options are used by applications that send and receive data to and from the networking stack. Some ports are designated for certain applications such as telnet, ssh, http, and so on.

f. From the DSCP drop-down list, choose one of these options to specify the differentiated services code point (DSCP) value of this ACL. DSCP is an IP header text box that can be used to define the quality of service across the Internet.

- **Any**—Any DSCP (this is the default value)
- **Specific**—A specific DSCP from 0 to 63, which you enter in the DSCP edit box

g. From the Direction drop-down list, choose one of these options to specify the direction of the traffic to which this ACL applies:

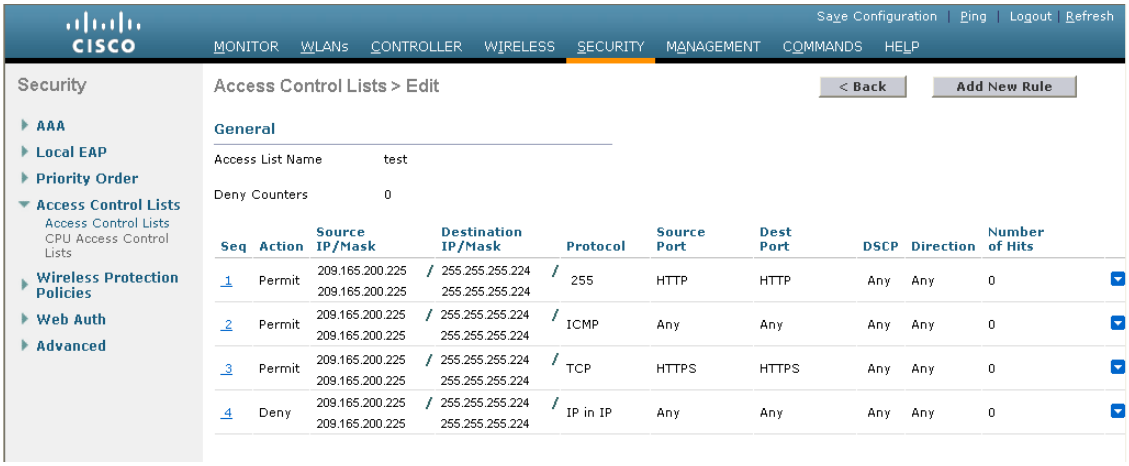
- **Any**—Any direction (this is the default value)
- **Inbound**—From the client
- **Outbound**—To the client

Note If you are planning to apply this ACL to the controller CPU, the packet direction does not have any significance, it is always 'Any'.

h. From the Action drop-down list, choose **Deny** to cause this ACL to block packets or **Permit** to cause this ACL to allow packets. The default value is Deny.

i. Click **Apply** to commit your changes. The Access Control Lists > Edit page reappears, showing the rules for this ACL. See Figure 6-33.

Figure 6-33 Access Control Lists > Edit Page



The Deny Counters fields shows the number of times that packets have matched the explicit deny ACL rule. The Number of Hits field shows the number of times that packets have matched an ACL rule. You must enable ACL counters on the Access Control Lists page to enable these fields.

Note If you want to edit a rule, click the sequence number of the desired rule to open the Access Control Lists > Rules > Edit page. If you want to delete a rule, hover your cursor over the blue drop-down arrow for the desired rule and choose **Remove**.

j. Repeat this procedure to add any additional rules for this ACL.

Step 8 Click **Save Configuration** to save your changes.

Step 9 Repeat this procedure to add any additional ACLs.

Using the GUI to Apply Access Control Lists

These sections describe how to apply ACLs using the controller GUI:

- Applying an Access Control List to an Interface, page 6-66
- Applying an Access Control List to the Controller CPU, page 6-67
- Applying an Access Control List to a WLAN, page 6-68
- Applying a Preauthentication Access Control List to a WLAN, page 6-69

Note If you apply an ACL to an interface or a WLAN, wireless throughput is degraded when downloading from a 1-Gbps file server. To improve throughput, remove the ACL from the interface or WLAN, move the ACL to a neighboring wired device with a policy rate-limiting restriction, or connect the file server using 100 Mbps rather than 1 Gbps.

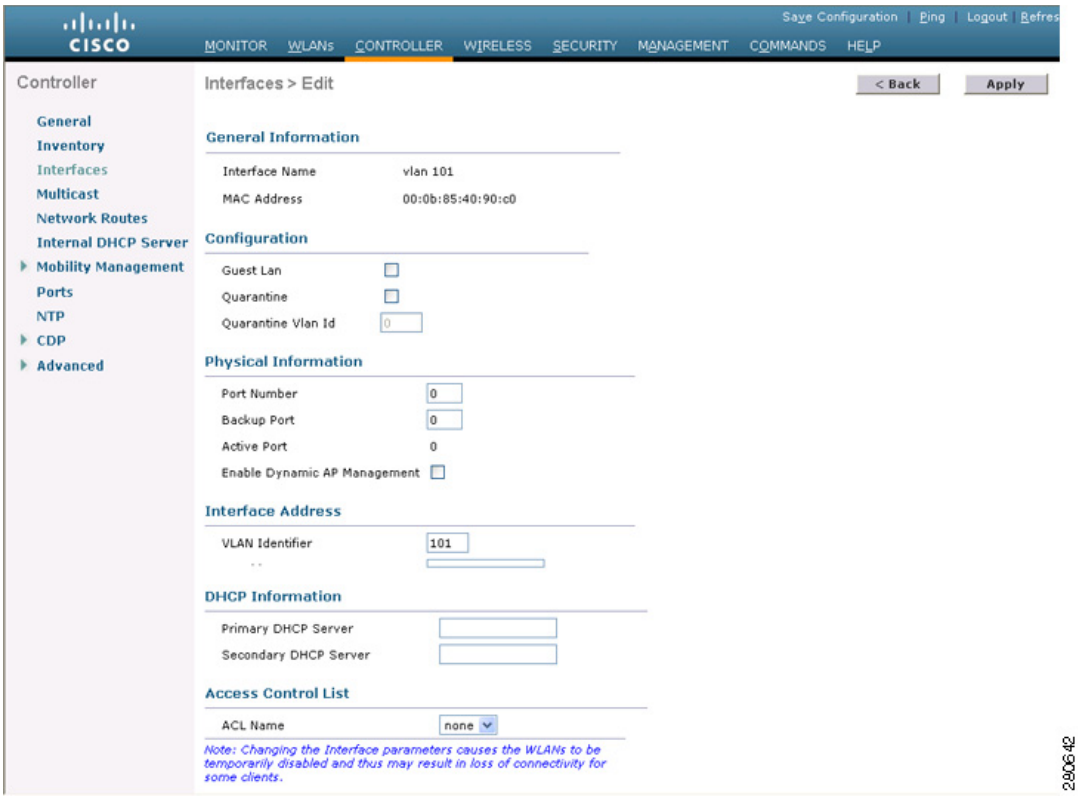
Applying an Access Control List to an Interface

To apply an ACL to a management, AP-manager, or dynamic interface using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Interfaces**.

Step 2 Click the name of the desired interface. The Interfaces > Edit page for that interface appears (see Figure 6-34).

Figure 6-34 Interfaces > Edit Page



Step 3 Choose the desired ACL from the ACL Name drop-down list and click **Apply**. None is the default value.

Note See Chapter 3, "Configuring Ports and Interfaces," for more information on configuring controller interfaces.

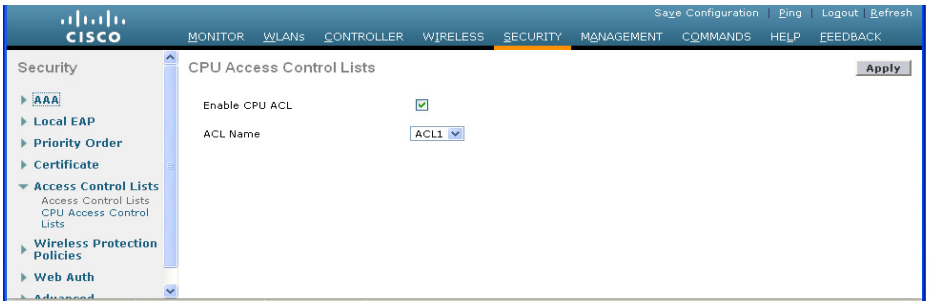
Step 4 Click **Save Configuration** to save your changes.

Applying an Access Control List to the Controller CPU

To apply an ACL to the controller CPU to control traffic to the CPU using the controller GUI, follow these steps:

Step 1 Choose **Security > Access Control Lists > CPU Access Control Lists** to open the CPU Access Control Lists page (see Figure 6-35).

Figure 6-35 CPU Access Control Lists Page



Step 2 Select the **Enable CPU ACL** check box to enable a designated ACL to control the traffic to the controller CPU or unselect the check box to disable the CPU ACL feature and remove any ACL that had been applied to the CPU. The default value is unselected.

Step 3 From the ACL Name drop-down list, choose the ACL that will control the traffic to the controller CPU. None is the default value when the CPU ACL feature is disabled. If you choose None while the CPU ACL Enable check box is selected, an error message appears indicating that you must choose an ACL.

Note This parameter is available only if you have selected the CPU ACL Enable check box.

Note When CPU ACL is enabled, it is applicable to both wireless and wired traffic.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Applying an Access Control List to a WLAN

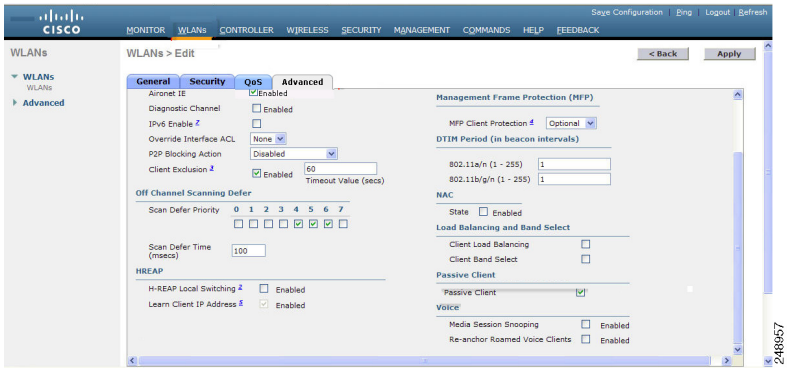
To apply an ACL to a WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 6-36).

Figure 6-36 WLANs > Edit (Advanced) Page



Step 4 From the Override Interface ACL drop-down list, choose the ACL that you want to apply to this WLAN. The ACL that you choose overrides any ACL that is configured for the interface. None is the default value.

Note See Chapter 7, "Configuring WLANs," for more information on configuring WLANs.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Applying a Preauthentication Access Control List to a WLAN

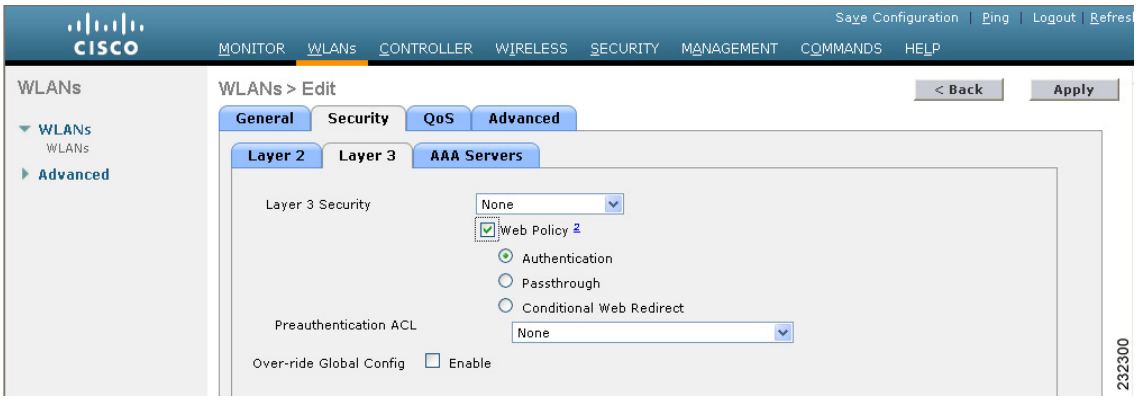
To apply a preauthentication ACL to a WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Security** and **Layer 3** tabs to open the WLANs > Edit (Security > Layer 3) page (see Figure 6-37).

Figure 6-37 WLANs > Edit (Security > Layer 3) Page



Step 4 Select the **Web Policy** check box.

Step 5 From the Preauthentication ACL drop-down list, choose the desired ACL and click **Apply**. None is the default value.

Note See Chapter 7, "Configuring WLANs" for more information on configuring WLANs.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure Access Control Lists

To configure ACLs using the controller CLI, follow these steps:

Step 1 See all of the ACLs that are configured on the controller by entering this command:

show acl summary

Information similar to the following appears:

```
ACL Counter Status         Enabled
-------------------------------------
ACL Name                    Applied
------------------------- -----------
acl1                          Yes
acl2                          Yes
acl3                         Yes
```

Step 2 See detailed information for a particular ACL by entering this command:

show acl detailed *acl_name*

Information similar to the following appears:

```
            Source          Destination        Source Port Dest Port
I Dir IP Address/Netmask IP Address/Netmask Prot    Range Range   DSCP Action Counter
- --- ------------------ ------------------ ---- ----------- -------- ----- ------ -------
1 Any 0.0.0.0/0.0.0.0    0.0.0.0/0.0.0.0    Any    0-65535  0-65535  0     Deny    0
2 In  0.0.0.0/0.0.0.0    200.200.200.0/     6      80-80    0-65535  Any   Permit  0
                         255.255.255.0

DenyCounter :     0
```

The Counter text box increments each time a packet matches an ACL rule, and the DenyCounter text box increments each time a packet does not match any of the rules.

Note If a traffic/request is allowed from the controller by a permit rule, then the response to the traffic/request in the opposite direction also is allowed and cannot be blocked by a deny rule in the ACL.

Step 3 Enable or disable ACL counters for your controller by entering this command:

config acl counter {**start** | **stop**}

Note If you want to clear the current counters for an ACL, enter the **clear acl counters** *acl_name* command.

Note ACL counters are available only on the Cisco 5500 Series Controller, Cisco 4400 Series Controller, Cisco WiSM, and Catalyst 3750G Integrated Wireless LAN Controller Switch.

Step 4 Add a new ACL by entering this command:

config acl create *acl_name*

You can enter up to 32 alphanumeric characters for the *acl_name* parameter.

Note When you try to create an interface name with space, the controller CLI does not create an interface. For example, if you want to create an interface name *int 3,* the CLI will not create this since there is a space between int and 3. If you want to use *int 3* as the interface name, you need to enclose within single quotes like '*int 3'*.

Step 5 Add a rule for an ACL by entering this command:

config acl rule add *acl_name rule_index*

Step 6 Configure an ACL rule by entering this command:

config acl rule

action *acl_name rule_index* {**permit** | **deny**} |

change index *acl_name old_index new_index* |

destination address *acl_name rule_index ip_address netmask* |

destination port range *acl_name rule_index start_port end_port* |

direction *acl_name rule_index* {**in** | **out** | **any**} |

dscp *acl_name rule_index dscp* |

protocol *acl_name rule_index protocol* |

source address *acl_name rule_index ip_address netmask* |

source port range *acl_name rule_index start_port end_port* |

swap index *acl_name index_1 index_2*}

See Step 7 of the "Using the GUI to Configure Access Control Lists" section on page 6-62 for explanations of the rule parameters.

Step 7 Save your settings by entering this command:

save config

Note To delete an ACL, enter the **config acl delete** *acl_name* command. To delete an ACL rule, enter the **config acl rule delete** *acl_name rule_index* command.

Using the CLI to Apply Access Control Lists

To apply ACLs using the controller CLI, follow these steps:

Step 1 Perform any of the following:

- To apply an ACL to a management, AP-manager, or dynamic interface, enter this command:

  config interface acl {**management** | **ap-manager** | *dynamic_interface_name*} *acl_name*

  Note To see the ACL that is applied to an interface, enter the **show interface detailed** {**management** | **ap-manager** | *dynamic_interface_name*} command. To remove an ACL that is applied to an interface, enter the **config interface acl** {**management** | **ap-manager** | *dynamic_interface_name*} **none** command.

  See Chapter 3, "Configuring Ports and Interfaces," for more information on configuring controller interfaces.

- To apply an ACL to the data path, enter this command:

  config acl apply *acl_name*

- To apply an ACL to the controller CPU to restrict the type of traffic (wired, wireless, or both) reaching the CPU, enter this command:

  config acl cpu *acl_name* {**wired** | **wireless** | **both**}

  Note To see the ACL that is applied to the controller CPU, enter the **show acl cpu** command. To remove the ACL that is applied to the controller CPU, enter the **config acl cpu none** command.

- To apply an ACL to a WLAN, enter this command:

  config wlan acl *wlan_id acl_name*

  Note To see the ACL that is applied to a WLAN, enter the **show wlan** *wlan_id* command. To remove the ACL that is applied to a WLAN, enter the **config wlan acl** *wlan_id* **none** command.

- To apply a preauthentication ACL to a WLAN, enter this command:

  config wlan security web-auth acl *wlan_id acl_name*

  See Chapter 7, "Configuring WLANs," for more information on configuring WLANs.

Step 2 Save your changes by entering this command:

save config

Configuring Management Frame Protection

Management frame protection (MFP) provides security for the otherwise unprotected and unencrypted 802.11 management messages passed between access points and clients. MFP provides both infrastructure and client support. Controller software release 4.1 or later releases support both infrastructure and client MFP while controller software release 4.0 supports only infrastructure MFP.

- Infrastructure MFP—Protects management frames by detecting adversaries that are invoking denial-of-service attacks, flooding the network with associations and probes, interjecting as rogue access points, and affecting network performance by attacking the QoS and radio measurement frames. It also provides a quick and effective means to detect and report phishing incidents.

  Specifically, infrastructure MFP protects 802.11 session management functions by adding message integrity check information elements (MIC IEs) to the management frames emitted by access points (and not those emitted by clients), which are then validated by other access points in the network. Infrastructure MFP is passive. It can detect and report intrusions but has no means to stop them.

- Client MFP—Shields authenticated clients from spoofed frames, preventing many of the common attacks against wireless LANs from becoming effective. Most attacks, such as deauthentication attacks, revert to simply degrading performance by contending with valid clients.

  Specifically, client MFP encrypts management frames are sent between access points and CCXv5 clients so that both the access points and clients can take preventative action by dropping spoofed class 3 management frames (that is, management frames passed between an access point and a client that is authenticated and associated). Client MFP leverages the security mechanisms defined by IEEE 802.11i to protect the following types of class 3 unicast management frames: disassociation, deauthentication, and QoS (WMM) action. Client MFP protects a client-access point session from the most common type of denial-of-service attack. It protects class 3 management frames by using the same encryption method used for the session's data frames. If a frame received by the access point or client fails decryption, it is dropped, and the event is reported to the controller.

  To use client MFP, clients must support CCXv5 MFP and must negotiate WPA2 using either TKIP or AES-CCMP. EAP or PSK may be used to obtain the PMK. CCKM and controller mobility management are used to distribute session keys between access points for Layer 2 and Layer 3 fast roaming.

Note To prevent attacks using broadcast frames, access points supporting CCXv5 will not emit any broadcast class 3 management frames (such as disassociation, deauthentication, or action). CCXv5 clients and access points must discard broadcast class 3 management frames.

  Client MFP supplements infrastructure MFP rather than replaces it because infrastructure MFP continues to detect and report invalid unicast frames sent to clients that are not client-MFP capable as well as invalid class 1 and 2 management frames. Infrastructure MFP is applied only to management frames that are not protected by client MFP.

Infrastructure MFP consists of three main components:

- Management frame protection—The access point protects the management frames it transmits by adding a MIC IE to each frame. Any attempt to copy, alter, or replay the frame invalidates the MIC, causing any receiving access point configured to detect MFP frames to report the discrepancy.
- Management frame validation—In infrastructure MFP, the access point validates every management frame that it receives from other access points in the network. It ensures that the MIC IE is present (when the originator is configured to transmit MFP frames) and matches the content of the management frame. If it receives any frame that does not contain a valid MIC IE from a BSSID belonging to an access point that is configured to transmit MFP frames, it reports the discrepancy to the network management system. In order for the timestamps to operate properly, all controllers must be Network Transfer Protocol (NTP) synchronized.
- Event reporting—The access point notifies the controller when it detects an anomaly, and the controller aggregates the received anomaly events and can report the results through SNMP traps to the network management system.

Note Error reports generated on a hybrid-REAP access point in standalone mode cannot be forwarded to the controller and are dropped.

Note Client MFP uses the same event reporting mechanisms as infrastructure MFP.

Infrastructure MFP is enabled by default and can be disabled globally. When you upgrade from a previous software release, infrastructure MFP is disabled globally if access point authentication is enabled because the two features are mutually exclusive. Once infrastructure MFP is enabled globally, signature generation (adding MICs to outbound frames) can be disabled for selected WLANs, and validation can be disabled for selected access points.

Client MFP is enabled by default on WLANs that are configured for WPA2. It can be disabled, or it can be made mandatory (in which case, only clients that negotiate MFP are allowed to associate) on selected WLANs.

Note Infrastructure MFP is a global setting only in the 7.0.98.0 release. In the earlier releases, there was an option for you to enable or disable the MFP infrastructure protection for WLANs and MFP infrastructure validation for APs. These options are no longer available in the GUI or CLI.

Guidelines for Using MFP

Follow these guidelines for using MFP:

- MFP is supported for use with Cisco Aironet lightweight access points.
- Lightweight access points support infrastructure MFP in local and monitor modes and in hybrid-REAP mode when the access point is connected to a controller. They support client MFP in local, hybrid-REAP, and bridge modes.

Note OEAP 600 Series Access points do not support MFP.

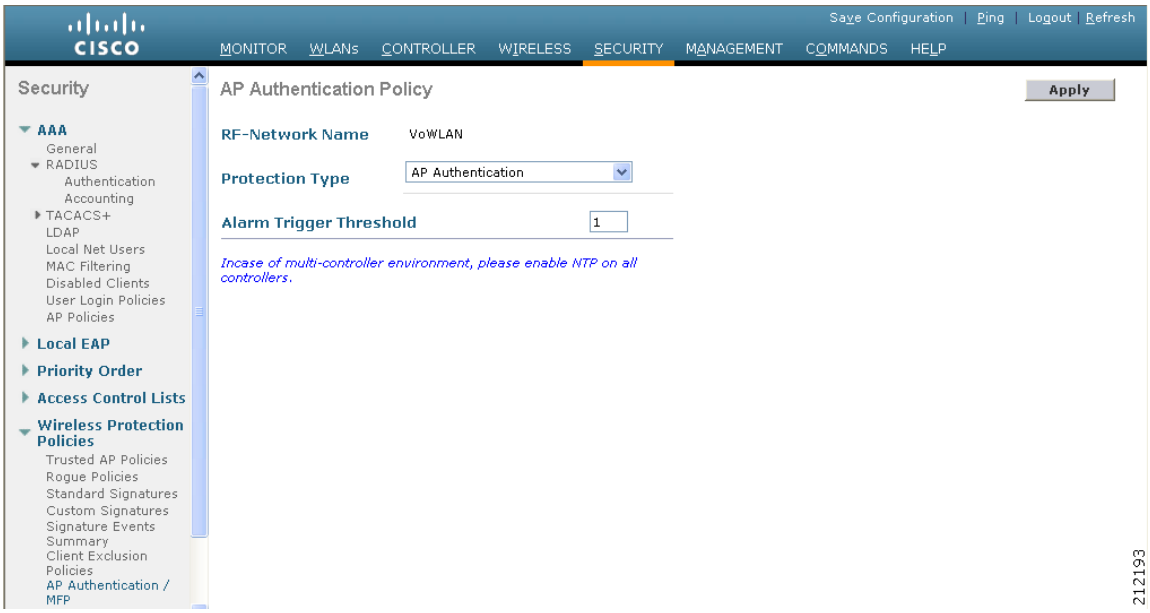
- Client MFP is supported for use only with CCXv5 clients using WPA2 with TKIP or AES-CCMP.
- Non-CCXv5 clients may associate to a WLAN if client MFP is disabled or optional.

Using the GUI to Configure MFP

To configure MFP using the controller GUI, follow these steps:

Step 1 Choose **Security** > **Wireless Protection Policies** > **AP Authentication/MFP** to open the AP Authentication Policy page (see Figure 6-38).

Figure 6-38 AP Authentication Policy Page



Step 2 Enable infrastructure MFP globally for the controller by choosing **Management Frame Protection** from the Protection Type drop-down list.

Step 3 Click **Apply** to commit your changes.

Note If more than one controller is included in the mobility group, you must configure a Network Time Protocol (NTP) server on all controllers in the mobility group that are configured for infrastructure MFP.

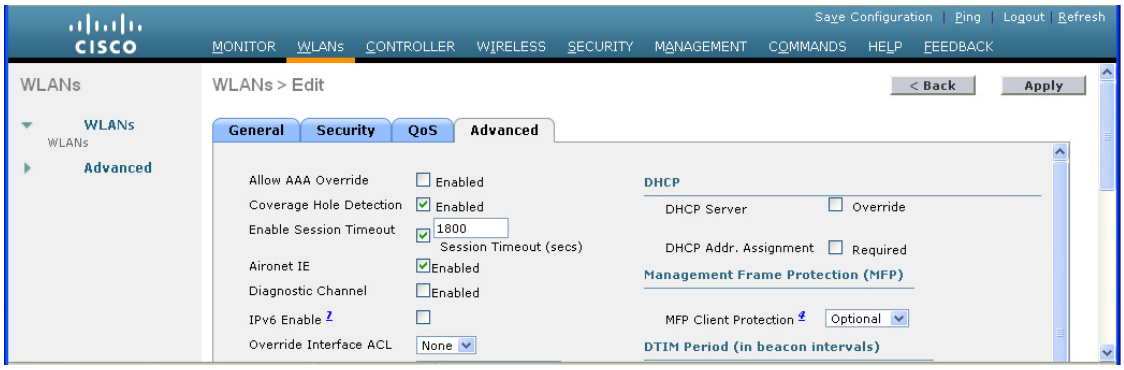
Step 4 Configure client MFP for a particular WLAN after infrastructure MFP has been enabled globally for the controller as follows:

a. Choose **WLANs**.

b. Click the profile name of the desired WLAN. The WLANs > Edit page appears.

c. Choose **Advanced**. The WLANs > Edit (Advanced) page appears (see Figure 6-39).

Figure 6-39 WLANs > Edit (Advanced) Page



d. Choose **Disabled**, **Optional**, or **Required** from the MFP Client Protection drop-down list. The default value is Optional. If you choose Required, clients are allowed to associate only if MFP is negotiated (that is, if WPA2 is configured on the controller and the client supports CCXv5 MFP and is also configured for WPA2).

Note For Cisco OEAP 600, MFP is not supported. It should either be Disabled or Optional.

e. Click **Apply** to commit your changes.

Step 5 Disable or reenable infrastructure MFP validation for a particular access point after infrastructure MFP has been enabled globally for the controller as follows:

a. Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

b. Click the name of the desired access point.

c. Choose the **Advanced** tab. The All APs > Details for (Advanced) page appears.

d. Unselect the **MFP Frame Validation** check box to disable MFP for this access point or select this check box to enable MFP for this access point. The default value is enabled. If global MFP is disabled, a note appears in parentheses to the right of the check box.

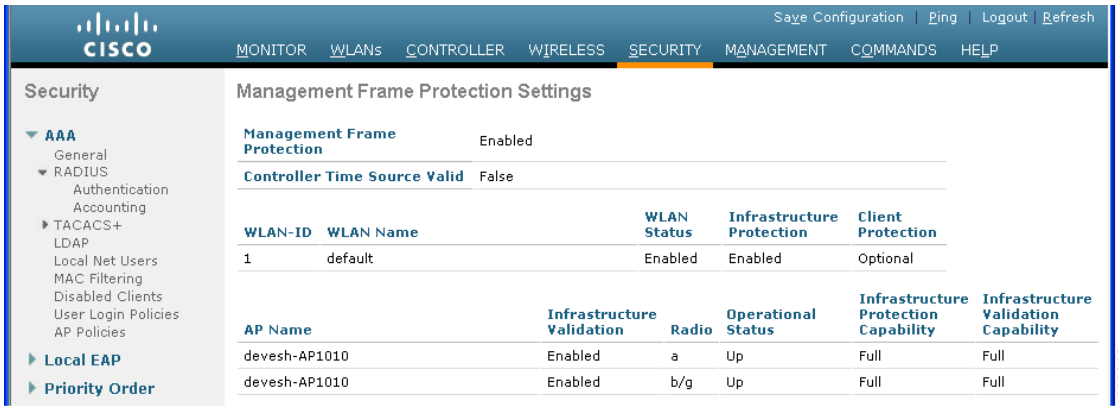
e. Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your settings.

Using the GUI to View MFP Settings

To see the controller's current global MFP settings, choose **Security** > **Wireless Protection Policies** > **Management Frame Protection**. The Management Frame Protection Settings page appears (see Figure 6-40).

Figure 6-40 Management Frame Protection Settings Page



On this page, you can see the following MFP settings:

- The Management Frame Protection field shows if infrastructure MFP is enabled globally for the controller.
- The Controller Time Source Valid field indicates whether the controller time is set locally (by manually entering the time) or through an external source (such as the NTP server). If the time is set by an external source, the value of this field is "True." If the time is set locally, the value is "False." The time source is used for validating the timestamp on management frames between access points of different controllers within a mobility group.
- The Infrastructure Protection field shows if infrastructure MFP is enabled for individual WLANs.
- The Client Protection field shows if client MFP is enabled for individual WLANs and whether it is optional or required.
- The Infrastructure Validation text box shows if infrastructure MFP is enabled for individual access points.

Using the CLI to Configure MFP

To configure MFP using the controller CLI, use these commands:

- Enable or disable infrastructure MFP globally for the controller by entering this command:

  config wps mfp infrastructure {**enable** | **disable**}

- Enable or disable infrastructure MFP validation on an access point by entering this command:

  config ap mfp infrastructure validation {**enable** | **disable**} *Cisco_AP*

  Note MFP validation is activated only if infrastructure MFP is globally enabled.

- Enable or disable client MFP on a specific WLAN by entering this command:

  config wlan mfp client {**enable** | **disable**} *wlan_id* [**required**]

  If you enable client MFP and use the optional **required** parameter, clients are allowed to associate only if MFP is negotiated.

Using the CLI to View MFP Settings

To view MFP settings using the controller CLI, use these commands:

- See the controller's current MFP settings by entering this command:

  show wps mfp summary

  Information similar to the following appears:

```
Global Infrastructure MFP state.... Enabled
Controller Time Source Valid....... False

                    WLAN       Infra.      Client
WLAN ID  WLAN Name Status     Protection  Protection
-------  ---------- -------- ----------  -----------
1        test1      Enabled   Disabled   Disabled
2        open       Enabled   Enabled    Required
3        testpsk    Enabled   *Enabled   Optional but inactive (WPA2 not configured)

         Infra.             Operational     --Infra. Capability--
AP Name  Validation  Radio  State           Protection  Validation
-------- ----------- -----  -----------  ----------- -----------
mapAP    Disabled    a      Up              Full        Full
                    b/g    Up              Full        Full
rootAP2  Enabled     a      Up              Full        Full
                    b/g    Up              Full        Full
HReap    *Enabled   b/g    Up             Full        Full
                    a      Down            Full        Full
```

- See the current MFP configuration for a particular WLAN by entering this command:

  show wlan *wlan_id*

  Information similar to the following appears:

```
WLAN Identifier.......................... 1
Profile Name............................. test1
Network Name (SSID)...................... test1
Status................................... Enabled
MAC Filtering............................ Disabled
Broadcast SSID........................... Enabled
...
Local EAP Authentication................. Enabled (Profile 'test')
Diagnostics Channel...................... Disabled
Security

   802.11 Authentication:.................. Open System
   Static WEP Keys......................... Disabled
   802.1X.................................. Enabled
        Encryption:.............................. 104-bit WEP
   Wi-Fi Protected Access (WPA/WPA2)...... Disabled
   CKIP ................................... Disabled
   IP Security............................. Disabled
   IP Security Passthru.................... Disabled
   Web Based Authentication................ Disabled
   Web-Passthrough......................... Disabled
   Conditional Web Redirect................ Disabled
   Auto Anchor............................. Enabled
    H-REAP Local Switching.................. Disabled
   Infrastructure MFP protection.......... Enabled
   Client MFP............................. Required
...
```

- See the current MFP configuration for a particular access point by entering this command:

show ap config general *ap_name*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 0
Cisco AP Name.................................... ap:52:c5:c0
AP Regulatory Domain............................. 80211bg: -N 80211a: -N
Switch Port Number .............................. 1
MAC Address...................................... 00:0b:85:52:c5:c0
IP Address Configuration......................... Static IP assigned
IP Address....................................... 10.67.73.33
IP NetMask....................................... 255.255.255.192
...
AP Mode ......................................... Local
Remote AP Debug ................................. Disabled
S/W  Version .................................... 4.0.2.0
Boot  Version ................................... 2.1.78.0
Mini IOS Version ................................      --
Stats Reporting Period .......................... 180
LED State........................................ Enabled
ILP Pre Standard Switch.......................... Disabled
ILP Power Injector............................... Disabled
Number Of Slots.................................. 2
AP Model......................................... AP1020
AP Serial Number................................. WCN09260057
AP Certificate Type.............................. Manufacture Installed
Management Frame Protection Validation .......... Enabled
```

- See whether client MFP is enabled for a specific client by entering this command:

  show client detail *client_mac*

```
Client MAC Address............................... 00:14:1c:ed:34:72
...
Policy Type...................................... WPA2
Authentication Key Management.................... PSK
Encryption Cipher................................ CCMP (AES)
Management Frame Protection...................... Yes
...
```

- See MFP statistics for the controller by entering this command:

  show wps mfp statistics

  Information similar to the following appears:

Note This report contains no data unless an active attack is in progress. Examples of various error types are shown for illustration only. This table is cleared every 5 minutes when the data is forwarded to any network management stations.

```
BSSID             Radio Validator AP Last Source Addr  Found  Error Type Count Frame Types
----------------- ----- ------------ ----------------- ------ ------------ ----- -------
00:0b:85:56:c1:a0  a    jatwo-1000b 00:01:02:03:04:05 Infra  Invalid MIC 183  Assoc Req
                                                                              Probe Req
                                                                              Beacon
                                                      Infra  Out of seq     4  Assoc Req
                                                      Infra  Unexpected MIC 85 Reassoc Req
                                                      Client Decrypt err  1974 Reassoc Req
                                                                              Disassoc
                                                      Client Replay err     74 Assoc Req
                                                                              Probe Req
                                                                              Beacon
```

```
                                                    Client Invalid ICV   174 Reassoc Req
                                                                             Disassoc
                                                    Client Invalid header174 Assoc Req
                                                                             Probe Req
                                                                             Beacon
                                                    Client Brdcst disass 174 Reassoc Req
                                                                             Disassoc
00:0b:85:56:c1:a0  b/g  jatwo-1000b 00:01:02:03:04:05 Infra  Out of seq  185 Reassoc Resp
                                                    Client Not encrypted 174 Assoc Resp
                                                                             Probe Resp
```

Using the CLI to Debug MFP Issues

Use this command if you experience any problems with MFP:

- **debug wps mfp** *?* {**enable** | **disable**}

  where *?* is one of the following:

  client—Configures debugging for client MFP messages.

  capwap—Configures debugging for MFP messages between the controller and access points.

  detail—Configures detailed debugging for MFP messages.

  report—Configures debugging for MFP reporting.

  mm—Configures debugging for MFP mobility (inter-controller) messages.

Configuring Client Exclusion Policies

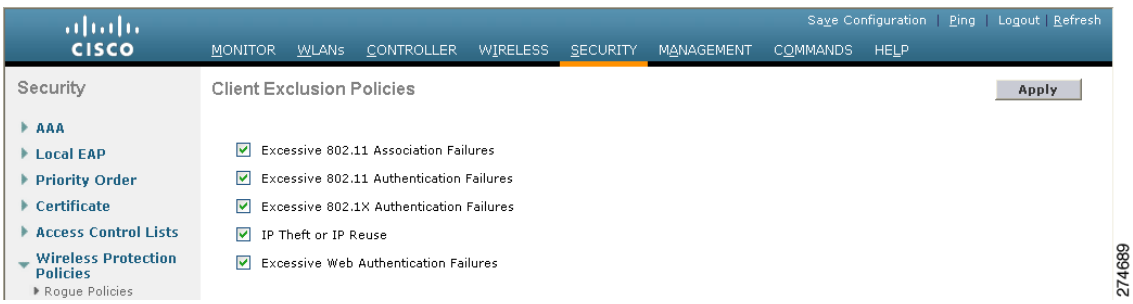
This section describes how to configure the controller to exclude clients under certain conditions using the controller GUI or CLI.

Using the GUI to Configure Client Exclusion Policies

To configure client exclusion policies using the controller GUI, follow these steps:

Step 1 Choose **Security > Wireless Protection Policies > Client Exclusion Policies** to open the Client Exclusion Policies page (see Figure 6-41).

Figure 6-41 Client Exclusion Policies Page



Step 2 Select any of these check boxes if you want the controller to exclude clients for the condition specified. The default value for each exclusion policy is enabled.

- **Excessive 802.11 Association Failures**—Clients are excluded on the sixth 802.11 association attempt, after five consecutive failures.
- **Excessive 802.11 Authentication Failures**—Clients are excluded on the sixth 802.11 authentication attempt, after five consecutive failures.
- **Excessive 802.1X Authentication Failures**—Clients are excluded on the fourth 802.1X authentication attempt, after three consecutive failures.
- **IP Theft or IP Reuse**—Clients are excluded if the IP address is already assigned to another device.
- **Excessive Web Authentication Failures**—Clients are excluded on the fourth web authentication attempt, after three consecutive failures.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Using the CLI to Configure Client Exclusion Policies

To configure client exclusion policies using the controller CLI, follow these steps:

Step 1 Enable or disable the controller to exclude clients on the sixth 802.11 association attempt, after five consecutive failures by entering this command:

config wps client-exclusion 802.11-assoc {**enable** | **disable**}

Step 2 Enable or disable the controller to exclude clients on the sixth 802.11 authentication attempt, after five consecutive failures by entering this command:

config wps client-exclusion 802.11-auth {**enable** | **disable**}

Step 3 Enable or disable the controller to exclude clients on the fourth 802.1X authentication attempt, after three consecutive failures by entering this command:

config wps client-exclusion 802.1x-auth {**enable** | **disable**}

Step 4 Enable or disable the controller to exclude clients if the IP address is already assigned to another device by entering this command:

config wps client-exclusion ip-theft {**enable** | **disable**}

Step 5 Enable or disable the controller to exclude clients on the fourth web authentication attempt, after three consecutive failures by entering this command:

config wps client-exclusion web-auth {**enable** | **disable**}

Step 6 Enable or disable the controller to exclude clients for all of the above reasons by entering this command:

config wps client-exclusion all {**enable** | **disable**}

Step 7 Use the following command to add or delete client exclusion entries.

config exclusionlist {**add** MAC [*description*] | **delete** MAC | **description** MAC [*description*]}

Step 8 Save your changes by entering this command:

save config

Step 9 See a list of clients that have been dynamically excluded, by entering this command:

show exclusionlist

Information similar to the following appears:

```
Dynamically Disabled Clients
----------------------------
  MAC Address             Exclusion Reason        Time Remaining (in secs)
  -----------             ----------------        ------------------------

00:40:96:b4:82:55         802.1X Failure          51
```

Step 10 See the client exclusion policy configuration settings by entering this command:

show wps summary

Information similar to the following appears:

```
Auto-Immune
  Auto-Immune.................................... Disabled

Client Exclusion Policy
  Excessive 802.11-association failures.......... Enabled
  Excessive 802.11-authentication failures....... Enabled
  Excessive 802.1x-authentication................ Enabled
  IP-theft....................................... Enabled
  Excessive Web authentication failure........... Enabled

Signature Policy
  Signature Processing....................... Enabled
```

Configuring Identity Networking

These sections explain the identity networking feature, how it is configured, and the expected behavior for various security policies:

- Identity Networking Overview, page 6-82
- RADIUS Attributes Used in Identity Networking, page 6-83
- Configuring AAA Override, page 6-86

Identity Networking Overview

In most wireless LAN systems, each WLAN has a static policy that applies to all clients associated with an SSID. Although powerful, this method has limitations because it requires clients to associate with different SSIDs to inherit different QoS and security policies.

However, the Cisco Wireless LAN solution supports identity networking, which allows the network to advertise a single SSID but allows specific users to inherit different QoS or security policies based on their user profiles. The specific policies that you can control using identity networking are as follows:

- Quality of service. When present in a RADIUS Access Accept, the QoS-Level value overrides the QoS value specified in the WLAN profile.
- ACL. When the ACL attribute is present in the RADIUS Access Accept, the system applies the ACL-Name to the client station after it authenticates, which overrides any ACLs that are assigned to the interface.

- VLAN. When a VLAN Interface-Name or VLAN-Tag is present in a RADIUS Access Accept, the system places the client on a specific interface.

Note The VLAN feature only supports MAC filtering, 802.1X, and WPA. The VLAN feature does not support web authentication or IPsec.

- Tunnel Attributes.

Note When any of the other RADIUS attributes (QoS-Level, ACL-Name, Interface-Name, or VLAN-Tag), which are described later in this section, are returned, the Tunnel Attributes must also be returned.

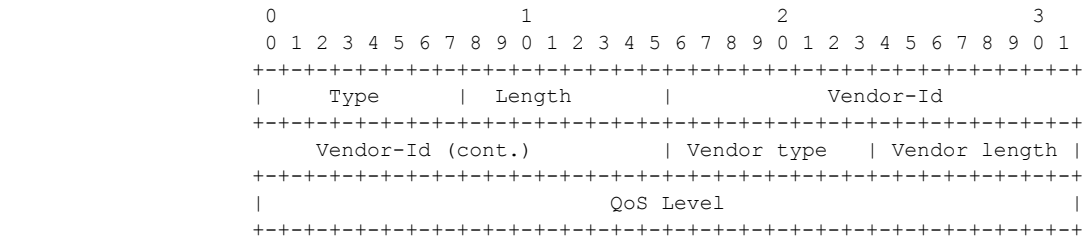
The operating system's local MAC filter database has been extended to include the interface name, allowing local MAC filters to specify to which interface the client should be assigned. A separate RADIUS server can also be used, but the RADIUS server must be defined using the Security menus.

RADIUS Attributes Used in Identity Networking

This section explains the RADIUS attributes used in identity networking.

QoS-Level

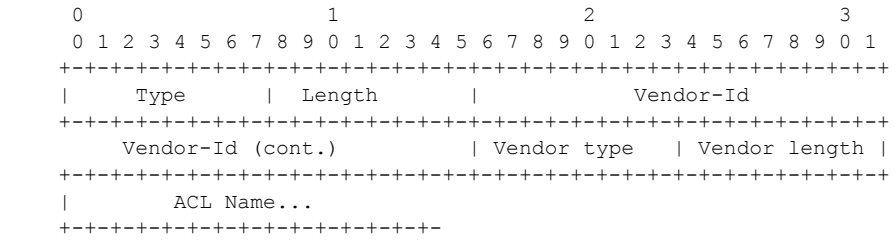
This attribute indicates the QoS level to be applied to the mobile client's traffic within the switching fabric, as well as over the air. This example shows a summary of the QoS-Level Attribute format. The text boxes are transmitted from left to right.



- Type – 26 for Vendor-Specific
- Length – 10
- Vendor-Id – 14179
- Vendor type – 2
- Vendor length – 4
- Value – Three octets:
  - 0 – Bronze (Background)
  - 1 – Silver (Best Effort)
  - 2 – Gold (Video)
  - 3 – Platinum (Voice)

ACL-Name

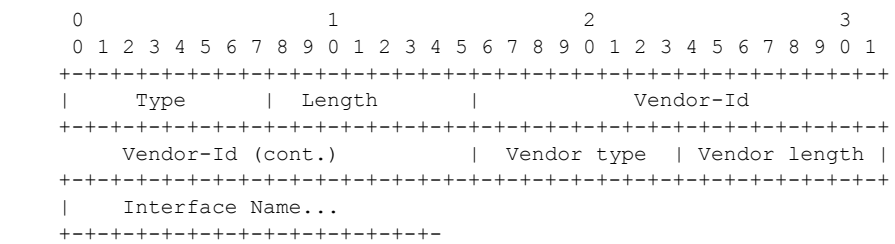
This attribute indicates the ACL name to be applied to the client. A summary of the ACL-Name Attribute format is shown below. The text boxes are transmitted from left to right.



- Type – 26 for Vendor-Specific
- Length – >7
- Vendor-Id – 14179
- Vendor type – 6
- Vendor length – >0
- Value – A string that includes the name of the ACL to use for the client

Interface-Name

This attribute indicates the VLAN Interface a client is to be associated to. A summary of the Interface-Name Attribute format is shown below. The text boxes are transmitted from left to right.



- Type – 26 for Vendor-Specific
- Length – >7
- Vendor-Id – 14179
- Vendor type – 5
- Vendor length – >0
- Value – A string that includes the name of the interface the client is to be assigned to.

Note This Attribute only works when MAC filtering is enabled or if 802.1X or WPA is used as the security policy.

VLAN-Tag

This attribute indicates the group ID for a particular tunneled session and is also known as the Tunnel-Private-Group-ID attribute.

This attribute might be included in the Access-Request packet if the tunnel initiator can predetermine the group resulting from a particular connection and should be included in the Access-Accept packet if this tunnel session is to be treated as belonging to a particular private group. Private groups may be used to associate a tunneled session with a particular group of users. For example, it may be used to facilitate routing of unregistered IP addresses through a particular interface. It should be included in Accounting-Request packets which contain Acct-Status-Type attributes with values of either Start or Stop and which pertain to a tunneled session.

A summary of the Tunnel-Private-Group-ID Attribute format is shown below. The text boxes are transmitted from left to right.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Type     |    Length     |     Tag       |   String...
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

- Type – 81 for Tunnel-Private-Group-ID.
- Length – >= 3
- Tag – The Tag text box is one octet in length and is intended to provide a means of grouping attributes in the same packet which refer to the same tunnel. If the value of the Tag text box is greater than 0x00 and less than or equal to 0x1F, it should be interpreted as indicating which tunnel (of several alternatives) this attribute pertains. If the Tag text box is greater than 0x1F, it should be interpreted as the first byte of the following String text box.
- String – This text box must be present. The group is represented by the String text box. There is no restriction on the format of group IDs.

Tunnel Attributes

Note When any of the other RADIUS attributes (QoS-Level, ACL-Name, Interface-Name, or VLAN-Tag) are returned, the Tunnel Attributes must also be returned.

RFC 2868 defines RADIUS tunnel attributes used for authentication and authorization, and RFC2867 defines tunnel attributes used for accounting. Where the IEEE 802.1X authenticator supports tunneling, a compulsory tunnel may be set up for the Supplicant as a result of the authentication.

In particular, it may be desirable to allow a port to be placed into a particular VLAN, defined in IEEE 8021Q, based on the result of the authentication. This configuration can be used, for example, to allow a wireless host to remain on the same VLAN as it moves within a campus network.

The RADIUS server typically indicates the desired VLAN by including tunnel attributes within the Access-Accept. However, the IEEE 802.1X authenticator may also provide a hint as to the VLAN to be assigned to the Supplicant by including Tunnel attributes within the AccessRequest.

For use in VLAN assignment, the following tunnel attributes are used:

- Tunnel-Type=VLAN (13)
- Tunnel-Medium-Type=802
- Tunnel-Private-Group-ID=VLANID

The VLAN ID is 12 bits, with a value between 1 and 4094, inclusive. Because the Tunnel-Private-Group-ID is of type String as defined in RFC 2868, for use with IEEE 802.1X, the VLANID integer value is encoded as a string.

When Tunnel attributes are sent, it is necessary to fill in the Tag text box. As noted in RFC 2868, section 3.1:

- The Tag text box is one octet in length and is intended to provide a means of grouping attributes in the same packet that refer to the same tunnel. Valid values for this text box are 0x01 through 0x1F, inclusive. If the Tag text box is unused, it must be zero (0x00).
- For use with Tunnel-Client-Endpoint, Tunnel-Server-Endpoint, Tunnel-Private-Group-ID, Tunnel-Assignment-ID, Tunnel-Client-Auth-ID or Tunnel-Server-Auth-ID attributes (but not Tunnel-Type, Tunnel-Medium-Type, Tunnel-Password, or Tunnel-Preference), a tag text box of greater than 0x1F is interpreted as the first octet of the following text box.
- Unless alternative tunnel types are provided, (e.g. for IEEE 802.1X authenticators that may support tunneling but not VLANs), it is only necessary for tunnel attributes to specify a single tunnel. As a result, where it is only desired to specify the VLANID, the tag text box should be set to zero (0x00) in all tunnel attributes. Where alternative tunnel types are to be provided, tag values between 0x01 and 0x1F should be chosen.

Configuring AAA Override

The Allow AAA Override option of a WLAN allows you to configure the WLAN for identity networking. It allows you to apply VLAN tagging, QoS, and ACLs to individual clients based on the returned RADIUS attributes from the AAA server.

Note If a client moves to a new interface due to the AAA override and then you apply an ACL to that interface, the ACL does not take effect until the client reauthenticates. To work around this issue, apply the ACL and then enable the WLAN so that all clients connect to the ACL that is already configured on the interface, or disable and then reenable the WLAN after you apply the interface so that the clients can reauthenticate.

Note When the interface group is mapped to a WLAN and clients connect to the WLAN, the client does not get the IP address in a round robin fashion. The AAA override with interface group is not supported.

Most of the configuration for allowing AAA override is done at the RADIUS server, where you should configure the Access Control Server (ACS) with the override properties you would like it to return to the controller (for example, Interface-Name, QoS-Level, and VLAN-Tag).

On the controller, enable the Allow AAA Override configuration parameter using the GUI or CLI. Enabling this parameter allows the controller to accept the attributes returned by the RADIUS server. The controller then applies these attributes to its clients.

Note AAA override is not supported with H-REAP.

Updating the RADIUS Server Dictionary File for Proper QoS Values

If you are using a Steel-Belted RADIUS (SBR), FreeRadius, or similar RADIUS server, clients may not obtain the correct QoS values after the AAA override feature is enabled. For these servers, which allow you to edit the dictionary file, you need to update the file to reflect the proper QoS values: Silver is 0, Gold is 1, Platinum is 2, and Bronze is 3. To update the RADIUS server dictionary file, follow these steps:

Note This issue does not apply to the Cisco Secure Access Control Server (ACS).

To update the RADIUS server dictionary file, follow these steps:

Step 1 Stop the SBR service (or other RADIUS service).

Step 2 Save the following text to the Radius_Install_Directory\Service folder as ciscowlan.dct:

```
##################################################################################
# CiscoWLAN.dct- Cisco Wireless Lan Controllers
#
# (See README.DCT for more details on the format of this file)
##################################################################################

# Dictionary - Cisco WLAN Controllers
#
# Start with the standard Radius specification attributes
#
@radius.dct
#
# Standard attributes supported by Airespace
#
# Define additional vendor specific attributes (VSAs)
#

MACRO Airespace-VSA(t,s) 26 [vid=14179 type1=%t% len1=+2 data=%s%]

ATTRIBUTE   WLAN-Id                 Airespace-VSA(1, integer)     cr
ATTRIBUTE   Aire-QoS-Level         Airespace-VSA(2, integer)     r
VALUE Aire-QoS-Level Bronze  3
VALUE Aire-QoS-Level Silver   0
VALUE Aire-QoS-Level Gold     1
VALUE Aire-QoS-Level Platinum 2

ATTRIBUTE   DSCP                    Airespace-VSA(3, integer)     r
ATTRIBUTE   802.1P-Tag              Airespace-VSA(4, integer)     r
ATTRIBUTE   Interface-Name          Airespace-VSA(5, string)      r
ATTRIBUTE   ACL-Name                Airespace-VSA(6, string)      r

# This should be last.

##################################################################################
# CiscoWLAN.dct - Cisco WLC dictionary
##################################################################################
```

Step 3 Open the dictiona.dcm file (in the same directory) and add the line "@ciscowlan.dct."

Step 4 Save and close the dictiona.dcm file.

Step 5 Open the vendor.ini file (in the same directory) and add the following text:

```
vendor-product       = Cisco WLAN Controller
dictionary           = ciscowlan
ignore-ports         = no
port-number-usage    = per-port-type
help-id             =
```

Step 6 Save and close the vendor.ini file.

Step 7 Start the SBR service (or other RADIUS service).

Step 8 Launch the SBR Administrator (or other RADIUS Administrator).

Step 9 Add a RADIUS client (if not already added). Choose **Cisco WLAN Controller** from the Make/Model drop-down list.

Using the GUI to Configure AAA Override

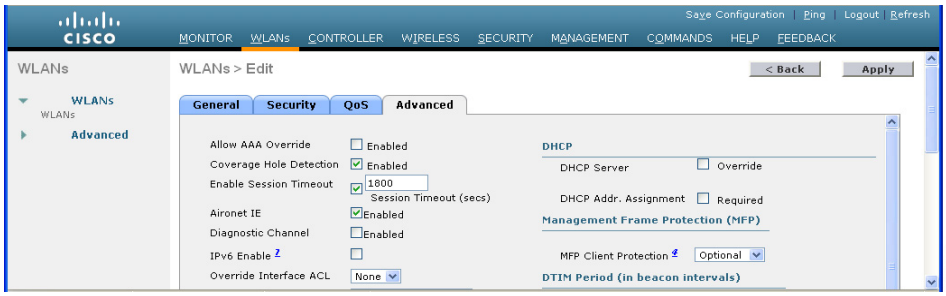
To configure AAA override using the controller GUI, follow these steps:

Step 1 Choose **WLAN**s to open the WLANs page.

Step 2 Click the ID number of the WLAN that you want to configure. The WLANs > Edit page appears.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 6-42).

Figure 6-42 WLANs > Edit (Advanced) Page



Step 4 Select the **Allow AAA Override** check box to enable AAA override or unselect it to disable this feature. The default value is disabled.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure AAA Override

Use this command to enable or disable AAA override using the controller CLI:

config wlan aaa-override {**enable** | **disable**} *wlan_id*

For *wlan_id*, enter an ID from 1 to 16.

Managing Rogue Devices

This section describes security solutions for rogue devices. A rogue device is an unknown access point or client that is detected by managed access points in your network as not belonging to your system.

Challenges

Rogue access points can disrupt wireless LAN operations by hijacking legitimate clients and using plain-text or other denial-of-service or man-in-the-middle attacks. That is, a hacker can use a rogue access point to capture sensitive information, such as usernames and passwords. The hacker can then transmit a series of clear-to-send (CTS) frames. This action mimics an access point informing a particular client to transmit and instructing all others to wait, which results in legitimate clients being unable to access network resources. Wireless LAN service providers have a strong interest in banning rogue access points from the air space.

Because rogue access points are inexpensive and readily available, employees sometimes plug unauthorized rogue access points into existing LANs and build ad-hoc wireless networks without IT department knowledge or consent. These rogue access points can be a serious breach of network security because they can be plugged into a network port behind the corporate firewall. Because employees generally do not enable any security settings on the rogue access point, it is easy for unauthorized users to use the access point to intercept network traffic and hijack client sessions. Even more alarming, wireless users frequently publish unsecure access point locations, increasing the odds of having enterprise security breached.

Detecting Rogue Devices

The controller continuously monitors all nearby access points and automatically discovers and collects information on rogue access points and clients. When the controller discovers a rogue access point, it uses the Rogue Location Discovery Protocol (RLDP) to determine if the rogue is attached to your network.

You can configure the controller to use RLDP on all access points or only on access points configured for monitor (listen-only) mode. The latter option facilitates automated rogue access point detection in a crowded RF space, allowing monitoring without creating unnecessary interference and without affecting regular data access point functionality. If you configure the controller to use RLDP on all access points, the controller always chooses the monitor access point for RLDP operation if a monitor access point and a local (data) access point are both nearby. If RLDP determines that the rogue is on your network, you can choose to either manually or automatically contain the detected rogue.

Starting in release 7.0.116.0 and later releases, the controller software provides enhanced rogue containment strategies. In previous releases, when a rogue device was detected, the controller sent containment frames at regular intervals to the rogue devices. In release 7.0.116.0 and later, the containment frames are sent immediately after authorization and associations are detected. The enhanced containment algorithm provides more effective containment of ad hoc clients.

A rogue access point is moved to a contained state either automatically or manually. The controller selects the best available access point for containment and pushes the information to the access point. The access point stores the list of containments per radio. For auto-containment, you can configure the controller to use only monitor mode access point.

The containment operation happens in following two ways:

- The container access point goes through the list of containments periodically and sends unicast containment frames. For rogue access point containment, the frames are sent only if there is a rogue client associated.
- Whenever a contained rogue activity is detected, containment frames are transmitted.

The individual rogue containment involves sending a sequence of unicast disassociation and deauthentication frames.

Notes about Rogue Devices

Note In a dense RF environment where maximum rogue access points are suspected, the chances of detecting rogue access points by a local and hybrid-REAP mode access point in channel 157 or 161 are less when compared to other channels. To mitigate this problem, we recommended that you use dedicate monitor mode access points.

Note The local and hybrid REAP mode access points are designed to serve associated clients and these access points spend relatively less time performing off-channel scanning. The access points spend about 50 milliseconds on each channel. If you want to perform high rogue detection, a monitor mode access point must be used. Alternatively, you can reduce the scan intervals from 180 seconds to a lesser value, for example, 120 or 60 seconds, ensuring that the radio goes off-channel more frequently which improves the chances of rogue detection. However, the access point would still spend about 50 milliseconds on each channel.

Classifying Rogue Access Points

Controller software release 5.0 or later releases improve the classification and reporting of rogue access points through the use of rogue states and user-defined classification rules that enable rogues to automatically move between states. In previous releases, the controller listed all rogue access points on one page sorted by MAC address or BSSID. Now you can create rules that enable the controller to organize and display rogue access points as Friendly, Malicious, or Unclassified.

By default, none of the classification rules are enabled. Therefore, all unknown access points are categorized as Unclassified. When you create a rule, configure conditions for it, and enable the rule, the unclassified access points are reclassified. Whenever you change a rule, it is applied to all access points (friendly, malicious, and unclassified) in the Alert state only.

Note Rule-based rogue classification does not apply to ad-hoc rogues and rogue clients.

Note The Cisco 5500 Series Controllers support up to 2000 rogues (including acknowledged rogues); the 4400 series controllers, Cisco WiSM, and Catalyst 3750G Integrated Wireless LAN Controller Switch support up to 625 rogues; and the Cisco 2100 Series Controller and Controller Network Module for Integrated Services Routers support up to 125 rogues. Each controller limits the number of rogue containments to three per radio (or six per radio for access points in monitor mode).

When the controller receives a rogue report from one of its managed access points, it responds as follows:

1. The controller verifies that the unknown access point is in the friendly MAC address list. If it is, the controller classifies the access point as Friendly.
2. If the unknown access point is not in the friendly MAC address list, the controller starts applying rogue classification rules.
3. If the rogue is already classified as Malicious, Alert or Friendly, Internal or External, the controller does not reclassify it automatically. If the rogue is classified differently, the controller reclassifies it automatically only if the rogue is in the Alert state.
4. The controller applies the first rule based on priority. If the rogue access point matches the criteria specified by the rule, the controller classifies the rogue according to the classification type configured for the rule.
5. If the rogue access point does not match any of the configured rules, the controller classifies the rogue as Unclassified.
6. The controller repeats the previous steps for all rogue access points.
7. If RLDP determines that the rogue access point is on the network, the controller marks the rogue state as Threat and classifies it as Malicious automatically, even if no rules are configured. You can then manually contain the rogue (unless you have configured RLDP to automatically contain the rogue), which would change the rogue state to Contained. If the rogue access point is not on the network, the controller marks the rogue state as Alert, and you can manually contain the rogue.
8. If desired, you can manually move the access point to a different classification type and rogue state.

Table 6-8 shows the rogue states that can be adopted by a rogue access point in a particular classification type.

Table 6-8 Classification Mapping

Rule-Based Classification Type	Rogue States
Friendly	• Internal—If the unknown access point is inside the network and poses no threat to WLAN security, you would manually configure it as Friendly, Internal. An example is the access points in your lab network. • External—If the unknown access point is outside the network and poses no threat to WLAN security, you would manually configure it as Friendly, External. An example is an access point that belongs to a neighboring coffee shop. • Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list.
Malicious	• Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list. • Threat—The unknown access point is found to be on the network and poses a threat to WLAN security. • Contained—The unknown access point is contained. • Contained Pending—The unknown access point is marked Contained, but the action is delayed due to unavailable resources.

Table 6-8 Classification Mapping (continued)

Rule-Based Classification Type	Rogue States
Unclassified	• Pending—On first detection, the unknown access point is put in the Pending state for 3 minutes. During this time, the managed access points determine if the unknown access point is a neighbor access point. • Alert—The unknown access point is moved to Alert if it is not in the neighbor list or in the user-configured friendly MAC list. • Contained—The unknown access point is contained. • Contained Pending—The unknown access point is marked Contained, but the action is delayed due to unavailable resources.

If you upgrade to controller software release 5.0 or later releases, the classification and state of the rogue access points are reconfigured as follows:

- From Known to Friendly, Internal
- From Acknowledged to Friendly, External
- From Contained to Malicious, Contained

As mentioned previously, the controller can automatically change the classification type and rogue state of an unknown access point based on user-defined rules, or you can manually move the unknown access point to a different classification type and rogue state. Table 6-9 shows the allowable classification types and rogue states from and to which an unknown access point can be configured.

Table 6-9 Allowable Classification Type and Rogue State Transitions

From	To
Friendly (Internal, External, Alert)	Malicious (Alert)
Friendly (Internal, External, Alert)	Unclassified (Alert)
Friendly (Alert)	Friendly (Internal, External)
Malicious (Alert, Threat)	Friendly (Internal, External)
Malicious (Contained, Contained Pending)	Malicious (Alert)
Unclassified (Alert, Threat)	Friendly (Internal, External)
Unclassified (Contained, Contained Pending)	Unclassified (Alert)
Unclassified (Alert)	Malicious (Alert)

If the rogue state is Contained, you have to uncontain the rogue access point before you can change the classification type. If you want to move a rogue access point from Malicious to Unclassified, you must delete the access point and allow the controller to reclassify it.

WCS Interaction

WCS software release 5.0 or later releases also support rule-based classification. WCS uses the classification rules configured on the controller. The controller sends traps to WCS after the following events:

- If an unknown access point moves to Friendly for the first time, the controller sends a trap to WCS only if the rogue state is Alert. It does not send a trap if the rogue state is Internal or External.
- If a rogue entry is removed after the timeout expires, the controller sends a trap to WCS for rogue access points categorized as Malicious (Alert, Threat) or Unclassified (Alert). The controller does not remove rogue entries with the following rogue states: Contained, Contained Pending, Internal, and External.

Configuring Rogue Detection

You can configure RLDP to automatically detect and contain rogue devices using the controller GUI or CLI.

Using the GUI to Configure Rogue Detection

To configure RLDP using the controller GUI, follow these steps:

Step 1 Make sure that rogue detection is enabled on the desired access points. Rogue detection is enabled by default for all access points joined to the controller (except for OfficeExtend access points). However, in controller software release 6.0 or later releases, you can enable or disable it for individual access points by selecting or unselecting the **Rogue Detection** check box on the All APs > Details for (Advanced) page.

Note Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect a large number of rogue devices.

Step 2 Choose **Security > Wireless Protection Policies > Rogue Policies > General** to open the Rogue Policies page.

Step 3 Choose one of the following options from the Rogue Location Discovery Protocol drop-down list:

- **Disable**—Disables RLDP on all access points. This is the default value.
- **All APs**—Enables RLDP on all access points.
- **Monitor Mode APs**—Enables RLDP only on access points in monitor mode.

Step 4 In the Expiration Timeout for Rogue AP and Rogue Client Entries text box, enter the number of seconds after which the rogue access point and client entries expire and are removed from the list. The valid range is 240 to 3600 seconds, and the default value is 1200 seconds.

Note If a rogue access point or client entry times out, it is removed from the controller only if its rogue state is Alert or Threat for any classification type.

Step 5 If desired, select the **Validate Rogue Clients Against AAA** check box to use the AAA server or local database to validate if rogue clients are valid clients. The default value is unselected.

Step 6 If desired, select the **Detect and Report Ad-Hoc Networks** check box to enable ad-hoc rogue detection and reporting. The default value is selected.

Step 7 If you want the controller to automatically contain certain rogue devices, select the following check boxes. Otherwise, leave the check boxes unselected, which is the default value.

Caution When you enable any of these parameters, the following warning appears: "Using this feature may have legal consequences. Do you want to continue?" The 2.4- and 5-GHz frequencies in the Industrial, Scientific, and Medical (ISM) band are open to the public and can be used without a license. As such, containing devices on another party's network could have legal consequences.

- **Auto Containment Level**—Set the auto containment level by selecting a value from the drop-down list. The default is 1.
- **Auto Containment only for monitor mode APs**—Enable the check box if you want to use only monitor mode access points for auto-containment.
- **Rogue on Wire**—Automatically contains rogues that are detected on the wired network.
- **Using Our SSID**—Automatically contains rogues that are advertising your network's SSID. If you leave this parameter unselected, the controller only generates an alarm when such a rogue is detected.
- **Valid Client on Rogue AP**—Automatically contains a rogue access point to which trusted clients are associated. If you leave this parameter unselected, the controller only generates an alarm when such a rogue is detected.
- **AdHoc Rogue AP**—Automatically contains ad-hoc networks detected by the controller. If you leave this parameter unselected, the controller only generates an alarm when such a network is detected.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure RLDP

To configure RLDP using the controller CLI, follow these steps:

Step 1 Make sure that rogue detection is enabled on the desired access points. Rogue detection is enabled by default for all access points joined to the controller (except for OfficeExtend access points). However, in controller software release 6.0 or later releases, you can enable or disable it for individual access points by entering the **config rogue detection** {**enable** | **disable**} *Cisco_AP* command.

Note To see the current rogue detection configuration for a specific access point, enter the **show ap config general** *Cisco_AP* command.

Note Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect a large number of rogue devices.

Step 2 Enable, disable, or initiate RLDP by entering these commands:

- **config rogue ap rldp enable alarm-only**—Enables RLDP on all access points.
- **config rogue ap rldp enable alarm-only** *monitor_ap_only*—Enables RLDP only on access points in monitor mode.

- **config rogue ap rldp initiate** *rogue_mac_address*—Initiates RLDP on a specific rogue access point.
- **config rogue ap rldp disable**—Disables RLDP on all access points.

Step 3 Specify the number of seconds after which the rogue access point and client entries expire and are removed from the list by entering this command:

config rogue ap timeout *seconds*

The valid range for the *seconds* parameter is 240 to 3600 seconds (inclusive), and the default value is 1200 seconds.

Note If a rogue access point or client entry times out, it is removed from the controller only if its rogue state is Alert or Threat for any classification type.

Step 4 Enable or disable ad-hoc rogue detection and reporting by entering this command:

config rogue adhoc {**enable** | **disable**}

Step 5 Enable or disable the AAA server or local database to validate if rogue clients are valid clients by entering this command:

config rogue client aaa {**enable** | **disable**}

Step 6 If you want the controller to automatically contain certain rogue devices, enter these commands.

Caution When you enter any of these commands, the following warning appears: "Using this feature may have legal consequences. Do you want to continue?" The 2.4- and 5-GHz frequencies in the Industrial, Scientific, and Medical (ISM) band are open to the public and can be used without a license. As such, containing devices on another party's network could have legal consequences.

- **config rogue ap rldp enable auto-contain**—Automatically contains rogues that are detected on the wired network.
- **config rogue ap ssid auto-contain**—Automatically contains rogues that are advertising your network's SSID.

  Note If you want the controller to only generate an alarm when such a rogue is detected, enter the **config rogue ap ssid alarm** command.

- **config rogue ap valid-client auto-contain**—Automatically contains a rogue access point to which trusted clients are associated.

  Note If you want the controller to only generate an alarm when such a rogue is detected, enter the **config rogue ap valid-client alarm** command.

- **config rogue adhoc auto-contain**—Automatically contains adhoc networks detected by the controller.

  Note If you want the controller to only generate an alarm when such a network is detected, enter the **config rogue adhoc alert** command.

- **configure rogue auto-containment level {1 - 4}**—Set the auto containment level by entering a value between 1 and 4. The default is 1.
- **config rogue auto-contain level 1** *monitor_mode_ap_only*—Automatically contains only monitor mode access points.

Step 7 Configure RLDP scheduling by entering the following command:

- **config rogue ap rldp schedule add**—Enables you to schedule RLDP on a particular day of the week. You must enter the day of the week (for example **mon**, **tue**, **wed**, and so on) on which you want to schedule RLDP and the start time and end time in HH:MM:SS format. Here is an example:

  config rogue ap rldp schedule add mon 22:00:00 23:00:00

Note When you configure RLDP scheduling, it is assumed that the scheduling would occur in the future, that is, after the configuration is saved.

Step 8 Save your changes by entering this command:

save config

Configuring Rogue Classification Rules

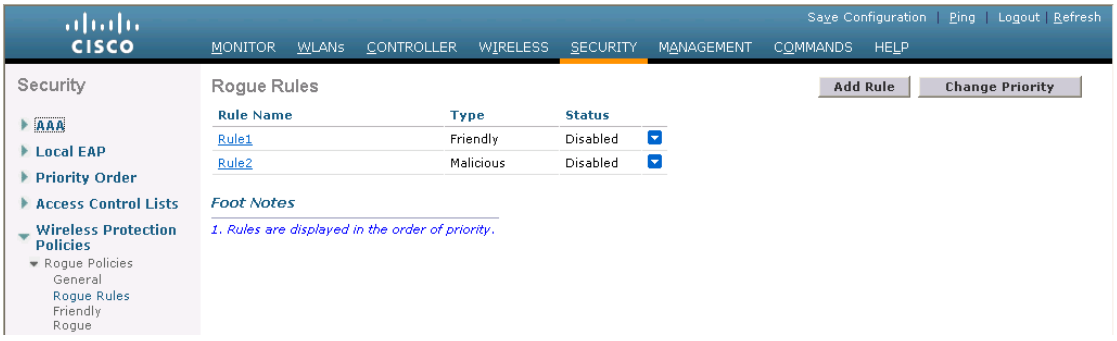
You can configure up to 64 rogue classification rules per controller using the controller GUI or CLI.

Using the GUI to Configure Rogue Classification Rules

To configure rogue classification rules using the controller GUI, follow these steps:

Step 1 Choose **Security > Wireless Protection Policies > Rogue Policies > Rogue Rules** to open the Rogue Rules page (see Figure 6-43).

Figure 6-43 Rogue Rules Page



Any rules that have already been created are listed in priority order. The name, type, and status of each rule is provided.

Note If you ever want to delete a rule, hover your cursor over the blue drop-down arrow for that rule and click **Remove**.

Step 2 Create a new rule as follows:

a. Click **Add Rule**. An Add Rule section appears at the top of the page.

b. In the Rule Name text box, enter a name for the new rule. Make sure that the name does not contain any spaces.

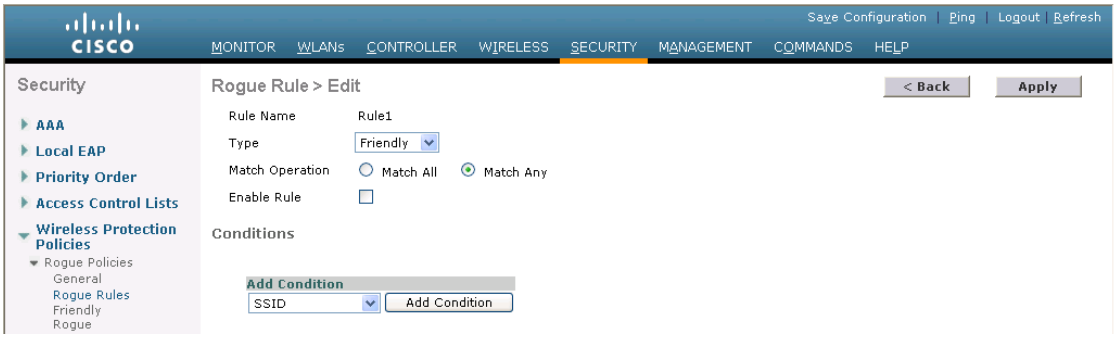
c. From the Rule Type drop-down list, choose **Friendly** or **Malicious** to classify rogue access points matching this rule as friendly or malicious.

d. Click **Add** to add this rule to the list of existing rules, or click **Cancel** to discard this new rule.

Step 3 Edit a rule as follows:

a. Click the name of the rule that you want to edit. The Rogue Rule > Edit page appears (see Figure 6-44).

Figure 6-44 Rogue Rule > Edit Page



b. From the Type drop-down list, choose **Friendly** or **Malicious** to classify rogue access points matching this rule as friendly or malicious.

c. From the Match Operation text box, choose one of the following:

- **Match All**—If this rule is enabled, a detected rogue access point must meet all of the conditions specified by the rule in order for the rule to be matched and the rogue to adopt the classification type of the rule.
- **Match Any**—If this rule is enabled, a detected rogue access point must meet any of the conditions specified by the rule in order for the rule to be matched and the rogue to adopt the classification type of the rule. This is the default value.

d. To enable this rule, select the **Enable Rule** check box. The default value is unselected.

e. From the Add Condition drop-down list, choose one or more of the following conditions that the rogue access point must meet and click **Add Condition**.

- SSID—Requires that the rogue access point have a specific user-configured SSID. If you choose this option, enter the SSID in the User Configured SSID text box, and click **Add SSID**.

Note To delete an SSID, highlight the SSID and click **Remove**.

- RSSI—Requires that the rogue access point have a minimum received signal strength indication (RSSI) value. For example, if the rogue access point has an RSSI that is greater than the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum RSSI value in the Minimum RSSI text box. The valid range is –95 to –50 dBm (inclusive), and the default value is 0 dBm.
- Duration—Requires that the rogue access point be detected for a minimum period of time. If you choose this option, enter a value for the minimum detection period in the Time Duration text box. The valid range is 0 to 3600 seconds (inclusive), and the default value is 0 seconds.
- Client Count—Requires that a minimum number of clients be associated to the rogue access point. For example, if the number of clients associated to the rogue access point is greater than or equal to the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum number of clients to be associated to the rogue access point in the Minimum Number of Rogue Clients text box. The valid range is 1 to 10 (inclusive), and the default value is 0.
- No Encryption—Requires that the rogue access point's advertised WLAN does not have encryption enabled. If a rogue access point has encryption disabled, it is likely that more clients will try to associate to it. No further configuration is required for this option.

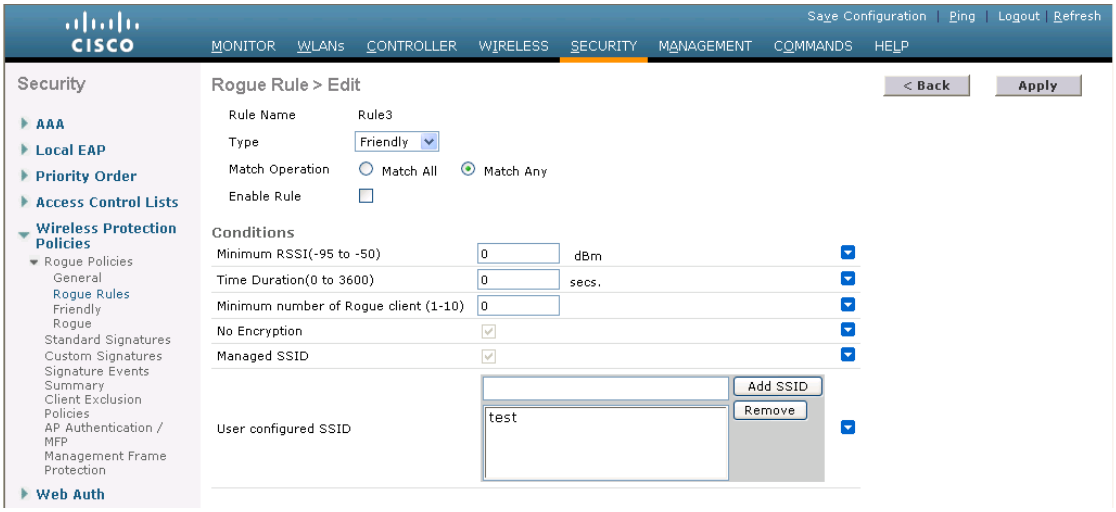
Note WCS refers to this option as "Open Authentication."

- Managed SSID—Requires that the rogue access point's managed SSID (the SSID configured for the WLAN) be known to the controller. No further configuration is required for this option.

Note The SSID and Managed SSID conditions cannot be used with the Match All operation because these two SSID lists are mutually exclusive. If you define a rule with Match All and have these two conditions configured, the rogue access points are never classified as friendly or malicious because one of the conditions can never be met.

You can add up to six conditions per rule. When you add a condition, it appears under the Conditions section (see Figure 6-45).

Figure 6-45 Rogue Rule > Edit Page



Note If you ever want to delete a condition from this rule, hover your cursor over the blue drop-down arrow for that condition and click **Remove**.

f. Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 If you want to change the order in which rogue classification rules are applied, follow these steps:

a. Click **Back** to return to the Rogue Rules page.

b. Click **Change Priority** to access the Rogue Rules > Priority page (see Figure 6-46).

Figure 6-46 Rogue Rules > Priority Page

The rogue rules are listed in priority order in the Change Rules Priority text box.

c. Highlight the rule for which you want to change the priority, and click **Up** to raise its priority in the list or **Down** to lower its priority in the list.

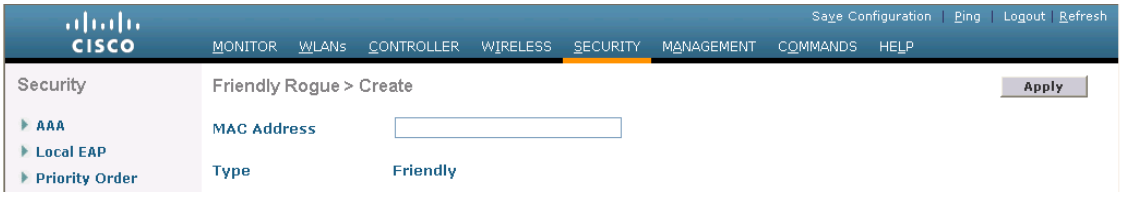
d. Continue to move the rules up or down until the rules are in the desired order.

e. Click **Apply** to commit your changes.

Step 6 Classify any rogue access points as friendly and add them to the friendly MAC address list as follows:

a. Choose **Security** > **Wireless Protection Policies** > **Rogue Policies** > **Friendly Rogue** to open the Friendly Rogue > Create page (see Figure 6-47).

Figure 6-47 Friendly Rogue > Create Page



b. In the MAC Address text box, enter the MAC address of the friendly rogue access point.

c. Click **Apply** to commit your changes.

d. Click **Save Configuration** to save your changes. This access point is added to the controller's list of friendly access points and should now appear on the Friendly Rogue APs page.

Using the CLI to Configure Rogue Classification Rules

To configure rogue classification rules using the controller CLI, follow these steps:

Step 1 Create a rule by entering this command:

config rogue rule add ap priority *priority* **classify** {**friendly** | **malicious**} *rule_name*

Note If you later want to change the priority of this rule and shift others in the list accordingly, enter the **config rogue rule priority** *priority rule_name* command. If you later want to change the classification of this rule, enter the **config rogue rule classify** {**friendly** | **malicious**} *rule_name* command.

Note If you ever want to delete all of the rogue classification rules or a specific rule, enter the **config rogue rule delete** {**all** | *rule_name*} command.

Step 2 Disable all rules or a specific rule by entering this command:

config rogue rule disable {**all** | *rule_name*}

Note A rule must be disabled before you can modify its attributes.

Step 3 Add conditions to a rule that the rogue access point must meet by entering this command:

config rogue rule condition ap set *condition_type condition_value rule_name*

where *condition_type* is one of the following:

- **ssid**—Requires that the rogue access point have a specific SSID. You should add SSIDs that are not managed by the controller. If you choose this option, enter the SSID for the *condition_value* parameter. The SSID is added to the user-configured SSID list.

  Note If you ever want to delete all of the SSIDs or a specific SSID from the user-configured SSID list, enter the **config rogue rule condition ap delete ssid** {**all** | *ssid*} *rule_name* command.

- **rssi**—Requires that the rogue access point have a minimum RSSI value. For example, if the rogue access point has an RSSI that is greater than the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum RSSI value for the *condition_value* parameter. The valid range is –95 to –50 dBm (inclusive), and the default value is 0 dBm.
- **duration**—Requires that the rogue access point be detected for a minimum period of time. If you choose this option, enter a value for the minimum detection period for the *condition_value* parameter. The valid range is 0 to 3600 seconds (inclusive), and the default value is 0 seconds.

- **client-count**—Requires that a minimum number of clients be associated to the rogue access point. For example, if the number of clients associated to the rogue access point is greater than or equal to the configured value, then the access point could be classified as malicious. If you choose this option, enter the minimum number of clients to be associated to the rogue access point for the *condition_value* parameter. The valid range is 1 to 10 (inclusive), and the default value is 0.
- **no-encryption**—Requires that the rogue access point's advertised WLAN does not have encryption enabled. A *condition_value* parameter is not required for this option.
- **managed-ssid**—Requires that the rogue access point's SSID be known to the controller. A *condition_value* parameter is not required for this option.

Note You can add up to six conditions per rule. If you ever want to delete all of the conditions or a specific condition from a rule, enter the **config rogue rule condition ap delete** {**all** | *condition_type*} *condition_value rule_name* command.

Step 4 Specify whether a detected rogue access point must meet all or any of the conditions specified by the rule in order for the rule to be matched and the rogue access point to adopt the classification type of the rule by entering this command:

config rogue rule match {**all** | **any**} *rule_name*

Step 5 Enable all rules or a specific rule by entering this command:

config rogue rule enable {**all** | *rule_name*}

Note For your changes to become effective, you must enable the rule.

Step 6 Add a new friendly access point entry to the friendly MAC address list or delete an existing friendly access point entry from the list by entering this command:

config rogue ap friendly {**add** | **delete**} *ap_mac_address*

Step 7 Save your changes by entering this command:

save config

Step 8 View the rogue classification rules that are configured on the controller by entering this command:

show rogue rule summary

Information similar to the following appears:

```
Priority Rule Name  State      Type        Match  Hit Count
-------- ---------- -------- ------------ ------ ---------
1        Rule1      Disabled   Friendly      Any   0
2        Rule2      Enabled    Malicious     Any  339
3       Rule3      Disabled   Friendly     Any   0
```

Step 9 View detailed information for a specific rogue classification rule by entering this command:

show rogue rule detailed *rule_name*

Information similar to the following appears:

```
Priority..................................... 2
Rule Name.................................... Rule2
State........................................ Enabled
Type......................................... Malicious
Match Operation.............................. Any
Hit Count.................................... 352
Total Conditions............................. 6
```

```
Condition 1
    type..................................... Client-count
    value.................................... 10
Condition 2
    type..................................... Duration
    value (seconds).......................... 2000
Condition 3
    type..................................... Managed-ssid
    value.................................... Enabled
Condition 4
    type..................................... No-encryption
    value.................................... Enabled
Condition 5
    type..................................... Rssi
    value (dBm).............................. -50
Condition 6
    type..................................... Ssid
    SSID Count............................... 1
    SSID 1................................... test
```

Viewing and Classifying Rogue Devices

Using the controller GUI or CLI, you can view rogue devices and determine the action that the controller should take.

Caution When you choose to contain a rogue device, the following warning appears: "There may be legal issues following this containment. Are you sure you want to continue?" The 2.4- and 5-GHz frequencies in the Industrial, Scientific, and Medical (ISM) band are open to the public and can be used without a license. As such, containing devices on another party's network could have legal consequences.

Using the GUI to View and Classify Rogue Devices

To view and classify rogue devices using the controller GUI, follow these steps:

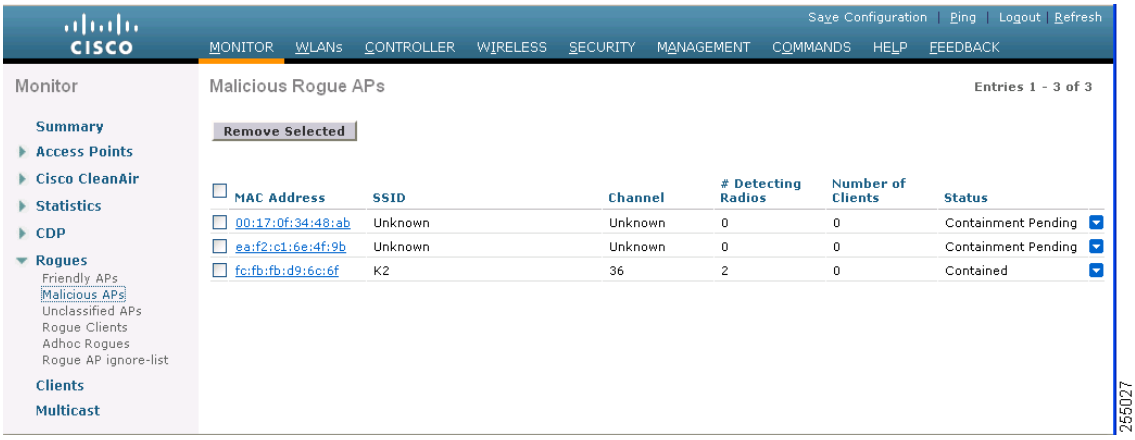
Step 1 Choose **Monitor > Rogues**.

Step 2 Choose the following options to view the different types of rogue access points detected by the controller:

- **Friendly APs**
- **Malicious APs**
- **Unclassified APs**

A page similar to the following appears (see Figure 6-48).

Figure 6-48 Friendly Rogue APs Page

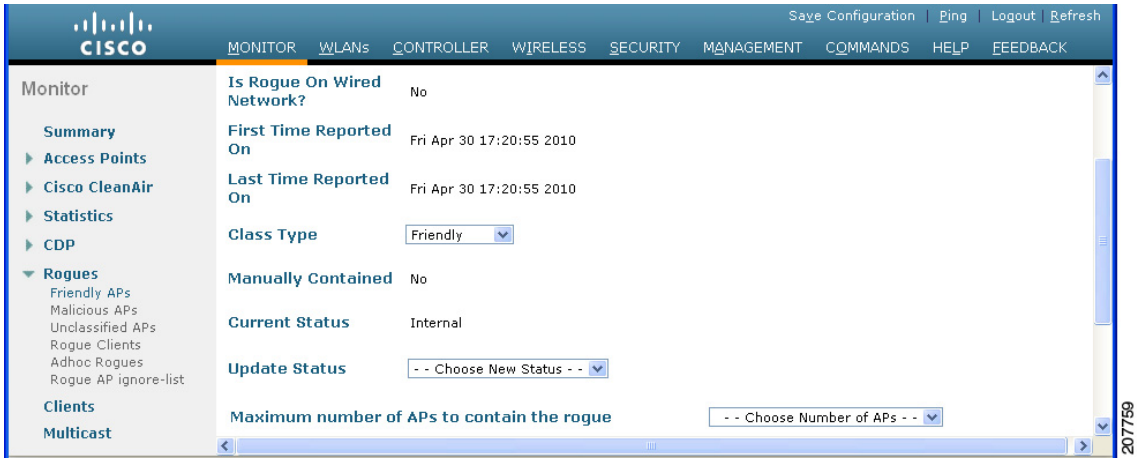


The Friendly Rogue APs page, Malicious Rogue APs page, and Unclassified Rogue APs page provide the following information: the MAC address and SSID of the rogue access point, Channel Number, the number of clients connected to the rogue access point, the number of radios that detected the rogue access point, and the current status of the rogue access point.

Note If you ever want to delete a rogue access point from one of these pages, hover your cursor over the blue drop-down arrow and click **Remove**. To delete multiple rogue access points, check the check box corresponding to the row you want to delete and click **Remove Selected**.

Step 3 Obtain more details about a rogue access point by clicking the MAC address of the access point. The Rogue AP Detail page appears (see Figure 6-49).

Figure 6-49 Rogue AP Detail Page



This page provides the following information: the MAC address of the rogue device, the type of rogue device (such as an access point), whether the rogue device is on the wired network, the dates and times when the rogue device was first and last reported, and the current status of the device.

The Class Type text box shows the current classification for this rogue access point:

- Friendly—An unknown access point that matches the user-defined friendly rules or an existing known and acknowledged rogue access point. Friendly access points cannot be contained.
- Malicious—An unknown access point that matches the user-defined malicious rules or is moved manually by the user from the Friendly or Unclassified classification type.

Note Once an access point is classified as Malicious, you cannot apply rules to it in the future, and it cannot be moved to another classification type. If you want to move a malicious access point to the Unclassified classification type, you must delete the access point and allow the controller to reclassify it.

- Unclassified—An unknown access point that does not match the user-defined friendly or malicious rules. An unclassified access point can be contained. It can also be moved to the Friendly or Malicious classification type automatically in accordance with user-defined rules or manually by the user.

Step 4 If you want to change the classification of this device, choose a different classification from the Class Type drop-down list.

Note A rogue access point cannot be moved to another class if its current state is Contain.

Step 5 From the Update Status drop-down list, choose one of the following options to specify how the controller should respond to this rogue access point:

- **Internal**—The controller trusts this rogue access point. This option is available if the Class Type is set to Friendly.
- **External**—The controller acknowledges the presence of this rogue access point. This option is available if the Class Type is set to Friendly.
- **Contain**—The controller contains the offending device so that its signals no longer interfere with authorized clients. This option is available if the Class Type is set to Malicious or Unclassified.
- **Alert**—The controller forwards an immediate alert to the system administrator for further action. This option is available if the Class Type is set to Malicious or Unclassified.

The bottom of the page provides information on both the access points that detected this rogue access point and any clients that are associated to it. To see more details for any of the clients, click **Edit** to open the Rogue Client Detail page.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Step 8 View any rogue clients that are connected to the controller by choosing **Rogue Clients**. The Rogue Clients page appears. This page shows the following information: the MAC address of the rogue client, the MAC address of the access point to which the rogue client is associated, the SSID of the rogue client, the number of radios that detected the rogue client, the date and time when the rogue client was last reported, and the current status of the rogue client.

Step 9 Obtain more details about a rogue client by clicking the MAC address of the client. The Rogue Client Detail page appears (see Figure 6-50).

Figure 6-50 Rogue Client Detail Page

This page provides the following information: the MAC address of the rogue client, the MAC address of the rogue access point to which this client is associated, the SSID and IP address of the rogue client, the dates and times when the rogue client was first and last reported, and the current status of the rogue client.

Step 10 From the Update Status drop-down list, choose one of the following options to specify how the controller should respond to this rogue client:

- **Contain**—The controller contains the offending device so that its signals no longer interfere with authorized clients.
- **Alert**—The controller forwards an immediate alert to the system administrator for further action.

The bottom of the page provides information on the access points that detected this rogue client.

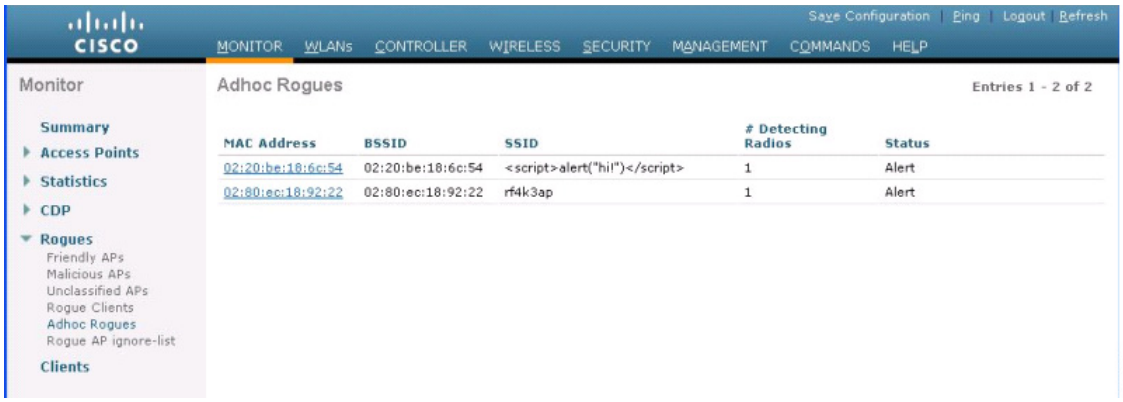
Step 11 Click **Apply** to commit your changes.

Step 12 If desired, you can test the controller's connection to this client by clicking **Ping**.

Step 13 Click **Save Configuration** to save your changes.

Step 14 See any ad-hoc rogues detected by the controller by choosing **Adhoc Rogues**. The Adhoc Rogues page appears (see Figure 6-51).

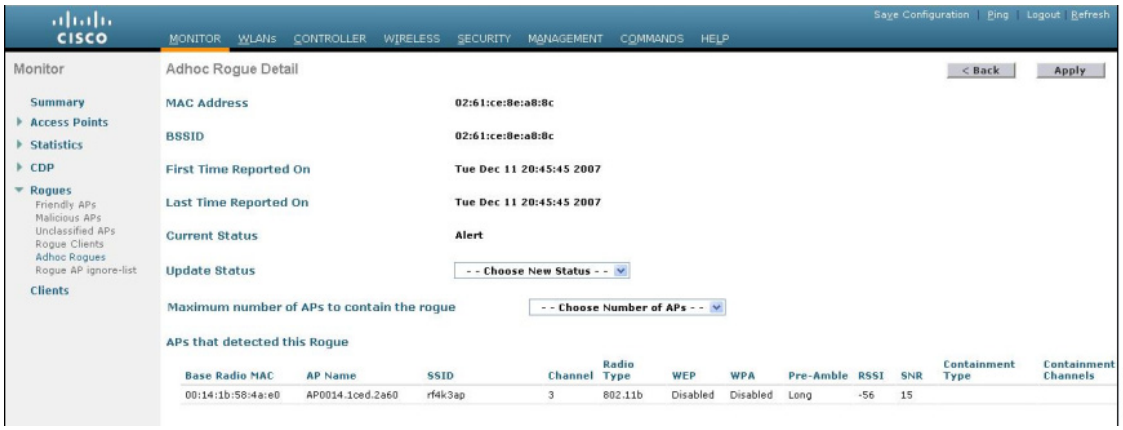
Figure 6-51 Adhoc Rogues Page



This page shows the following information: the MAC address, BSSID, and SSID of the ad-hoc rogue, the number of radios that detected the ad-hoc rogue, and the current status of the ad-hoc rogue.

Step 15 Obtain more details about an ad-hoc rogue by clicking the MAC address of the rogue. The Adhoc Rogue Detail page appears (see Figure 6-52).

Figure 6-52 Adhoc Rogue Detail Page



This page provides the following information: the MAC address and BSSID of the ad-hoc rogue, the dates and times when the rogue was first and last reported, and the current status of the rogue.

Step 16 From the Update Status drop-down list, choose one of the following options to specify how the controller should respond to this ad-hoc rogue:

- **Contain**—The controller contains the offending device so that its signals no longer interfere with authorized clients.
- **Alert**—The controller forwards an immediate alert to the system administrator for further action.
- **Internal**—The controller trusts this rogue access point.
- **External**—The controller acknowledges the presence of this rogue access point.

Step 17 From the Maximum Number of APs to Contain the Rogue drop-down list, choose one of the following options to specify the maximum number of access points used to contain this ad-hoc rogue: **1**, **2**, **3**, or **4.**

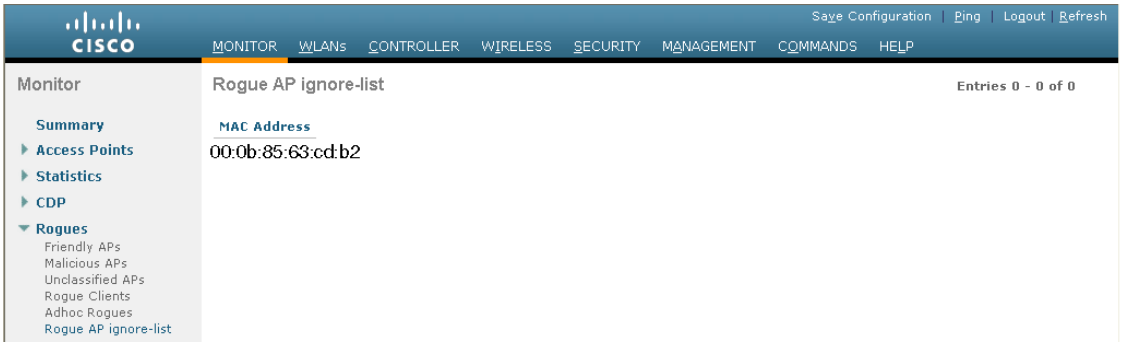
The bottom of the page provides information on the access points that detected this ad-hoc rogue.

Step 18 Click **Apply** to commit your changes.

Step 19 Click **Save Configuration** to save your changes.

Step 20 View any access points that have been configured to be ignored by choosing **Rogue AP Ignore-List**. The Rogue AP Ignore-List page appears (see Figure 6-53).

Figure 6-53 Rogue AP Ignore-List Page



This page shows the MAC addresses of any access points that are configured to be ignored. The rogue-ignore list contains a list of any autonomous access points that have been manually added to WCS maps by WCS users. The controller regards these autonomous access points as rogues even though WCS is managing them. The rogue-ignore list allows the controller to ignore these access points. The list is updated as follows:

- When the controller receives a rogue report, it checks to see if the unknown access point is in the rogue-ignore access point list.
- If the unknown access point is in the rogue-ignore list, the controller ignores this access point and continues to process other rogue access points.
- If the unknown access point is not in the rogue-ignore list, the controller sends a trap to WCS. If WCS finds this access point in its autonomous access point list, WCS sends a command to the controller to add this access point to the rogue-ignore list. This access point is then ignored in future rogue reports.
- If a user removes an autonomous access point from WCS, WCS sends a command to the controller to remove this access point from the rogue-ignore list.

Using the CLI to View and Classify Rogue Devices

To view and classify rogue devices using the controller CLI, use these commands:

- View a list of all rogue access points detected by the controller by entering this command:

  show rogue ap summary

  Information similar to the following appears:

```
Rogue Location Discovery Protocol..... Enabled
Rogue AP timeout.............................. 1200

MAC Address        Classification     # APs # Clients Last Heard
-----------------  -----------------  ----- --------- ----------------------
00:0a:b8:7f:08:c0  Friendly           0     0         Not Heard
00:0b:85:01:30:3f  Malicious          1     0         Fri Nov 30 11:30:59 2007
```

```
00:0b:85:63:70:6f  Malicious          1     0         Fri Nov 30 11:20:14 2007
00:0b:85:63:cd:bf Malicious         1        0       Fri Nov 30 11:23:12 2007
...
```

- See a list of the friendly rogue access points detected by the controller by entering this command:

  show rogue ap friendly summary

  Information similar to the following appears:

```
Number of APs.................................. 1

MAC Address        State              # APs # Clients Last Heard
-----------------  -----------------  ----- --------- -------------------------
00:0a:b8:7f:08:c0  Internal           1   0        Tue Nov 27 13:52:04 2007
```

- See a list of the malicious rogue access points detected by the controller by entering this command:

  show rogue ap malicious summary

  Information similar to the following appears:

```
Number of APs.................................. 264

MAC Address        State              # APs # Clients Last Heard
-----------------  -----------------  ----- --------- ----------------------
00:0b:85:01:30:3f  Alert              1     0         Fri Nov 30 11:20:01 2007
00:0b:85:63:70:6f  Alert              1     0         Fri Nov 30 11:20:14 2007
00:0b:85:63:cd:bf  Alert              1     0         Fri Nov 30 11:23:12 2007
00:0b:85:63:cd:dd  Alert              1     0         Fri Nov 30 11:27:03 2007
00:0b:85:63:cd:de  Alert              1     0         Fri Nov 30 11:26:23 2007
00:0b:85:63:cd:df Alert            1     0        Fri Nov 30 11:26:50 2007
...
```

- See a list of the unclassified rogue access points detected by the controller by entering this command:

  show rogue ap unclassified summary

  Information similar to the following appears:

```
Number of APs.................................. 164

MAC Address        State              # APs # Clients Last Heard
-----------------  -----------------  ----- --------- ----------------------
00:0b:85:63:cd:bd  Alert              1  0         Fri Nov 30 11:12:52 2007
00:0b:85:63:cd:e7  Alert              1  0         Fri Nov 30 11:29:01 2007
00:0b:85:63:ce:05  Alert              1  0         Fri Nov 30 11:26:23 2007
00:0b:85:63:ce:07Alert             1     0        Fri Nov 30 11:26:23 2007
...
```

- See detailed information for a specific rogue access point by entering this command:

  show rogue ap detailed *ap_mac_address*

  Information similar to the following appears:

```
Rogue BSSID.................................... 00:1d:70:59:95:9d
Rogue Radio Type............................... 802.11a
State.......................................... Alert
First Time Rogue was Reported.................. Tue Sep 21 09:57:08 2010
Last Time Rogue was Reported................... Tue Sep 21 10:00:56 2010
Rogue Client IP address........................ Not known
Reported By
    AP 1
        MAC Address............................ 68:ef:bd:e1:fd:30
        Name................................... AP5475.d074.48e4
```

```
        RSSI..................................... -80 dBm
        SNR...................................... 18 dB
        Channel.................................. 40
        Last reported by this AP................. Tue Sep 21 10:00:56 2010
```

- See the rogue report (which shows the number of rogue devices detected on different channel widths) for a specific 802.11a/n radio by entering this command:

  show ap auto-rf 802.11a *Cisco_AP*

  Information similar to the following appears:

```
Number Of Slots.............................. 2
AP Name...................................... AP2
MAC Address.................................. 00:1b:d5:13:39:74
  Radio Type................................. RADIO_TYPE_80211a
  Noise Information
    Noise Profile............................ PASSED
    Channel 36..............................  -80 dBm
    Channel 40..............................  -78 dBm
    ...
  Interference Information
    Interference Profile..................... PASSED
    Channel 36..............................  -81 dBm @  8 % busy
    Channel 40..............................  -66 dBm @  4 % busy
   ...
Rogue Histogram (20/40_ABOVE/40_BELOW)
    Channel 36............................... 21/ 1/ 0
    Channel 40..............................  7/ 0/ 0
    ...
```

- See a list of all rogue clients that are associated to a rogue access point by entering this command:

  show rogue ap clients *ap_mac_address*

  Information similar to the following appears:

```
MAC Address        State              # APs  Last Heard
-----------------  ------------------ -----  -------------------------
00:bb:cd:12:ab:ff  Alert               1     Fri Nov 30 11:26:23 2007
```

- See a list of all rogue clients detected by the controller by entering this command:

  show rogue client summary

  Information similar to the following appears:

```
Validate rogue clients against AAA.............. Disabled

MAC Address        State              # APs Last Heard
-----------------  ------------------ ----- ----------------------
00:0a:8a:7d:f5:f5  Alert              1     Mon Dec  3 21:56:36 2007
00:18:ba:78:c4:44  Alert              1     Mon Dec  3 21:59:36 2007
00:18:ba:78:c4:d1  Alert              1     Mon Dec  3 21:47:36 2007
00:18:ba:78:ca:f8 Alert           1     Mon Dec  3 22:02:36 2007
...
```

- See detailed information for a specific rogue client by entering this command:

  show rogue client detailed *client_mac_address*

  Information similar to the following appears:

```
Rogue BSSID.................................. 00:0b:85:23:ea:d1
State........................................ Alert
First Time Rogue was Reported................ Mon Dec  3 21:50:36 2007
Last Time Rogue was Reported................. Mon Dec  3 21:50:36 2007
```

```
Rogue Client IP address..... Not known
Reported By
    AP 1
        MAC Address..... 00:15:c7:82:b6:b0
        Name..... AP0016.47b2.31ea
        Radio Type..... 802.11a
        RSSI..... -71 dBm
        SNR..... 23 dB
        Channel..... 149
        Last reported by this AP..... Mon Dec  3 21:50:36 2007
```

- See a list of all ad-hoc rogues detected by the controller by entering this command:

  show rogue adhoc summary

  Information similar to the following appears:

```
Detect and report Ad-Hoc Networks..... Enabled

Client MAC Address  Adhoc BSSID         State    # APs   Last Heard
------------------  ------------------  -------  -------  ------------------------
00:bb:cd:12:ab:ff  super              Alert       1       Fri Nov 30 11:26:23 2007
```

- See detailed information for a specific ad-hoc rogue by entering this command:

  show rogue adhoc detailed *rogue_mac_address*

  Information similar to the following appears:

```
Adhoc Rogue MAC address..... 02:61:ce:8e:a8:8c
Adhoc Rogue BSSID..... 02:61:ce:8e:a8:8c
State..... Alert
First Time Adhoc Rogue was Reported..... Tue Dec 11 20:45:45 2007
Last Time Adhoc Rogue was Reported..... Tue Dec 11 20:45:45 2007
Reported By
    AP 1
        MAC Address..... 00:14:1b:58:4a:e0
        Name..... AP0014.1ced.2a60
        Radio Type..... 802.11b
        SSID..... rf4k3ap
        Channel..... 3
        RSSI..... -56 dBm
        SNR..... 15 dB
        Encryption..... Disabled
        ShortPreamble..... Disabled
        WPA Support..... Disabled
       Last reported by this AP..... Tue Dec 11 20:45:45 2007
```

- See a list of rogue access points that are configured to be ignore by entering this command:

  show rogue ignore-list

  Information similar to the following appears:

```
MAC Address
------------------
10:bb:17:cc:01:ef
```

Note See Step 20 of the "Using the GUI to View and Classify Rogue Devices" section on page 6-102 for more information on the rogue-ignore access point list.

- Classify a rogue access point as friendly by entering this command:

  config rogue ap classify friendly state {**internal** | **external**} *ap_mac_address*

where

- **internal** means that the controller trusts this rogue access point.
- **external** means that the controller acknowledges the presence of this rogue access point.

Note A rogue access point cannot be moved to the Friendly class if its current state is Contain.

- Mark a rogue access point as malicious by entering this command:

  config rogue ap classify malicious state {**alert** | **contain**} *ap_mac_address*

  where

  - **alert** means that the controller forwards an immediate alert to the system administrator for further action.
  - **contain** means that the controller contains the offending device so that its signals no longer interfere with authorized clients.

  Note A rogue access point cannot be moved to the Malicious class if its current state is Contain.

- Mark a rogue access point as unclassified by entering this command:

  config rogue ap classify unclassified state {**alert** | **contain**} *ap_mac_address*

  Note A rogue access point cannot be moved to the Unclassified class if its current state is Contain.

  - **alert** means that the controller forwards an immediate alert to the system administrator for further action.
  - **contain** means that the controller contains the offending device so that its signals no longer interfere with authorized clients.
- Specify how the controller should respond to a rogue client by entering one of these commands:
  - **config rogue client alert** *client_mac_address*—The controller forwards an immediate alert to the system administrator for further action.
  - **config rogue client contain** *client_mac_address*—The controller contains the offending device so that its signals no longer interfere with authorized clients.
- Specify how the controller should respond to an ad-hoc rogue by entering one these commands:
  - **config rogue adhoc alert** *rogue_mac_address*—The controller forwards an immediate alert to the system administrator for further action.
  - **config rogue adhoc contain** *rogue_mac_address*—The controller contains the offending device so that its signals no longer interfere with authorized clients.
  - **config rogue adhoc external** *rogue_mac_address*—The controller acknowledges the presence of this ad-hoc rogue.
- Save your changes by entering this command:

  save config

Configuring IDS

The Cisco intrusion detection system/intrusion prevention system (CIDS/IPS) instructs controllers to block certain clients from accessing the wireless network when attacks involving these clients are detected at Layer 3 through Layer 7. This system offers significant network protection by helping to detect, classify, and stop threats including worms, spyware/adware, network viruses, and application abuse. Two methods are available to detect potential attacks:

- IDS sensors
- IDS signatures

Note The Cisco wireless intrusion prevention system (wIPS) is also supported on the controller through WCS. See the "Configuring wIPS" section on page 6-128 for more information.

Configuring IDS Sensors

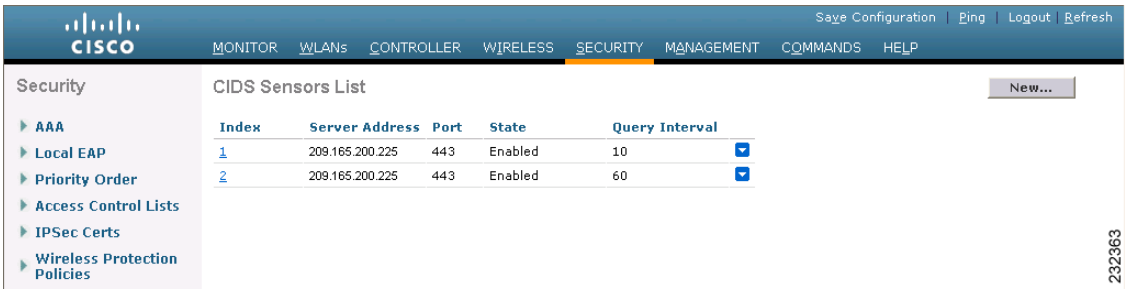
You can configure IDS sensors to detect various types of IP-level attacks in your network. When the sensors identify an attack, they can alert the controller to shun the offending client. When you add a new IDS sensor, you register the controller with that IDS sensor so that the controller can query the sensor to get the list of shunned clients. You can configure IDS sensor registration through either the GUI or the CLI.

Using the GUI to Configure IDS Sensors

To configure IDS sensors using the controller GUI, follow these steps:

Step 1 Choose **Security** > **Advanced** > **CIDs** > **Sensors** to open the CIDS Sensors List page (see Figure 6-54).

Figure 6-54 CIDS Sensors List Page

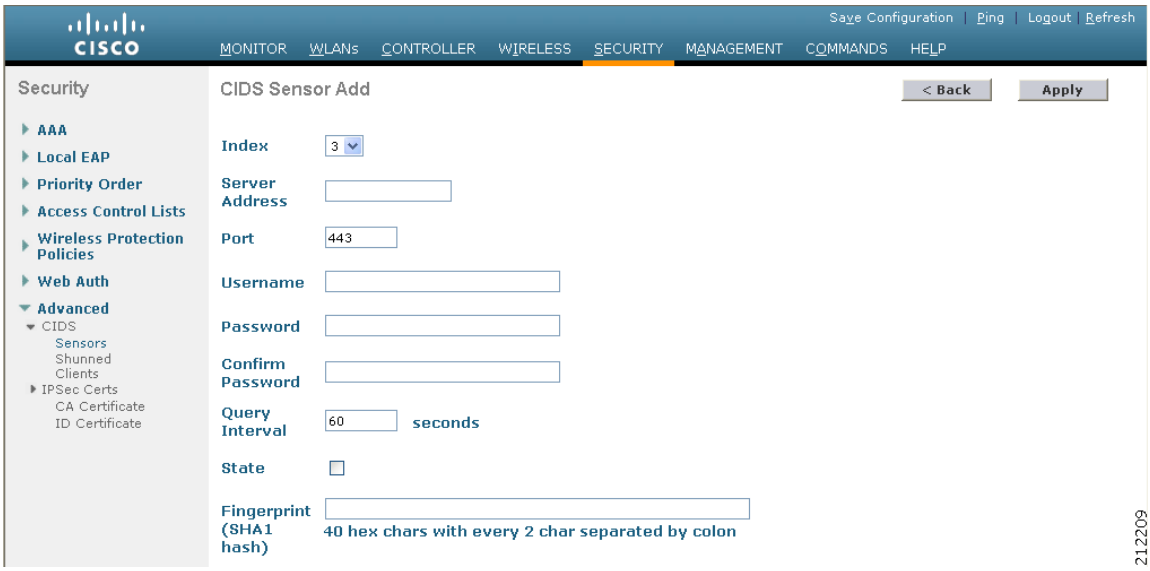


This page lists all of the IDS sensors that have been configured for this controller.

Note If you want to delete an existing sensor, hover your cursor over the blue drop-down arrow for that sensor and choose **Remove**.

Step 2 Add an IDS sensor to the list by clicking **New**. The CIDS Sensor Add page appears (see Figure 6-55).

Figure 6-55 CIDS Sensor Add Page



Step 3 The controller supports up to five IDS sensors. From the Index drop-down list, choose a number (between 1 and 5) to determine the sequence in which the controller consults the IDS sensors. For example, if you choose 1, the controller consults this IDS sensor first.

Step 4 In the Server Address text box, enter the IP address of your IDS server.

Step 5 The Port text box contains the number of the HTTPS port through which the controller is to communicate with the IDS sensor. We recommend that you set this parameter to 443 because the sensor uses this value to communicate by default.

The default value is 443 and the range is 1 to 65535.

Step 6 In the Username text box, enter the name that the controller uses to authenticate to the IDS sensor.

Note This username must be configured on the IDS sensor and have at least a read-only privilege.

Step 7 In the Password and Confirm Password text boxes, enter the password that the controller uses to authenticate to the IDS sensor.

Step 8 In the Query Interval text box, enter the time (in seconds) for how often the controller should query the IDS server for IDS events.

The default is 60 seconds and the range is 10 to 3600 seconds.

Step 9 Select the **State** check box to register the controller with this IDS sensor or unselected this check box to disable registration. The default value is disabled.

Step 10 Enter a 40-hexadecimal-character security key in the Fingerprint text box. This key is used to verify the validity of the sensor and is used to prevent security attacks.

Note Make sure you include colons that appear between every two bytes within the key. For example, enter AA:BB:CC:DD.

Step 11 Click **Apply**. Your new IDS sensor appears in the list of sensors on the CIDS Sensors List page.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure IDS Sensors

To configure IDS sensors using the controller CLI, follow these steps:

Step 1 Add an IDS sensor by entering this command:

config wps cids-sensor add *index ids_ip_address username password*

The *index* parameter determines the sequence in which the controller consults the IDS sensors. The controller supports up to five IDS sensors. Enter a number (between 1 and 5) to determine the priority of this sensor. For example, if you enter 1, the controller consults this IDS sensor first.

Note The username must be configured on the IDS sensor and have at least a read-only privilege.

Step 2 (Optional) Specify the number of the HTTPS port through which the controller is to communicate with the IDS sensor by entering this command:

config wps cids-sensor port *index port_number*

For the *port-number* parameter, you can enter a value between 1 and 65535. The default value is 443. This step is optional because we recommend that you use the default value of 443. The sensor uses this value to communicate by default.

Step 3 Specify how often the controller should query the IDS server for IDS events by entering this command:

config wps cids-sensor interval *index interval*

For the *interval* parameter, you can enter a value between 10 and 3600 seconds. The default value is 60 seconds.

Step 4 Enter a 40-hexadecimal-character security key used to verify the validity of the sensor by entering this command:

config wps cids-sensor fingerprint *index* **sha1** *fingerprint*

You can get the value of the fingerprint by entering **show tls fingerprint** on the sensor's console.

Note Make sure to include the colons that appear between every two bytes within the key (for example, AA:BB:CC:DD).

Step 5 Enable or disable this controller's registration with an IDS sensor by entering this command:

config wps cids-sensor {**enable** | **disable**} *index*

Step 6 Enable or disable protection from DoS attacks by entering this command:

config wps auto-immune {**enable** | **disable**}

The default value is disabled.

Note A potential attacker can use specially crafted packets to mislead the IDS into treating a legitimate client as an attacker. It causes the controller to wrongly disconnect this legitimate client and launches a DoS attack. The auto-immune feature, when enabled, is designed to protect against such attacks. However, conversations using Cisco 792x phones might be interrupted intermittently when the auto-immune feature is enabled. If you experience frequent disruptions when using 792x phones, you might want to disable this feature.

Step 7 Save your settings by entering this command:

save config

Step 8 See the IDS sensor configuration by entering one of these commands:

- **show wps cids-sensor summary**
- **show wps cids-sensor detail** *index*

The second command provides more information than the first.

Step 9 See the auto-immune configuration setting by entering this command:

show wps summary

Information similar to the following appears:

```
Auto-Immune
  Auto-Immune..................................... Disabled

Client Exclusion Policy
  Excessive 802.11-association failures.......... Enabled
  Excessive 802.11-authentication failures....... Enabled
  Excessive 802.1x-authentication................ Enabled
  IP-theft....................................... Enabled
  Excessive Web authentication failure........... Enabled

Signature Policy
  Signature Processing........................... Enabled
```

Step 10 Obtain debug information regarding IDS sensor configuration by entering this command:

debug wps cids enable

Note If you ever want to delete or change the configuration of a sensor, you must first disable it by entering the **config wps cids-sensor disable** *index* command. To delete the sensor, enter the **config wps cids-sensor delete** *index* command.

Viewing Shunned Clients

When an IDS sensor detects a suspicious client, it alerts the controller to shun this client. The shun entry is distributed to all controllers within the same mobility group. If the client to be shunned is currently joined to a controller in this mobility group, the anchor controller adds this client to the dynamic exclusion list, and the foreign controller removes the client. The next time that the client tries to connect to a controller, the anchor controller rejects the handoff and informs the foreign controller that the client is being excluded. See Chapter 14, "Configuring Mobility Groups," for more information on mobility groups.

You can view the list of clients that the IDS sensors have identified to be shunned through either the GUI or the CLI.

Using the GUI to View Shunned Clients

To view the list of clients that the IDS sensors have identified to be shunned using the controller GUI, follow these steps:

Step 1 Choose **Security** > **Advanced** > **CIDS** > **Shunned Clients** to open the CIDS Shun List page (see Figure 6-56).

Figure 6-56 CIDS Shun List Page

This page shows the IP address and MAC address of each shunned client, the length of time that the client's data packets should be blocked by the controller as requested by the IDS sensor, and the IP address of the IDS sensor that discovered the client.

Step 2 Click **Re-sync** to purge and reset the list as desired.

Using the CLI to View Shunned Clients

To view the list of clients that the IDS sensors have identified to be shunned using the controller CLI, follow these steps:

Step 1 View the list of clients to be shunned by entering this command:

show wps shun-list

Step 2 Force the controller to synchronize with other controllers in the mobility group for the shun list by entering this command:

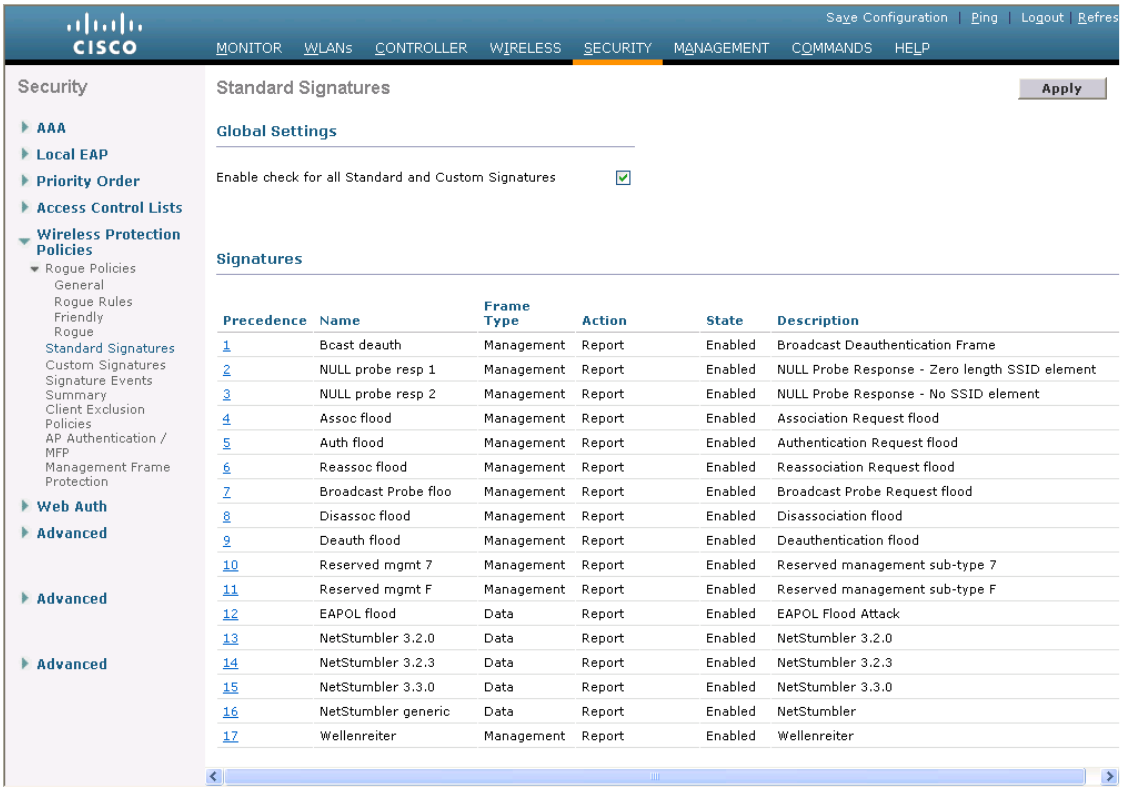
config wps shun-list re-sync

Configuring IDS Signatures

You can configure IDS signatures, or bit-pattern matching rules used to identify various types of attacks in incoming 802.11 packets, on the controller. When the signatures are enabled, the access points joined to the controller perform signature analysis on the received 802.11 data or management frames and report any discrepancies to the controller. If an attack is detected, appropriate mitigation is initiated.

Cisco supports 17 standard signatures on the controller as shown on the Standard Signatures page (see Figure 6-57).

Figure 6-57 Standard Signatures Page



These signatures are divided into six main groups. The first four groups contain management signatures, and the last two groups contain data signatures.

- Broadcast deauthentication frame signatures—During a broadcast deauthentication frame attack, a hacker sends an 802.11 deauthentication frame to the broadcast MAC destination address of another client. This attack causes the destination client to disassociate from the access point and lose its connection. If this action is repeated, the client experiences a denial of service. When the broadcast deauthentication frame signature (precedence 1) is used to detect such an attack, the access point listens for clients transmitting broadcast deauthentication frames that match the characteristics of the signature. If the access point detects such an attack, it alerts the controller. Depending on how your system is configured, the offending device is contained so that its signals no longer interfere with authorized clients, or the controller forwards an immediate alert to the system administrator for further action, or both.

- NULL probe response signatures—During a NULL probe response attack, a hacker sends a NULL probe response to a wireless client adapter. As a result, the client adapter locks up. When a NULL probe response signature is used to detect such an attack, the access point identifies the wireless client and alerts the controller. The NULL probe response signatures are as follows:
  - NULL probe resp 1 (precedence 2)
  - NULL probe resp 2 (precedence 3)
- Management frame flood signatures—During a management frame flood attack, a hacker floods an access point with 802.11 management frames. The result is a denial of service to all clients associated or attempting to associate to the access point. This attack can be implemented with different types of management frames: association requests, authentication requests, reassociation requests, probe requests, disassociation requests, deauthentication requests, and reserved management subtypes.

  When a management frame flood signature is used to detect such an attack, the access point identifies management frames matching the entire characteristic of the signature. If the frequency of these frames is greater than the value of the frequency set in the signature, an access point that hears these frames triggers an alarm. The controller generates a trap and forwards it to WCS.

  The management frame flood signatures are as follows:
  - Assoc flood (precedence 4)
  - Auth flood (precedence 5)
  - Reassoc flood (precedence 6)
  - Broadcast probe flood (precedence 7)
  - Disassoc flood (precedence 8)
  - Deauth flood (precedence 9)
  - Reserved mgmt 7 (precedence 10)
  - Reserved mgmt F (precedence 11)

  The reserved management frame signatures 7 and F are reserved for future use.
- Wellenreiter signature—Wellenreiter is a wireless LAN scanning and discovery utility that can reveal access point and client information. When the Wellenreiter signature (precedence 17) is used to detect such an attack, the access point identifies the offending device and alerts the controller.
- EAPOL flood signature—During an EAPOL flood attack, a hacker floods the air with EAPOL frames that contain 802.1X authentication requests. As a result, the 802.1X authentication server cannot respond to all of the requests and fails to send successful authentication responses to valid clients. The result is a denial of service to all affected clients. When the EAPOL flood signature (precedence 12) is used to detect such an attack, the access point waits until the maximum number of allowed EAPOL packets is exceeded. It then alerts the controller and proceeds with the appropriate mitigation.
- NetStumbler signatures—NetStumbler is a wireless LAN scanning utility that reports access point broadcast information (such as operating channel, RSSI information, adapter manufacturer name, SSID, WEP status, and the latitude and longitude of the device running NetStumbler when a GPS is attached). If NetStumbler succeeds in authenticating and associating to an access point, it sends a data frame with the following strings, depending on the NetStumbler version:

Version	String
3.2.0	“Flurble gronk bloopit, bnip Frundletrune”

Version	String
3.2.3	“All your 802.11b are belong to us”
3.3.0	Sends white spaces

When a NetStumbler signature is used to detect such an attack, the access point identifies the offending device and alerts the controller. The NetStumbler signatures are as follows:

- NetStumbler 3.2.0 (precedence 13)
- NetStumbler 3.2.3 (precedence 14)
- NetStumbler 3.3.0 (precedence 15)
- NetStumbler generic (precedence 16)

A standard signature file exists on the controller by default. You can upload this signature file from the controller, or you can create a custom signature file and download it to the controller or modify the standard signature file to create a custom signature. You can configure signatures through either the GUI or the CLI.

Using the GUI to Configure IDS Signatures

To configure signatures using the controller GUI, follow these steps:

- Uploading or downloading IDS signatures, page 6-119
- Enabling or disabling IDS signatures, page 6-121
- Viewing IDS signature events, page 6-123

Using the GUI to Upload or Download IDS Signatures

To upload or download IDS signatures using the controller GUI, follow these steps:

Step 1 If desired, create your own custom signature file.

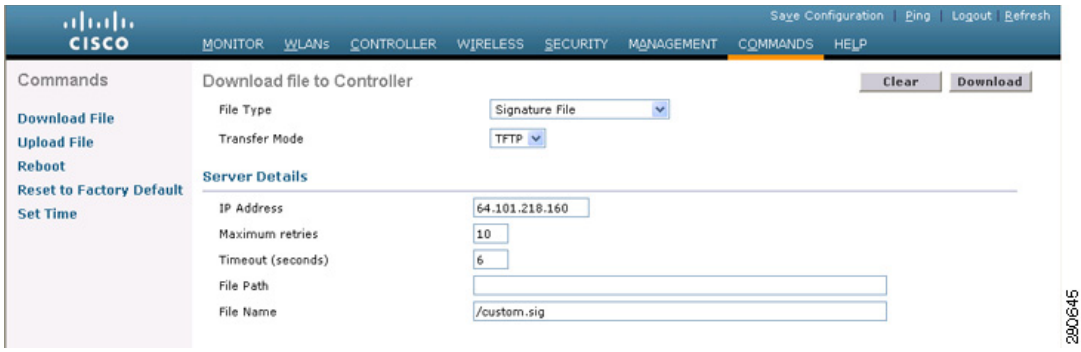
Step 2 Make sure that you have a Trivial File Transfer Protocol (TFTP) server available. Follow these guidelines when setting up a TFTP server:

- If you are downloading through the service port, the TFTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP server cannot run on the same computer as the Cisco WCS because the WCS built-in TFTP server and the third-party TFTP server require the same communication port.

Step 3 If you are downloading a custom signature file (*.sig), copy it to the default directory on your TFTP server.

Step 4 Choose **Commands** to open the Download File to Controller page (see Figure 6-58).

Figure 6-58 Download File to Controller Page



Step 5 Perform one of the following:

- If you want to download a custom signature file to the controller, choose **Signature File** from the File Type drop-down list on the Download File to Controller page.
- If you want to upload a standard signature file from the controller, choose **Upload File** and then **Signature File** from the File Type drop-down list on the Upload File from Controller page.

Step 6 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 7 In the IP Address text box, enter the IP address of the TFTP or FTP server.

Step 8 If you are downloading the signature file using a TFTP server, enter the maximum number of times that the controller should attempt to download the signature file in the Maximum retries text box.

The range is 1 to 254 and the default value is 10.

Step 9 If you are downloading the signature file using a TFTP server, enter the amount of time in seconds before the controller times out while attempting to download the signature file in the Timeout text box.

The range is 1 to 254 seconds and the default is 6 seconds.

Step 10 In the File Path text box, enter the path of the signature file to be downloaded or uploaded. The default value is "/."

Step 11 In the File Name text box, enter the name of the signature file to be downloaded or uploaded.

Note When uploading signatures, the controller uses the filename that you specify as a base name and then adds "_std.sig" and "_custom.sig" to it in order to upload *both* standard and custom signature files to the TFTP server. For example, if you upload a signature file called "ids1," the controller automatically generates and uploads both ids1_std.sig and ids1_custom.sig to the TFTP server. If desired, you can then modify ids1_custom.sig on the TFTP server (making sure to set "Revision = custom") and download it by itself.

Step 12 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the download occurs. The default value is 21.

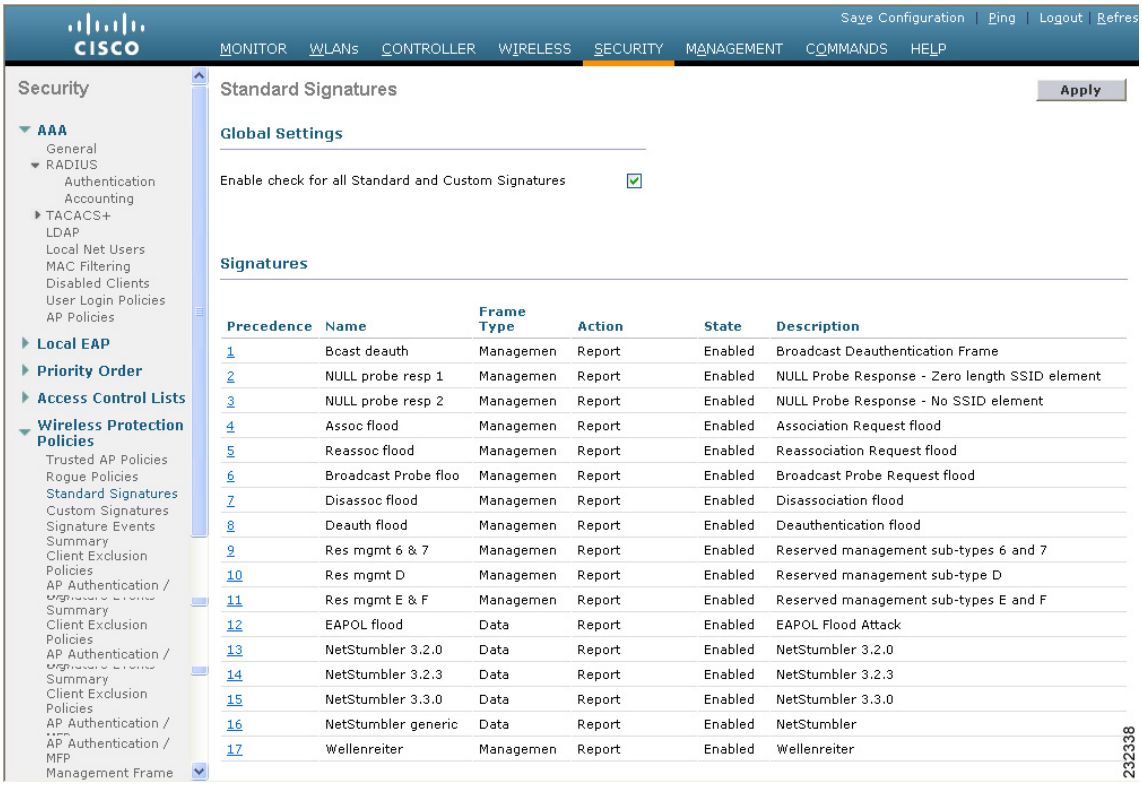
Step 13 Choose **Download** to download the signature file to the controller or **Upload** to upload the signature file from the controller.

Using the GUI to Enable or Disable IDS Signatures

To enable or disable IDS signatures using the controller GUI, follow these steps:

Step 1 Choose **Security > Wireless Protection Policies > Standard Signatures** or **Custom Signatures** to open the Standard Signatures page (see Figure 6-59) or the Custom Signatures page.

Figure 6-59 Standard Signatures Page



The Standard Signatures page shows the list of Cisco-supplied signatures that are currently on the controller. The Custom Signatures page shows the list of customer-supplied signatures that are currently on the controller. This page shows the following information for each signature:

- The order, or precedence, in which the controller performs the signature checks.
- The name of the signature, which specifies the type of attack that the signature is trying to detect.
- The frame type on which the signature is looking for a security attack. The possible frame types are data and management.
- The action that the controller is directed to take when the signature detects an attack. The possible actions are None and Report.
- The state of the signature, which indicates whether the signature is enabled to detect security attacks.
- A description of the type of attack that the signature is trying to detect.

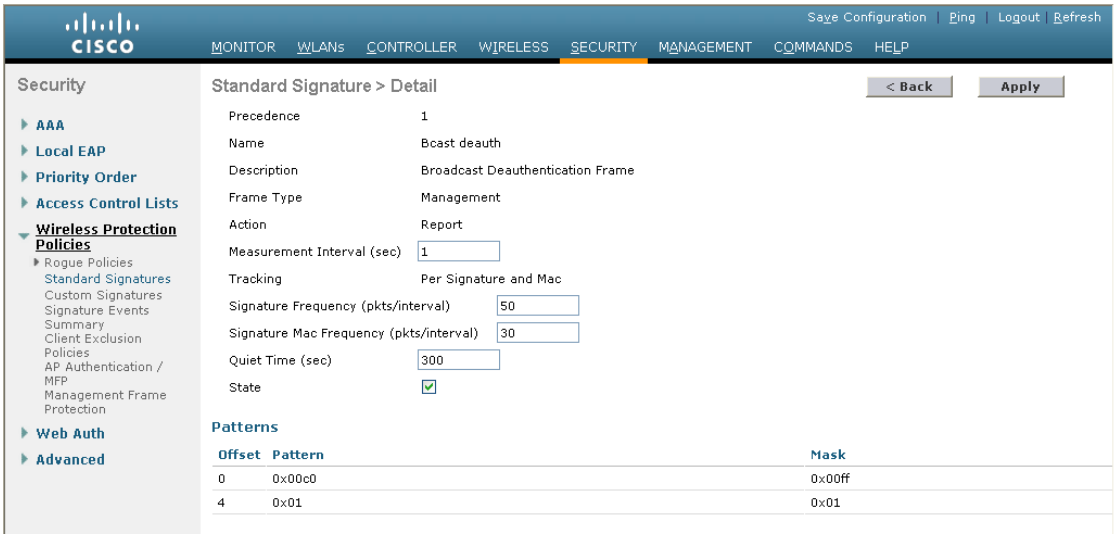
Step 2 Perform one of the following:

- If you want to allow all signatures (both standard and custom) whose individual states are set to Enabled to remain enabled, select the **Enable Check for All Standard and Custom Signatures** check box at the top of either the Standard Signatures page or the Custom Signatures page. The default value is enabled (or selected). When the signatures are enabled, the access points joined to the controller perform signature analysis on the received 802.11 data or management frames and report any discrepancies to the controller.
- If you want to disable all signatures (both standard and custom) on the controller, unselect the **Enable Check for All Standard and Custom Signatures** check box. If you unselected this check box, all signatures are disabled, even the ones whose individual states are set to Enabled.

Step 3 Click **Apply** to commit your changes.

Step 4 Click the precedence number of the desired signature to enable or disable an individual signature. The Standard Signature (or Custom Signature) > Detail page appears (see Figure 6-60).

Figure 6-60 Standard Signature > Detail Page



This page shows much of the same information as the Standard Signatures and Custom Signatures pages but provides these additional details:

- The tracking method used by the access points to perform signature analysis and report the results to the controller. The possible values are as follows:
  - Per Signature—Signature analysis and pattern matching are tracked and reported on a per-signature and per-channel basis.
  - Per MAC—Signature analysis and pattern matching are tracked and reported separately for individual client MAC addresses on a per-channel basis.
  - Per Signature and MAC—Signature analysis and pattern matching are tracked and reported on a per-signature and per-channel basis as well as on a per-MAC-address and per-channel basis.
- The pattern that is being used to detect a security attack

Step 5 In the Measurement Interval text box, enter the number of seconds that must elapse before the signature frequency threshold is reached within the configured interval. The range is 1 to 3600 seconds, and the default value varies per signature.

Step 6 In the Signature Frequency text box, enter the number of matching packets per interval that must be identified at the individual access point level before an attack is detected. The range is 1 to 32,000 packets per interval, and the default value varies per signature.

Step 7 In the Signature MAC Frequency text box, enter the number of matching packets per interval that must be identified per client per access point before an attack is detected. The range is 1 to 32,000 packets per interval, and the default value varies per signature.

Step 8 In the Quiet Time text box, enter the length of time (in seconds) after which no attacks have been detected at the individual access point level and the alarm can stop. The range is 60 to 32,000 seconds, and the default value varies per signature.

Step 9 Select the **State** check box to enable this signature to detect security attacks or unselect it to disable this signature. The default value is enabled (or selected).

Step 10 Click **Apply** to commit your changes. The Standard Signatures or Custom Signatures page reflects the signature's updated state.

Step 11 Click **Save Configuration** to save your changes.

Using the GUI to View IDS Signature Events

To view signature events using the controller GUI, follow these steps:

Step 1 Choose **Security > Wireless Protection Policies > Signature Events Summary** to open the Signature Events Summary page (see Figure 6-61).

Figure 6-61 Signature Events Summary Page

This page shows the number of attacks detected by the enabled signatures.

Step 2 Click the signature type link for that signature to see more information on the attacks detected by a particular signature. The Signature Events Detail page appears (see Figure 6-62).

Figure 6-62 Signature Events Detail Page

This page shows the following information:

- The MAC addresses of the clients identified as attackers
- The method used by the access point to track the attacks
- The number of matching packets per second that were identified before an attack was detected
- The number of access points on the channel on which the attack was detected
- The day and time when the access point detected the attack

Step 3 Click the **Detail** link for that attack to see more information for a particular attack. The Signature Events Track Detail page appears (see Figure 6-63).

Figure 6-63 Signature Events Track Detail Page

This page shows the following information:

- The MAC address of the access point that detected the attack
- The name of the access point that detected the attack
- The type of radio (802.11a or 802.11b/g) used by the access point to detect the attack
- The radio channel on which the attack was detected
- The day and time when the access point reported the attack

Using the CLI to Configure IDS Signatures

To configure IDS signatures using the controller CLI, follow these steps:

Step 1 If desired, create your own custom signature file.

Step 2 Make sure that you have a TFTP server available. See the guidelines for setting up a TFTP server in Step 2 of the "Using the GUI to Upload or Download IDS Signatures" section on page 6-119.

Step 3 Copy the custom signature file (*.sig) to the default directory on your TFTP server.

Step 4 Specify the download or upload mode by entering the **transfer** {**download** | **upload**} **mode tftp** command.

Step 5 Specify the type of file to be downloaded or uploaded by entering the **transfer** {**download** | **upload**} **datatype signature** command.

Step 6 Specify the IP address of the TFTP server by entering the **transfer** {**download** | **upload**} **serverip** *tftp-server-ip-address* command.

Note Some TFTP servers require only a forward slash (/) as the TFTP server IP address, and the TFTP server automatically determines the path to the correct directory.

Step 7 Specify the download or upload path by entering the **transfer** {**download** | **upload**} **path** *absolute-tftp-server-path-to-file* command.

Step 8 Specify the file to be downloaded or uploaded by entering the **transfer** {**download** | **upload**} **filename** *filename.sig* command.

Note When uploading signatures, the controller uses the filename you specify as a base name and then adds "_std.sig" and "_custom.sig" to it in order to upload *both* standard and custom signature files to the TFTP server. For example, if you upload a signature file called "ids1," the controller automatically generates and uploads both ids1_std.sig and ids1_custom.sig to the TFTP server. If desired, you can then modify ids1_custom.sig on the TFTP server (making sure to set "Revision = custom") and download it by itself.

Step 9 Enter the **transfer** {**download** | **upload**} **start** command and answer **y** to the prompt to confirm the current settings and start the download or upload.

Step 10 Specify the number of seconds that must elapse before the signature frequency threshold is reached within the configured interval by entering this command:

config wps signature interval *signature_id interval*

where *signature_id* is a number used to uniquely identify a signature. The range is 1 to 3600 seconds, and the default value varies per signature.

Step 11 Specify the number of matching packets per interval that must be identified at the individual access point level before an attack is detected by entering this command:

config wps signature frequency *signature_id frequency*

The range is 1 to 32,000 packets per interval, and the default value varies per signature.

Step 12 Specify the number of matching packets per interval that must be identified per client per access point before an attack is detected by entering this command:

config wps signature mac-frequency *signature_id mac_frequency*

The range is 1 to 32,000 packets per interval, and the default value varies per signature.

Step 13 Specify the length of time (in seconds) after which no attacks have been detected at the individual access point level and the alarm can stop by entering by entering this command:

config wps signature quiet-time *signature_id quiet_time*

The range is 60 to 32,000 seconds, and the default value varies per signature.

Step 14 Perform one of the following:

- To enable or disable an individual IDS signature, enter this command:

  config wps signature {**standard** | **custom**} **state** *signature_id* {**enable** | **disable**}

- To enable or disable IDS signature processing, which enables or disables the processing of all IDS signatures, enter this command:

  config wps signature {**enable** | **disable**}

Note If IDS signature processing is disabled, all signatures are disabled, regardless of the state configured for individual signatures.

Step 15 Save your changes by entering this command:

save config

Step 16 If desired, you can reset a specific signature or all signatures to default values. To do so, enter this command:

config wps signature reset {*signature_id* | **all**}

Note You can reset signatures to default values only through the controller CLI.

Using the CLI to View IDS Signature Events

To view signature events using the controller CLI, use these commands:

- See whether IDS signature processing is enabled or disabled on the controller by entering this command:

  show wps summary

  Information similar to the following appears:

```
Auto-Immune
  Auto-Immune................................... Disabled

Client Exclusion Policy
  Excessive 802.11-association failures.......... Enabled
  Excessive 802.11-authentication failures....... Enabled
  Excessive 802.1x-authentication................ Enabled
  IP-theft....................................... Enabled
  Excessive Web authentication failure........... Enabled

Signature Policy
  Signature Processing.......................... Enabled
```

Note If IDS signature processing is disabled, all signatures are disabled, regardless of the state configured for individual signatures.

- See individual summaries of all of the standard and custom signatures installed on the controller by entering this command:

  show wps signature summary

  Information similar to the following appears:

```
Signature-ID..................................... 1
Precedence....................................... 1
Signature Name................................... Bcast deauth
Type............................................. standard
FrameType........................................ management
State............................................ enabled
Action........................................... report
Tracking......................................... per Signature and Mac
Signature Frequency.............................. 50 pkts/interval
Signature Mac Frequency.......................... 30 pkts/interval
Interval......................................... 1 sec
Quiet Time....................................... 300 sec
Description...................................... Broadcast Deauthentication Frame
Patterns:
                0(Header):0x00c0:0x00ff
               4(Header):0x01:0x01
```

- See the number of attacks detected by the enabled signatures by entering this command:

  show wps signature events summary

  Information similar to the following appears:

```
Precedence Signature Name     Type     # Events
---------- ------------------ -----    -----------
1          Bcast deauth       Standard    2
2          NULL probe resp 1  Standard    1
```

- See more information on the attacks detected by a particular standard or custom signature by entering this command:

  show wps signature events {**standard** | **custom**} *precedence#* **summary**

  Information similar to the following appears:

```
Precedence....................................... 1
Signature Name................................... Bcast deauth
Type............................................. Standard
Number of active events..................... 2

Source MAC Addr   Track Method  Frequency No. APs Last Heard
----------------- ------------  --------- -------- -----------------------
00:01:02:03:04:01 Per Signature   4          3    Tue Dec 6 00:17:44 2005
00:01:02:03:04:01 Per Mac         6          2    Tue Dec 6 00:30:04 2005
```

- See information on attacks that are tracked by access points on a per-signature and per-channel basis by entering this command:

  show wps signature events {**standard** | **custom**} *precedence#* **detailed per-signature** *source_mac*

- See information on attacks that are tracked by access points on an individual-client basis (by MAC address) by entering this command:

  show wps signature events {**standard** | **custom**} *precedence#* **detailed per-mac** *source_mac*

  Information similar to the following appears:

```
Source MAC....................................... 00:01:02:03:04:01
Precedence....................................... 1
Signature Name................................... Bcast deauth
```

```
Type.......................................... Standard
Track......................................... Per Mac
Frequency..................................... 6
Reported By
    AP 1
        MAC Address........................... 00:0b:85:01:4d:80
        Name.................................. Test_AP_1
        Radio Type............................ 802.11bg
        Channel............................... 4
        Last reported by this AP.............. Tue Dec 6 00:17:49 2005
    AP 2
        MAC Address........................... 00:0b:85:26:91:52
        Name.................................. Test_AP_2
        Radio Type............................ 802.11bg
        Channel............................... 6
         Last reported by this AP.............. Tue Dec 6 00:30:04 2005
```

Configuring wIPS

The Cisco Adaptive wireless intrusion prevention system (wIPS) is an advanced approach to wireless threat detection and performance management. It combines network traffic analysis, network device and topology information, signature-based techniques, and anomaly detection to deliver highly accurate and complete wireless threat prevention. With a fully infrastructure-integrated solution, you can continually monitor wireless traffic on both the wired and wireless networks and use that network intelligence to analyze attacks from many sources to more accurately pinpoint and proactively prevent attacks rather than waiting until damage or exposure has occurred.

The Cisco Adaptive wIPS is enabled by the Cisco 3300 Series Mobility Services Engine (MSE), which centralizes the processing of intelligence collected by the continuous monitoring of Cisco Aironet access points. With Cisco Adaptive wIPS functionalities and WCS integration into the MSE, the wIPS service can configure, monitor, and report wIPS policies and alarms.

Note If your wIPS deployment consists of a controller, access point, and MSE, you must set all the three entities to the UTC time zone.

The Cisco Adaptive wIPS is not configured on the controller. Instead, WCS forwards the profile configuration to the wIPS service, which forwards the profile to the controller. The profile is stored in flash memory on the controller and sent to access points when they join the controller. When an access point disassociates and joins another controller, it receives the wIPS profile from the new controller.

Starting release 7.0.116.0, the regular local mode or H-REAP mode access point has been extended with a subset of Wireless Intrusion Prevention System (wIPS) capabilities. This feature enables you to deploy your access points to provide protection without needing a separate overlay network.

Local mode or Hybrid REAP mode access points with a subset of wIPS capabilities is referred to as Enhanced Local Mode access point or just ELM AP. You can configure an access point to work in wIPS mode if the access point is in any of the following modes:

- Monitor
- Local
- Hybrid REAP

Note wIPS ELM is not supported on 1130 and 1240 access points.

wIPS ELM has limited capability of detecting off-channel alarms. The access point periodically goes off-channel, and monitors the non-serving channels for a short duration, and triggers alarms if any attack is detected on the channel. But the off-channel alarm detection is best effort and it takes longer time to detect attacks and trigger alarms, which might cause the ELM AP intermittently detect an alarm and clear it because it is not visible. Access points in any of the above modes can periodically send alarms based on the policy profile to the wIPS service through the controller. The wIPS service stores and processes the alarms and generates SNMP traps. WCS configures its IP address as a trap destination to receive SNMP traps from the MSE.

Note In all of the above cases, the controller functions solely as a forwarding device.

Note For more information on the Cisco Adaptive wIPS, see the *Cisco Wireless Control System Configuration Guide, Release 7.0.172.0* and the *Cisco 3300 Series Mobility Services Engine Configuration Guide, Release 7.0.*201.0.

Using the GUI to Configure wIPS on an Access Point

To configure wIPS on an access point using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > All APs >** *access point name*.

Step 2 Set the **AP Mode** parameter. To configure an access point for wIPS, you must choose one of the following modes from the AP Mode drop-down list:

- Local
- H-REAP
- Monitor

Step 3 Set the AP Sub Mode to wIPS by choosing **wIPS** from the AP Sub Mode drop-down list.

Step 4 Click **Apply**.

Using the CLI to Configure wIPS on an Access Point

To configure wIPS on an access point using the controller CLI, follow these steps:

Step 1 Configure an access point for monitor mode by entering this command:

config ap mode {monitor | local | h-reap} *Cisco_AP*

Note To configure an access point for wIPS, the access point must be in **monitor**, **local**, or **h-reap** modes.

Step 2 Enter **Y** when you see the message that the access point will be rebooted if you want to continue.

Step 3 Save your changes by entering this command:

save config

Step 4 Disable the access point radio by entering this command:

config {**802.11a** | **802.11b**} **disable** *Cisco_AP*

Step 5 Configure the wIPS submode on the access point by entering this command:

config ap mode *ap_mode* **submode wips** *Cisco_AP*

Note To disable wIPS on the access point, enter the **config ap mode** *ap_mode* **submode none** *Cisco_AP* command.

Step 6 Enable wIPS optimized channel scanning for the access point by entering this command:

config ap monitor-mode wips-optimized *Cisco_AP*

The access point scans each channel for 250 milliseconds. It derives the list of channels to be scanned from the monitor configuration. You can choose one of these options:

- **All**—All channels supported by the access point's radio
- **Country**—Only the channels supported by the access point's country of operation
- **DCA**—Only the channel set used by the dynamic channel assignment (DCA) algorithm, which by default includes all of the nonoverlapping channels allowed in the access point's country of operation

The 802.11a or 802.11b Monitor Channels text box in the output of the **show advanced** {**802.11a** | **802.11b**} **monitor** command shows the monitor configuration channel set:

```
Default 802.11b AP monitoring
  802.11b Monitor Mode..................... enable
  802.11b Monitor Channels................. Country channels
  802.11b AP Coverage Interval............. 180 seconds
  802.11b AP Load Interval................. 60 seconds
  802.11b AP Noise Interval................ 180 seconds
  802.11b AP Signal Strength Interval...... 60 seconds
```

Step 7 Reenable the access point radio by entering this command:

config {**802.11a** | **802.11b**} **enable** *Cisco_AP*

Step 8 Save your changes by entering this command:

save config

Viewing wIPS Information

To view wIPS information using the controller CLI, use these commands:

Note You can also view the access point submode from the controller GUI. To do so, choose **Wireless** > **Access Points** > **All APs** > the access point name > the **Advanced** tab. The AP Sub Mode text box shows *wIPS* if the access point in is monitor mode and the wIPS submode is configured on the access point or *None* if the access point is not in monitor mode or the access point is in monitor mode but the wIPS submode is not configured.

- See the wIPS submode on the access point by entering this command:

  show ap config general *Cisco_AP*

  Information similar to the following appears:

```
Cisco AP Identifier.............................. 3
Cisco AP Name.................................... AP1131:46f2.98ac
...
AP Mode ......................................... Monitor
Public Safety ................................... Disabled  Disabled
AP SubMode ...................................... WIPS
...
```

- See the wIPS optimized channel scanning configuration on the access point by entering this command:

  show ap monitor-mode summary

  Information similar to the following appears:

```
AP Name             Ethernet MAC         Status      Scanning Channel List
------------------ -------------------- ----------  ----------------------
AP1131:46f2.98ac    00:16:46:f2:98:ac     wIPS           1, 6, NA, NA
```

- See the wIPS configuration forwarded by WCS to the controller by entering this command:

  show wps wips summary

  Information similar to the following appears:

```
Policy Name.............. Default
Policy Version.......... 3
```

- See the current state of wIPS operation on the controller by entering this command:

  show wps wips statistics

  Information similar to the following appears:

```
Policy Assignment Requests............ 1
Policy Assignment Responses........... 1
Policy Update Requests................ 0
Policy Update Responses............... 0
Policy Delete Requests................ 0
Policy Delete Responses............... 0
Alarm Updates......................... 13572
Device Updates........................ 8376
Device Update Requests................ 0
Device Update Responses............... 0
Forensic Updates...................... 1001
Invalid WIPS Payloads................. 0
Invalid Messages Received............. 0
NMSP Transmitted Packets.............. 22950
NMSP Transmit Packets Dropped......... 0
NMSP Largest Packet................... 1377
```

- Clear the wIPS statistics on the controller by entering this command:

  clear stats wps wips

Configuring Web Auth Proxy

This feature enables clients that have manual web proxy enabled in the browser to facilitate authentication with the controller. If the user's browser is configured with manual proxy settings with a configured port number as 8080 or 3128 and if the client requests any URL, the controller responds with a web page prompting the user to change the Internet proxy settings to automatically detect the proxy settings so that the browser's manual proxy settings information does not get lost. After enabling this settings, the user can get access to the network through the web authentication policy. This functionality is given for port 8080 and 3128 because these are the most commonly used ports for the web proxy server.

Note Webauth proxy redirect ports are not blocked via CPU ACL. If a CPU ACL is configured to block the port 8080, 3128, and one random port as part of webauth proxy configuration, then those ports are not blocked because the webauth rules take higher precedence than the CPU ACL rules, till the client is in webauth_req state.

A web browser has three types of Internet settings that can be configured by the user.

- Auto detect
- System Proxy
- Manual

In a manual proxy server configuration, the browser uses a proxy server's IP address and a port. If this configuration is enabled on the browser, the wireless client communicates with the destination proxy server's IP on the configured port. In a Web-Auth scenario, the controller does not listen to such proxy ports and the client would not able to establish a TCP connection with the controller. In effect, the user is unable to get any login page to authentication and get access to the network.

When a wireless client enters a web authenticated WLAN network, it tries to access a URL. If a manual proxy configuration is configured on the client's browser, all web traffic going out from the client will be destined to the proxy IP and port configured on the browser.

- A TCP connection is established between the client and the proxy server IP address that the controller proxies for.
- The client processes the DHCP response and obtains a JavaScript file from the controller. The script disables all proxy configurations on the client for that session.
- Any requests that are bypass the proxy configuration. The controller can then perform web-redirection, login, and authentication.
- When the client goes out of the network, and then back into its own network, a DHCP refresh occurs and the client continues to use the old proxy configuration configured on the browser.
- If the external DHCP server is used with webauth proxy, then DHCP option 252 must be configured on the DHCP server for that scope. The value of option 252 will have the format http://<virtual ip>/proxy.js. No extra configuration is needed for internal DHCP servers.

Using the GUI to Configure Web Auth Proxy

To configure web auth proxy using the controller GUI, follow these steps:

Step 1 Choose **Controller > General**

Step 2 Enable Web Auth Proxy by selecting **Enabled** from the **WebAuth Proxy Redirection Mode** from the drop-down menu.

Step 3 In the WebAuth Proxy Redirection Port text box, enter the port number of the web auth proxy .

This text box consists of the port numbers on which the controller listens to for web authentication proxy redirection. By default, the three ports 80, 8080, and 3128 are assumed. If you configured the web authentication redirection port to any port other than these values, you must specify that value.

Step 4 Click **Apply**.

Using the CLI to Configure Web Auth Proxy

To configure web auth proxy using the controller CLI, use the following commands:

- Enable web auth proxy redirection using the **config network web-auth proxy-redirect {enable | disable}**
- Set the web auth port number using the **config network web-auth port <*port-number*>**

  This parameter specifies the port numbers on which the controller listens to for web authentication proxy redirection. By default, the three ports 80, 8080, and 3128 are assumed. If you configured the web authentication redirection port to any port other than these values, you must specify that value.
- To see the current status of the web auth proxy configuration, use the **show network summary** or the **show running-config** command.

Detecting Active Exploits

The controller supports three active exploit alarms that serve as notifications of potential threats. They are enabled by default and therefore require no configuration on the controller.

- ASLEAP detection—The controller raises a trap event if an attacker launches a LEAP crack tool. The trap message is visible in the controller's trap log.
- Fake access point detection—The controller tweaks the fake access point detection logic to avoid false access point alarms in high-density access point environments.
- Honeypot access point detection—The controller raises a trap event if a rogue access point is using managed SSIDs (WLANs configured on the controller). The trap message is visible in the controller's trap log.

CHAPTER 7

Configuring WLANs

This chapter describes how to configure up to 512 WLANs for your Cisco UWN solution. It contains these sections:

WLAN Overview

The Cisco UWN solution can control up to 512 WLANs for lightweight access points. Each WLAN has a separate WLAN ID (1 through 512), a separate profile name, and a WLAN SSID. All controllers publish up to 16 WLANs to each connected access point, but you can create up to 512 WLANs and then selectively publish these WLANs (using access point groups) to different access points to better manage your wireless network.

Note Cisco 2106, 2112, and 2125 Controllers support only up to 16 WLANs.

Note All OfficeExtend access points should be in the same access point group, and that group should contain no more than 15 WLANs. A controller with OfficeExtend access points in an access point group publishes only up to 15 WLANs to each connected OfficeExtend access point because it reserves one WLAN for the personal SSID.

You can associate up to 16 WLANs with each access point group and assign specific access points to each group. Each access point advertises only the enabled WLANs that belong to its access point group. The access point does not advertise disabled WLANs in its access point group or WLANs that belong to another group. See the "Creating Access Point Groups" section on page 7-57 for more information on access point groups.

Note Controller software releases prior to 5.2 support up to only 16 WLANs. Cisco does not support downgrading the controller from software release 5.2 or later releases to a previous release because inconsistencies might occur for WLANs and wired guest LANs. As a result, you would need to reconfigure your WLAN, mobility anchor, and wired LAN configurations.

Note We recommend that you assign one set of VLANs for WLANs and a different set of VLANs for management interfaces to ensure that controllers properly route VLAN traffic.

Configuring WLANs

These sections describe how to configure WLANs:

Creating WLANs

This section describes how to create up to 512 WLANs using either the controller GUI or CLI.

You can configure WLANs with different Service Set Identifiers (SSIDs) or with the same SSID. An SSID identifies the specific wireless network that you want the controller to access.

The controller uses different attributes to differentiate between WLANs with the same SSID.

- WLANS with the same SSID and same L2 Policy cannot be created if the WLAN ID < 17.
- Two WLANs with ids greater than 17 having the same SSID and same L2 policy is allowed provided WLANS are added in different AP groups.

Note This requirement ensures that clients never detect the SSID present on the same access point radio.

When creating a WLAN with the same SSID, follow these guidelines and requirements:

- You must create a unique profile name for each WLAN.
- When multiple WLANs with the same SSID get assigned to the same AP radio, you must have a unique Layer 2 security policy so that clients can safely select between them.

WLANs with the same SSID must have unique Layer 2 security policies so that clients can make a WLAN selection based on information advertised in beacon and probe responses. The available Layer 2 security policies are as follows:

- None (open WLAN)
- Static WEP or 802.1X

Note Because static WEP and 802.1X are both advertised by the same bit in beacon and probe responses, they cannot be differentiated by clients. Therefore, they cannot both be used by multiple WLANs with the same SSID.

- CKIP
- WPA/WPA2

Note Although WPA and WPA2 cannot be used by multiple WLANs with the same SSID, you can configure two WLANs with the same SSID with WPA/TKIP with PSK and WPA (Wi-Fi Protected Access) /TKIP (Temporal Key Integrity Protocol) with 802.1X, respectively, or with WPA/TKIP with 802.1X or WPA/AES with 802.1X, respectively.

Caution Some clients might not be able to connect to WLANs properly if they detect the same SSID with multiple security policies. Use this feature with care.

Note The OEAP 600 Series access point supports a maximum of two WLANs and one remote LAN. If you have configured more than two WLANs and one remote LAN, you can assign the 600 Series access point to an AP group. The support for two WLANs and one remote LAN still applies to the AP Group If the 600 Series OEAP is in the default group, the WLAN or remote LAN IDs must be lower than 8.

Cisco Flex 7500 Series Controller does not support the 802.1x security variants on a centrally switched WLAN. For example, the following configurations are not allowed on a centrally switched WLAN:

- WPA1/WPA2 with 802.1x AKM
- WPA1/WPA2 with CCKM
- Dynamic-WEP
- Conditional webauth
- Splash WEB page redirect

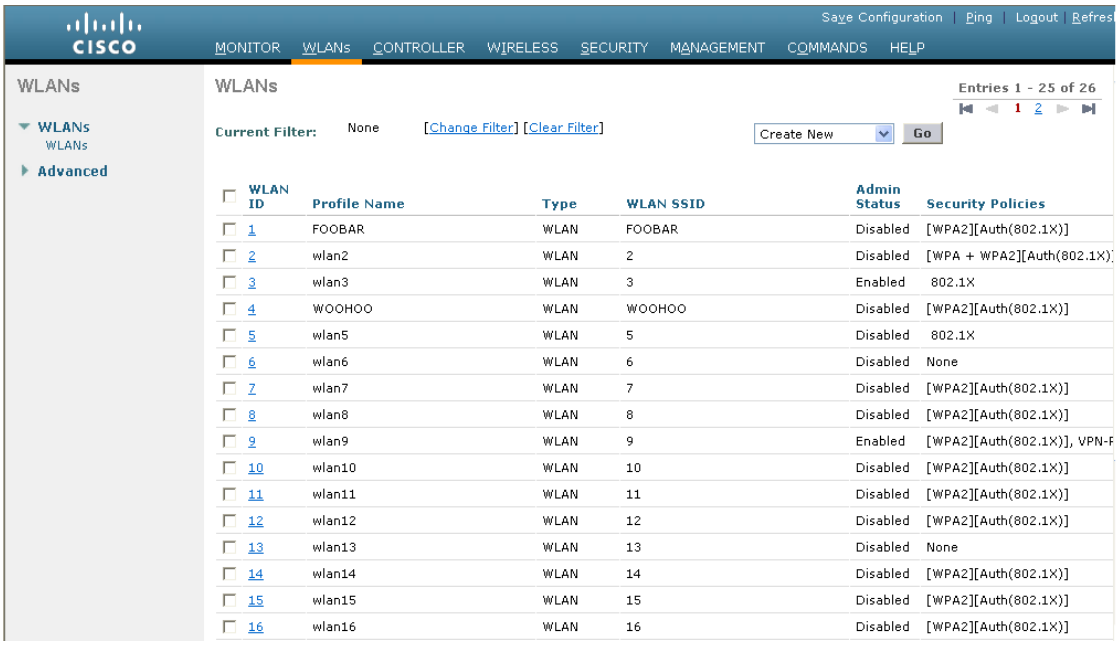
If you want to configure your WLAN in any of the above combinations, the WLAN must be configured to use local switching.

Using the GUI to Create WLANs

To create WLANs using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page (see Figure 7-1).

Figure 7-1 WLANs Page



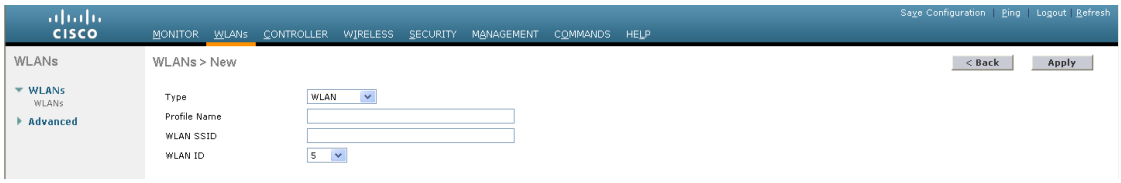
This page lists all of the WLANs currently configured on the controller. For each WLAN, you can see its WLAN ID, profile name, type, SSID, status, and security policies.

The total number of WLANs appears in the upper right-hand corner of the page. If the list of WLANs spans multiple pages, you can access these pages by clicking the page number links.

Note If you want to delete a WLAN, hover your cursor over the blue drop-down arrow for that WLAN and choose **Remove**, or select the check box to the left of the WLAN, choose **Remove Selected** from the drop-down list, and click **Go**. A message appears asking you to confirm your decision. If you proceed, the WLAN is removed from any access point group to which it is assigned and from the access point's radio.

Step 2 Create a new WLAN by choosing **Create New** from the drop-down list and clicking **Go**. The WLANs > New page appears (see Figure 7-2).

Figure 7-2 WLANs > New Page



Note When you upgrade to controller software release 5.2 or later releases, the controller creates the default-group access point group and automatically populates it with the first 16 WLANs (WLANs with IDs 1 through 16, or fewer if 16 WLANs are not configured). This default group cannot be modified (you cannot add WLANs to it nor delete WLANs from it). It is dynamically updated whenever the first 16 WLANs are added or deleted. If an access point does not belong to an access point group, it is assigned to the default group and uses the WLANs in that group. If an access point joins the controller with an undefined access point group name, the access point keeps its group name but uses the WLANs in the default-group access point group.

Step 3 From the Type drop-down list, choose **WLAN** to create a WLAN.

Note If you want to create a guest LAN for wired guest users, choose **Guest LAN** and follow the instructions in the "Configuring Wired Guest Access" section on page 11-27.

Step 4 In the Profile Name text box, enter up to 32 alphanumeric characters for the profile name to be assigned to this WLAN. The profile name must be unique.

Step 5 In the WLAN SSID text box, enter up to 32 alphanumeric characters for the SSID to be assigned to this WLAN.

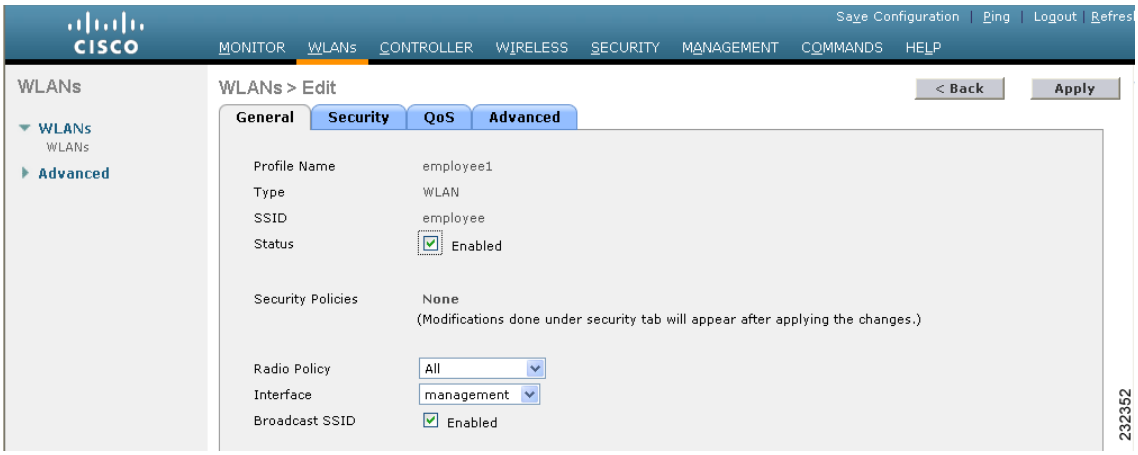
Step 6 From the WLAN ID drop-down list, choose the ID number for this WLAN.

Note If the Cisco OEAP 600 is in the default group, the WLAN/Remote LAN IDs need to be set as lower than ID 8.

Step 7 Click **Apply** to commit your changes. The WLANs > Edit page appears (see Figure 7-3).

Note You can also open the WLANs > Edit page from the WLANs page by clicking the ID number of the WLAN that you want to edit.

Figure 7-3 WLANs > Edit Page



Step 8 Use the parameters on the General, Security, QoS, and Advanced tabs to configure this WLAN. See the sections in the rest of this chapter for instructions on configuring specific features for WLANs.

Step 9 On the General tab, select the **Status** check box to enable this WLAN. Be sure to leave it unselected until you have finished making configuration changes to the WLAN.

Note You can also enable or disable WLANs from the WLANs page by selecting the check boxes to the left of the WLANs that you want to enable or disable, choosing **Enable Selected** or **Disable Selected** from the drop-down list, and clicking **Go**.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Create WLANs

Use these commands to create WLANs using the controller CLI:

- View the list of existing WLANs and to see whether they are enabled or disabled by entering this command:

  show wlan summary

- Create a new WLAN by entering this command:

  config wlan create *wlan_id* {*profile_name* | *foreign_ap*} *ssid*

Note If you do not specify an *ssid*, the *profile_name* parameter is used for both the profile name and the SSID.

Note When WLAN 1 is created in the configuration wizard, it is created in enabled mode. Disable it until you have finished configuring it. When you create a new WLAN using the **config wlan create** command, it is created in disabled mode. Leave it disabled until you have finished configuring it.

Note If you want to create a guest LAN for wired guest users, follow the instructions in the "Configuring Wired Guest Access" section on page 11-27.

- Disable a WLAN (for example, before making any modifications to a WLAN) by entering this command:

  config wlan disable {*wlan_id* | *foreign_ap* | **all**}

  where

  - *wlan_id* is a WLAN ID between 1 and 512.
  - *foreign_ap* is a third-party access point.
  - **all** is all WLANs.

  Note If the management and AP-manager interfaces are mapped to the same port and are members of the same VLAN, you must disable the WLAN before making a port-mapping change to either interface. If the management and AP-manager interfaces are assigned to different VLANs, you do not need to disable the WLAN.

- Enable a WLAN (for example, after you have finished making configuration changes to the WLAN) by entering this command:

  config wlan enable {*wlan_id* | *foreign_ap* | **all**}

  Note If the command fails, an error message appears (for example, "Request failed for wlan 10 - Static WEP key size does not match 802.1X WEP key size").

- Delete a WLAN by entering this command:

  config wlan delete {*wlan_id* | *foreign_ap*}

  Note An error message appears if you try to delete a WLAN that is assigned to an access point group. If you proceed, the WLAN is removed from the access point group and from the access point's radio.

Using the GUI to Search WLANs

You can search for specific WLANs in the list of up to 512 WLANs on the WLANs page. This feature is especially useful if your WLANs span multiple pages, preventing you from viewing them all at once.

To search for WLANs using the controller GUI, follow these steps:

Step 1 On the WLANs page, click **Change Filter**. The Search WLANs dialog box appears (see Figure 7-4).

Figure 7-4 Search WLANs Dialog Box

Step 2 Perform one of the following:

- To search for WLANs based on profile name, select the **Profile Name** check box and enter the desired profile name in the edit box.
- To search for WLANs based on SSID, select the **SSID** check box and enter the desired SSID in the edit box.
- To search for WLANs based on their status, select the **Status** check box and choose **Enabled** or **Disabled** from the drop-down list.

Step 3 Click **Find**. Only the WLANs that match your search criteria appear on the WLANs page, and the Current Filter field at the top of the page specifies the search criteria used to generate the list (for example, None, Profile Name:user1, SSID:test1, Status: disabled).

Note To clear any configured search criteria and display the entire list of WLANs, click **Clear Filter**.

Configuring the Maximum Number of Clients per WLAN

You can set a limit to the number of clients that can connect to a WLAN, which is useful in scenarios where you have a limited number of clients that can connect to a controller. For example, consider a scenario where the controller can serve up to 256 clients on a WLAN and these clients can be shared between enterprise users (employees) and guest users. You can set a limit on the number of guest clients that can access a given WLAN. The number of clients that you can configure per WLAN depends on the platform that you are using.

Note The maximum number of clients per WLAN feature is not supported when you use hybrid REAP local authentication.

Note The maximum number of clients per WLAN feature is supported only for access points that are in connected mode.

Table 7-1 describes the number of clients that you can configure for a given platform.

Table 7-1 Maximum Clients per Platform.

Platform	Maximum Number of Clients
Cisco 2106 Series Controller	350
Cisco 2500 Series Controller	500
Cisco 4400 Series Controller	5000
Cisco 5500 Series Controller	7000
Cisco Flex 7500 Series Controller	20000
WiSM2	10000

Using the GUI to Configure the Maximum Number of Clients per WLAN

To configure the maximum number of clients per WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to limit the number of clients. The WLANs > Edit page appears.

Step 3 On the Advanced tab, enter the Maximum Allowed Clients text box.

See Table 7-1 for the maximum number of clients supported per platform.

Step 4 Click **Apply** to commit your changes.

Using the CLI to Configure the Maximum Number of Clients per WLAN

To configure the maximum number of clients per WLAN using the controller CLI, follow these steps:

Step 1 Determine the WLAN ID for which you want to configure the maximum clients by entering this command:

show wlan summary

Obtain the WLAN ID from the list.

Step 2 Configure the maximum number of clients per WLAN by entering this command:

config wlan max-associated-clients *max-clients wlanid*

See Table 7-1 for the maximum number of clients supported per platform.

Configuring DHCP

WLANs can be configured to use the same or different Dynamic Host Configuration Protocol (DHCP) servers or no DHCP server. Two types of DHCP servers are available: internal and external.

Internal DHCP Server

The controllers contain an internal DHCP server. This server is typically used in branch offices that do not already have a DHCP server. The wireless network generally contains 10 access points or fewer, with the access points on the same IP subnet as the controller. The internal server provides DHCP addresses to wireless clients, direct-connect access points, appliance-mode access points on the management interface, and DHCP requests that are relayed from access points. Only lightweight access points are supported. When you want to use the internal DHCP server, you must set the management interface IP address of the controller as the DHCP server IP address.

DHCP option 43 is not supported on the internal server. Therefore, the access point must use an alternative method to locate the management interface IP address of the controller, such as local subnet broadcast, DNS, priming, or over-the-air discovery.

Note See Chapter 8, "Controlling Lightweight Access Points," or the *Controller Deployment Guide* at this URL for more information on how access points find controllers:

http://www.cisco.com/en/US/products/ps6366/prod_technical_reference_list.html

Note An internal DHCP server pool will only serve the wireless clients of that controller, not clients of other controllers. Also, internal DHCP server can only serve wireless clients and not wired clients.

Note Starting in release 7.0.116.0 release, when the DHCP lease on the controller for internal DHCP server is cleared, the associated access points reboots.

External DHCP Servers

The operating system is designed to appear as a DHCP Relay to the network and as a DHCP server to clients with industry-standard external DHCP servers that support DHCP Relay, which means that each controller appears as a DHCP Relay agent to the DHCP server and as a DHCP server at the virtual IP address to wireless clients.

Because the controller captures the client IP address obtained from a DHCP server, it maintains the same IP address for that client during intra-controller, inter-controller, and inter-subnet client roaming.

DHCP Assignment

You can configure DHCP on a per-interface or per-WLAN basis. The preferred method is to use the primary DHCP server address assigned to a particular interface.

Per-Interface Assignment

You can assign DHCP servers for individual interfaces. The management interface, AP-manager interface, and dynamic interfaces can be configured for a primary and secondary DHCP server, and the service-port interface can be configured to enable or disable DHCP servers.

Note See Chapter 10, "Managing Controller Software and Configurations," for information on configuring the controller's interfaces.

Per-WLAN Assignment

You can also define a DHCP server on a WLAN. This server will override the DHCP server address on the interface assigned to the WLAN.

Security Considerations

For enhanced security, we recommend that you require all clients to obtain their IP addresses from a DHCP server. To enforce this requirement, all WLANs can be configured with a DHCP Addr. Assignment Required setting, which disallows client static IP addresses. If DHCP Addr. Assignment Required is selected, clients must obtain an IP address via DHCP. Any client with a static IP address is not be allowed on the network. The controller monitors DHCP traffic because it acts as a DHCP proxy for the clients.

Note WLANs that support management over wireless must allow management (device-servicing) clients to obtain an IP address from a DHCP server. See the "Using Management over Wireless" section on page 6-58 for instructions on configuring management over wireless.

If slightly less security is tolerable, you can create WLANs with DHCP Addr. Assignment Required disabled. Clients then have the option of using a static IP address or obtaining an IP address from a designated DHCP server.

Note DHCP Addr. Assignment Required is not supported for wired guest LANs.

You are also allowed to create separate WLANs with DHCP Addr. Assignment Required disabled and then define the primary/secondary DHCP server as 0.0.0.0 on the interface assigned to the WLAN. These WLANs drop all DHCP requests and force clients to use a static IP address. These WLANs do not support management over wireless connections.

Note See Chapter 4, "Configuring Controller Settings," for instructions on globally configuring DHCP proxy.

Note If you want to specify a static IP address for an access point rather than having one assigned automatically by a DHCP server, see the "Configuring a Static IP Address on a Lightweight Access Point" section on page 8-66 for more information.

This section provides both GUI and CLI instructions for configuring DHCP.

Using the GUI to Configure DHCP

To configure DHCP using the controller GUI, follow these steps:

Step 1 Follow the instructions in the "Configuring the Management, AP-Manager, Virtual, and Service-Port Interfaces" section on page 3-11 or "Using the GUI to Configure Dynamic Interfaces" section on page 3-18 to configure a primary DHCP server for a management, AP-manager, or dynamic interface that will be assigned to the WLAN.

Note When you want to use the internal DHCP server, you must set the management interface IP address of the controller as the DHCP server IP address.

Step 2 Choose **WLANs** to open the WLANs page.

Step 3 Click the ID number of the WLAN for which you want to assign an interface. The WLANs > Edit (General) page appears.

Step 4 On the General tab, unselect the **Status** check box and click **Apply** to disable the WLAN.

Step 5 Reclick the ID number of the WLAN.

Step 6 On the General tab, choose the interface for which you configured a primary DHCP server to be used with this WLAN from the Interface drop-down list.

Step 7 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page.

Step 8 If you want to define a DHCP server on the WLAN that will override the DHCP server address on the interface assigned to the WLAN, select the **DHCP Server Override** check box and enter the IP address of the desired DHCP server in the **DHCP Server IP Addr** text box. The default value for the check box is disabled.

Note The preferred method for configuring DHCP is to use the primary DHCP address assigned to a particular interface instead of the DHCP server override.

Note DHCP Server override is applicable only for the default group.

Note If a WLAN has the DHCP server override option enabled and the controller has DHCP proxy enabled, any interface mapped to the WLAN must have a DHCP server IP address or the WLAN must be configured with a DHCP server IP address.

Note The diagnostic channel enables you to troubleshoot problems regarding client communication with a WLAN. You can use the controller GUI or CLI to enable the diagnostic channel. When the diagnostic channel is "enabled" for a WLAN, the other two fields "DHCP Address Assignment Required" and "DHCP override" fields are also enabled automatically. You can use the controller GUI or CLI to disable the diagnostic channel, the two DHCP fields need to be disabled manually if you are using the GUI and if you are disabling using the CLI, the two DHCP fields gets automatically disabled.

Step 9 If you want to require all clients to obtain their IP addresses from a DHCP server, select the **DHCP Addr. Assignment Required** check box. When this feature is enabled, any client with a static IP address is not allowed on the network. The default value is disabled.

Note DHCP Addr. Assignment Required is not supported for wired guest LANs.

Step 10 Click **Apply** to commit your changes.

Step 11 On the General tab, select the **Status** check box and click **Apply** to reenable the WLAN.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure DHCP

To configure DHCP using the controller CLI, follow these steps:

Step 1 Follow the instructions in the "Configuring the Management, AP-Manager, Virtual, and Service-Port Interfaces" section on page 3-11 or "Using the GUI to Configure Dynamic Interfaces" section on page 3-18 to configure a primary DHCP server for a management, AP-manager, or dynamic interface that will be assigned to the WLAN.

Step 2 Disable the WLAN by entering this command:

config wlan disable *wlan_id*

Step 3 Specify the interface for which you configured a primary DHCP server to be used with this WLAN by entering this command:

config wlan interface *wlan_id interface_name*

Step 4 If you want to define a DHCP server on the WLAN that will override the DHCP server address on the interface assigned to the WLAN, enter this command:

config wlan dhcp_server *wlan_id dhcp_server_ip_address*

Note The preferred method for configuring DHCP is to use the primary DHCP address assigned to a particular interface instead of the DHCP server override. If you enable the override, you can use the **show wlan** command to verify that the DHCP server has been assigned to the WLAN.

Note If a WLAN has the DHCP server override option enabled and the controller has DHCP proxy enabled, any interface mapped to the WLAN must have a DHCP server IP address or the WLAN must be configured with a DHCP server IP address.

Step 5 Reenable the WLAN by entering this command:

config wlan enable *wlan_id*

Using the CLI to Debug DHCP

Use these CLI commands to obtain debug information:

- **debug dhcp packet** {**enable** | **disable**}—Enables or disables debugging of DHCP packets.
- **debug dhcp message** {**enable** | **disable**}—Enables or disables debugging of DHCP error messages.
- **debug dhcp service-port** {**enable** | **disable**}—Enables or disables debugging of DHCP packets on the service port.

Configuring DHCP Scopes

Controllers have built-in DHCP relay agents. However, when you desire network segments that do not have a separate DHCP server, the controllers can have built-in DHCP scopes that assign IP addresses and subnet masks to wireless clients. Typically, one controller can have one or more DHCP scopes that each provide a range of IP addresses.

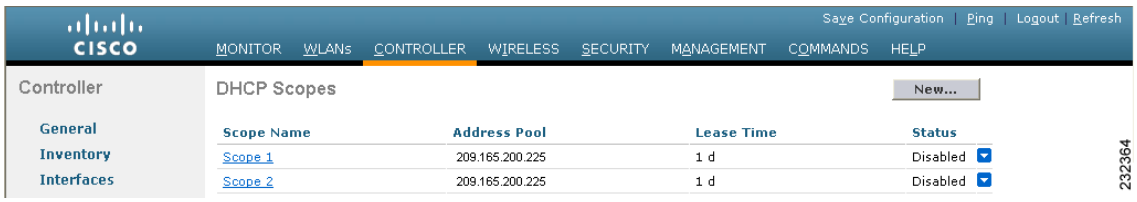
DHCP scopes are needed for internal DHCP to work. Once DHCP is defined on the controller, you can then point the primary DHCP server IP address on the management, AP-manager, and dynamic interfaces to the controller's management interface. You can configure up to 16 DHCP scopes using the controller GUI or CLI.

Using the GUI to Configure DHCP Scopes

To configure DHCP scopes using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Internal DHCP Server** > **DHCP Scope** to open the DHCP Scopes page (see Figure 7-5).

Figure 7-5 DHCP Scopes Page



This page lists any DHCP scopes that have already been configured.

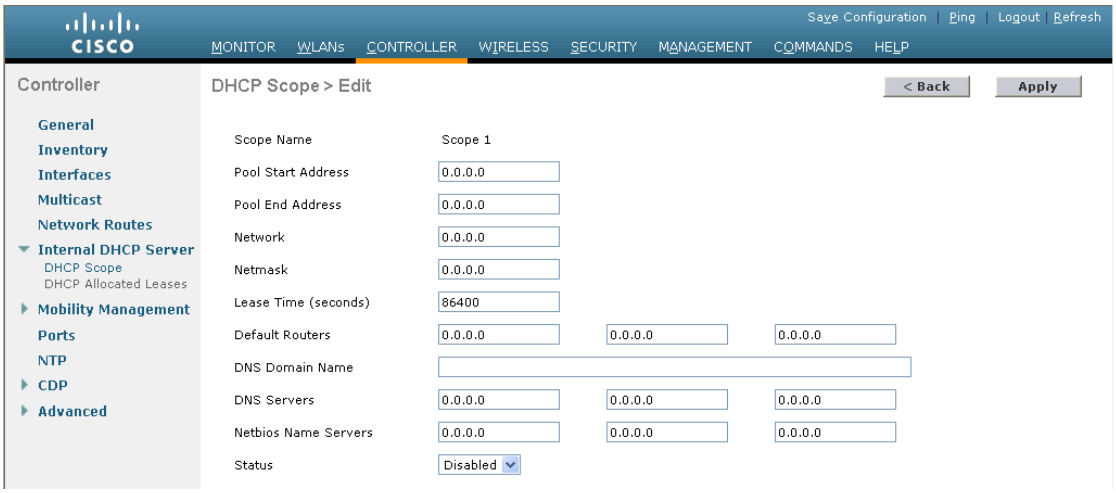
Note If you ever want to delete an existing DHCP scope, hover your cursor over the blue drop-down arrow for that scope and choose **Remove**.

Step 2 Click **New** to add a new DHCP scope. The DHCP Scope > New page appears.

Step 3 In the Scope Name text box, enter a name for the new DHCP scope.

Step 4 Click **Apply**. When the DHCP Scopes page reappears, click the name of the new scope. The DHCP Scope > Edit page appears (see Figure 7-6).

Figure 7-6 DHCP Scope > Edit Page



Step 5 In the Pool Start Address text box, enter the starting IP address in the range assigned to the clients.

Note This pool must be unique for each DHCP scope and must not include the static IP addresses of routers or other servers.

Step 6 In the Pool End Address text box, enter the ending IP address in the range assigned to the clients.

Note This pool must be unique for each DHCP scope and must not include the static IP addresses of routers or other servers.

Step 7 In the Network text box, enter the network served by this DHCP scope. This IP address is used by the management interface with Netmask applied, as configured on the Interfaces page.

Step 8 In the Netmask text box, enter the subnet mask assigned to all wireless clients.

Step 9 In the Lease Time text box, enter the amount of time (from 0 to 65536 seconds) that an IP address is granted to a client.

Step 10 In the Default Routers text box, enter the IP address of the optional router connecting the controllers. Each router must include a DHCP forwarding agent, which allows a single controller to serve the clients of multiple controllers.

Step 11 In the DNS Domain Name text box, enter the optional domain name system (DNS) domain name of this DHCP scope for use with one or more DNS servers.

Step 12 In the DNS Servers text box, enter the IP address of the optional DNS server. Each DNS server must be able to update a client's DNS entry to match the IP address assigned by this DHCP scope.

Step 13 In the Netbios Name Servers text box, enter the IP address of the optional Microsoft Network Basic Input Output System (NetBIOS) name server, such as the Internet Naming Service (WINS) server.

Step 14 From the Status drop-down list, choose **Enabled** to enable this DHCP scope or choose **Disabled** to disable it.

Step 15 Click **Apply** to commit your changes.

Step 16 Click **Save Configuration** to save your changes.

Step 17 Choose **DHCP Allocated Leases** to see the remaining lease time for wireless clients. The DHCP Allocated Lease page appears (see Figure 7-7), showing the MAC address, IP address, and remaining lease time for the wireless clients.

Figure 7-7 DHCP Allocated Lease Page

Using the CLI to Configure DHCP Scopes

To configure DHCP scopes using the controller CLI, follow these steps:

Step 1 Create a new DHCP scope by entering this command:

config dhcp create-scope *scope*

Note If you ever want to delete a DHCP scope, enter this command: **config dhcp delete-scope** *scope*.

Step 2 Specify the starting and ending IP address in the range assigned to the clients by entering this command:

config dhcp address-pool *scope start end*

Note This pool must be unique for each DHCP scope and must not include the static IP addresses of routers or other servers.

Step 3 Specify the network served by this DHCP scope (the IP address used by the management interface with the Netmask applied) and the subnet mask assigned to all wireless clients by entering this command:

config dhcp network *scope network netmask*

Step 4 Specify the amount of time (from 0 to 65536 seconds) that an IP address is granted to a client by entering this command:

config dhcp lease *scope lease_duration*

Step 5 Specify the IP address of the optional router connecting the controllers by entering this command:

config dhcp default-router *scope router_1* [*router_2*] [*router_3*]

Each router must include a DHCP forwarding agent, which allows a single controller to serve the clients of multiple controllers.

Step 6 Specify the optional domain name system (DNS) domain name of this DHCP scope for use with one or more DNS servers by entering this command:

config dhcp domain *scope domain*

Step 7 Specify the IP address of the optional DNS server(s) by entering this command:

config dhcp dns-servers *scope dns1* [*dns2*] [*dns3*]

Each DNS server must be able to update a client's DNS entry to match the IP address assigned by this DHCP scope

Step 8 Specify the IP address of the optional Microsoft Network Basic Input Output System (NetBIOS) name server, such as the Internet Naming Service (WINS) server by entering this command:

config dhcp netbios-name-server *scope wins1* [*wins2*] [*wins3*]

Step 9 Enable or disable this DHCP scope by entering this command:

config dhcp {**enable** | **disable**} *scope*

Step 10 Save your changes by entering this command:

save config

Step 11 See the list of configured DHCP scopes by entering this command:

show dhcp summary

Information similar to the following appears:

```
Scope Name            Enabled           Address Range
Scope 1                 No          0.0.0.0 -> 0.0.0.0
Scope 2                 No          0.0.0.0 -> 0.0.0.0
```

Step 12 Display the DHCP information for a particular scope by entering this command:

show dhcp *scope*

Information similar to the following appears:

```
Enabled..................................... No
Lease Time.................................. 0
Pool Start.................................. 0.0.0.0
Pool End.................................... 0.0.0.0
Network..................................... 0.0.0.0
Netmask..................................... 0.0.0.0
Default Routers............................. 0.0.0.0 0.0.0.0 0.0.0.0
DNS Domain.................................
DNS......................................... 0.0.0.0 0.0.0.0 0.0.0.0
Netbios Name Servers........................ 0.0.0.0 0.0.0.0 0.0.0.0
```

Configuring MAC Filtering for WLANs

When you use MAC filtering for client or administrator authorization, you need to enable it at the WLAN level first. If you plan to use local MAC address filtering for any WLAN, use the commands in this section to configure MAC filtering for a WLAN.

Enabling MAC Filtering

Use these commands to enable MAC filtering on a WLAN:

- Enable MAC filtering by entering the **config wlan mac-filtering enable** *wlan_id* command.
- Verify that you have MAC filtering enabled for the WLAN by entering the **show wlan** command.

When you enable MAC filtering, only the MAC addresses that you add to the WLAN are allowed to join the WLAN. MAC addresses that have not been added are not allowed to join the WLAN.

Creating a Local MAC Filter

Controllers have built-in MAC filtering capability, similar to that provided by a RADIUS authorization server.

Use these commands to add MAC addresses to a WLAN MAC filter:

- Create a MAC filter entry on the controller by entering the **config macfilter add** *mac_addr wlan_id* [*interface_name*] [*description*] [*IP_addr*] command.

  The following parameters are optional:

  - *mac_addr*—MAC address of the client.
  - *wlan_id*—WLAN id on which the client is associating.
  - *interface_name*—The name of the interface. This interface name is used to override the interface configured to the WLAN.

  Note You must have AAA enabled on the WLAN to override the interface name.

  - *description*—A brief description of the interface in double quotes (for example, “Interface1”).
  - *IP_addr*—The IP address which is used for a passive client with the MAC address specified by the *mac addr* value above.
- Assign an IP address to an existing MAC filter entry, if one was not assigned in the **config macfilter add** command by entering the **config macfilter ip-address** *mac_addr IP_addr* command.
- Verify that MAC addresses are assigned to the WLAN by entering the **show macfilter** command.

Configuring a Timeout for Disabled Clients

You can configure a timeout for disabled clients. Clients who fail to authenticate three times when attempting to associate are automatically disabled from further association attempts. After the timeout period expires, the client is allowed to retry authentication until it associates or fails authentication and is excluded again. Use these commands to configure a timeout for disabled clients:

- Configure the timeout for disabled clients by entering the **config wlan exclusionlist** *wlan_id timeout* command. Enter a timeout from **1** to **65535** seconds, or enter **0** to permanently disable the client.
- Verify the current timeout by entering the **show wlan** command.

Assigning WLANs to Interfaces

Use these commands to assign a WLAN to an interface:

- Assign a WLAN to an interface by entering this command:

  config wlan interface {*wlan_id* | **foreignAp**} *interface_id*

  - Use the *interface_id* option to assign the WLAN to a specific interface.
  - Use the **foreignAp** option to use a third-party access point.
- Verify the interface assignment status by entering the **show wlan summary** command.

Configuring the DTIM Period

In 802.11a/n and 802.11b/g/n networks, lightweight access points broadcast a beacon at regular intervals, which coincides with the Delivery Traffic Indication Map (DTIM). After the access point broadcasts the beacon, it transmits any buffered broadcast and multicast frames based on the value set for the DTIM period. This feature allows power-saving clients to wake up at the appropriate time if they are expecting broadcast or multicast data.

Typically, the DTIM value is set to 1 (transmit broadcast and multicast frames after every beacon) or 2 (transmit after every other beacon). For instance, if the beacon period of the 802.11a/n or 802.11b/g/n network is 100 ms and the DTIM value is set to 1, the access point transmits buffered broadcast and multicast frames 10 times per second. If the beacon period is 100 ms and the DTIM value is set to 2, the access point transmits buffered broadcast and multicast frames 5 times per second. Either of these settings may be suitable for applications, including VoIP, that expect frequent broadcast and multicast frames.

However, the DTIM value can be set as high as 255 (transmit broadcast and multicast frames after every 255th beacon) if all 802.11a/n or 802.11b/g/n clients have power save enabled. Because the clients have to listen only when the DTIM period is reached, they can be set to listen for broadcasts and multicasts less frequently, resulting in a longer battery life. For instance, if the beacon period is 100 ms and the DTIM value is set to 100, the access point transmits buffered broadcast and multicast frames once every 10 seconds, allowing the power-saving clients to sleep longer before they have to wake up and listen for broadcasts and multicasts, resulting in a longer battery life.

Note The beacon period in controllers is listed in terms of milliseconds. The beacon period can also be measured in time units, where one time unit equals 1024 microseconds or 102.4 milliseconds. If a beacon interval is listed as 100 milliseconds in a controller, it is only a rounded off value for 102.4 milliseconds. Due to hardware limitation in certain radios, even though the beacon interval is, say 100 time units, it is adjusted to 102 time units, which roughly equals 1044.48 milliseconds. When the beacon period is to be represented in terms of time units, the value is adjusted to the nearest multiple of 17.

Many applications cannot tolerate a long time between broadcast and multicast messages, which results in poor protocol and application performance. We recommend a low DTIM value for 802.11a/n and 802.11b/g/n networks that support such clients.

In controller software release 5.0 or later releases, you can configure the DTIM period for the 802.11a/n and 802.11b/g/n radio networks on specific WLANs. In previous software releases, the DTIM period was configured per radio network only, not per WLAN. The benefit of this change is that now you can configure a different DTIM period for each WLAN. For example, you might want to set different DTIM values for voice and data WLANs.

Note When you upgrade the controller software to release 5.0 or later releases, the DTIM period that was configured for a radio network is copied to all of the existing WLANs on the controller.

Using the GUI to Configure the DTIM Period

To configure the DTIM period for a WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

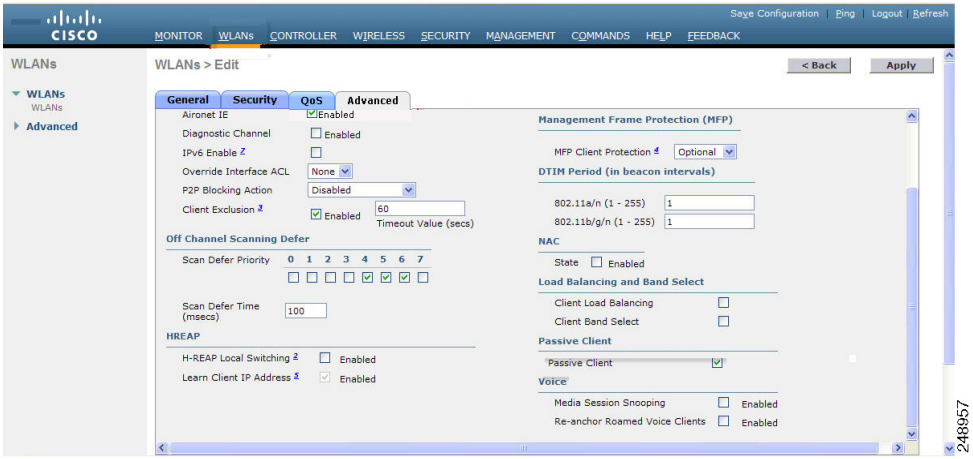
Step 2 Click the ID number of the WLAN for which you want to configure the DTIM period.

Step 3 Unselect the **Status** check box to disable the WLAN.

Step 4 Click **Apply** to commit your changes.

Step 5 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 7-8).

Figure 7-8 WLANs > Edit (Advanced) Page



Step 6 Under DTIM Period, enter a value between 1 and 255 (inclusive) in the 802.11a/n and 802.11b/g/n text boxes. The default value is 1 (transmit broadcast and multicast frames after every beacon).

Step 7 Click **Apply** to commit your changes.

Step 8 Choose the **General** tab to open the WLANs > Edit (General) page.

Step 9 Select the **Status** check box to reenable the WLAN.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Configure the DTIM Period

To configure the DTIM period for a WLAN using the controller CLI, follow these steps:

Step 1 Disable the WLAN by entering this command:

config wlan disable *wlan_id*

Step 2 Configure the DTIM period for either the 802.11a/n or 802.11b/g/n radio network on a specific WLAN by entering this command:

config wlan dtim {**802.11a** | **802.11b**} *dtim wlan_id*

where *dtim* is a value between 1 and 255 (inclusive). The default value is 1 (transmit broadcast and multicast frames after every beacon).

Step 3 Reenable the WLAN by entering this command:

config wlan enable *wlan_id*

Step 4 Save your changes by entering this command:

save config

Step 5 Verify the DTIM period by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... employee1
Network Name (SSID).............................. employee
Status........................................... Enabled
...
DTIM period for 802.11a radio..................... 1
DTIM period for 802.11b radio..................... 1
Local EAP Authentication..................... Disabled
...
```

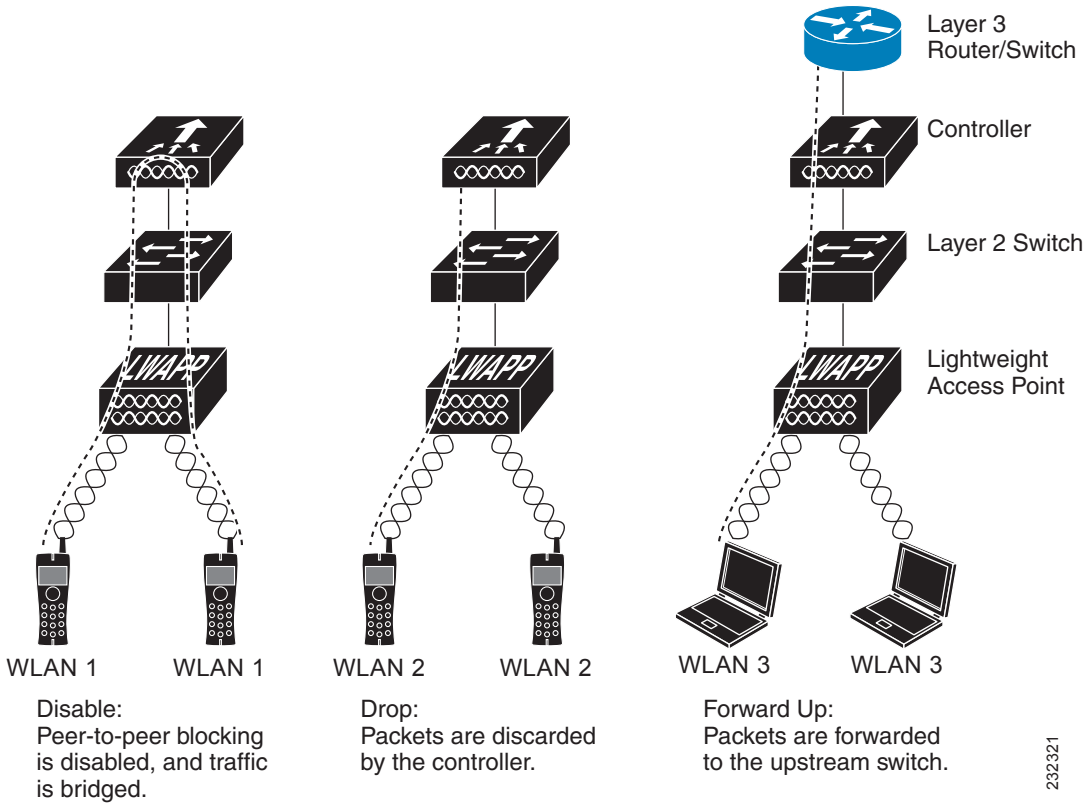
Configuring Peer-to-Peer Blocking

In controller software releases prior to 4.2, peer-to-peer blocking is applied globally to all clients on all WLANs and causes traffic between two clients on the same VLAN to be transferred to the upstream VLAN rather than being bridged by the controller. This behavior usually results in traffic being dropped at the upstream switch because switches do not forward packets out the same port on which they are received.

In controller software release 4.2 or later releases, peer-to-peer blocking is applied to individual WLANs, and each client inherits the peer-to-peer blocking setting of the WLAN to which it is associated. In software release 4.2 or later releases, you also have more control over how traffic is directed. For example, you can choose to have traffic bridged locally within the controller, dropped by the controller, or forwarded to the upstream VLAN. Figure 7-9 shows each option.

Note Peer-to-peer blocking will not work across the clients in different WLANs which are mapped to the same VLAN. For example, if WLAN-1 and WLAN-2 are mapped to the same interface say VLAN-1, then peer-to-peer blocking will not work. The WLAN-1 + WLAN-2 are configured with peer-to-peer blocking action in the WLAN as DROP. Clients in WLAN-1 will not be able to pass the traffic to clients in WLAN-2.

Figure 7-9 Peer-to-Peer Blocking Examples



Guidelines for Using Peer-to-Peer Blocking

Follow these guidelines when using peer-to-peer blocking:

- In controller software releases prior to 4.2, the controller forwards Address Resolution Protocol (ARP) requests upstream (just like all other traffic). In controller software release 4.2 or later releases, ARP requests are directed according to the behavior set for peer-to-peer blocking.
- Peer-to-peer blocking does not apply to multicast traffic.
- Locally switched hybrid-REAP WLANs and hybrid-REAP access points in standalone mode do not support peer-to-peer blocking.
- If you upgrade to controller software release 4.2 or later releases from a previous release that supports global peer-to-peer blocking, each WLAN is configured with the peer-to-peer blocking action of forwarding traffic to the upstream VLAN.

Using the GUI to Configure Peer-to-Peer Blocking

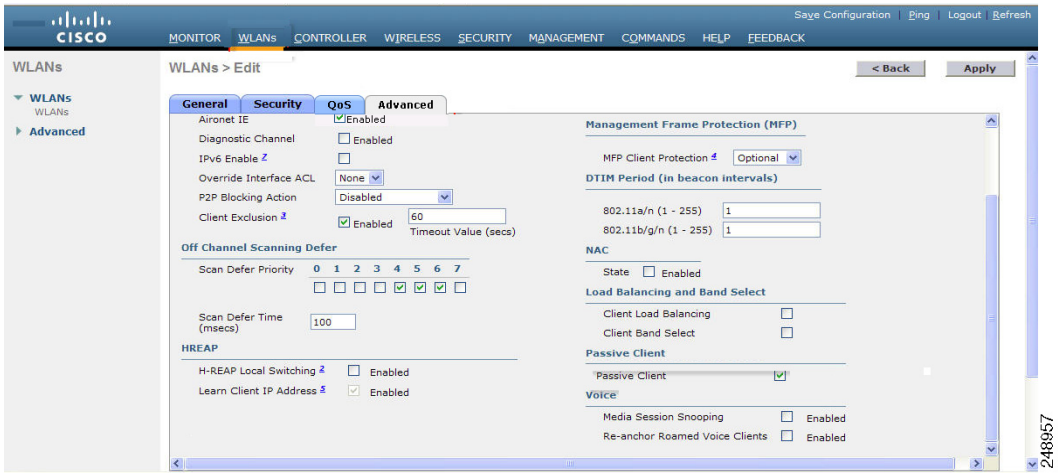
To configure a WLAN for peer-to-peer blocking using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure peer-to-peer blocking.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 7-10).

Figure 7-10 WLANs > Edit (Advanced) Page



Step 4 Choose one of the following options from the P2P Blocking drop-down list:

- **Disabled**—Disables peer-to-peer blocking and bridges traffic locally within the controller whenever possible. This is the default value.

Note Traffic is never bridged across VLANs in the controller.

- **Drop**—Causes the controller to discard the packets.
- **Forward-UpStream**—Causes the packets to be forwarded on the upstream VLAN. The device above the controller decides what action to take regarding the packets.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure Peer-to-Peer Blocking

To configure a WLAN for peer-to-peer blocking using the controller CLI, follow these steps:

Step 1 Configure a WLAN for peer-to-peer blocking by entering this command:

config wlan peer-blocking {**disable** | **drop** | **forward-upstream**} *wlan_id*

Note See the description of each parameter in the "Using the GUI to Configure Peer-to-Peer Blocking" section above.

Step 2 Save your changes by entering this command:

save config

Step 3 See the status of peer-to-peer blocking for a WLAN by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.............................. 1
Profile Name................................. test
Network Name (SSID).......................... test
Status....................................... Enabled
...
...
...
Peer-to-Peer Blocking Action................. Disabled
Radio Policy................................. All
Local EAP Authentication..................... Disabled
```

Configuring Layer 2 Security

This section describes how to assign Layer 2 security settings to WLANs.

Static WEP Keys

Controllers can control static WEP keys across access points. Use these commands to configure static WEP for WLANs:

- Disable the 802.1X encryption by entering this command:

  config wlan security 802.1X disable *wlan_id*

- Configure 40/64-bit or 104/128-bit WEP keys by entering this command:

  config wlan security static-wep-key encryption *wlan_id* {**40** | **104**} {**hex** | **ascii**} *key key_index*

  - Use the **40** or **104** option to specify 40/64-bit or 104/128-bit encryption. The default setting is 104/128.
  - Use the **hex** or **ascii** option to specify the character format for the WEP key.
  - Enter 10 hexadecimal digits (any combination of 0-9, a-f, or A-F) or five printable ASCII characters for 40-bit/64-bit WEP keys or enter 26 hexadecimal or 13 ASCII characters for 104-bit/128-bit keys.
  - Enter a key index (sometimes called a *key slot*). The default value is 0, which corresponds to a key index of 1; the valid values are 0 to 3 (key index of 1 to 4).

Dynamic 802.1X Keys and Authorization

Controllers can control 802.1X dynamic WEP keys using Extensible Authentication Protocol (EAP) across access points and support 802.1X dynamic key settings for WLANs.

Note To use LEAP with lightweight access points and wireless clients, make sure to choose **Cisco-Aironet** as the RADIUS server type when configuring the CiscoSecure Access Control Server (ACS).

- Check the security settings of each WLAN by entering this command:

  show wlan *wlan_id*

  The default security setting for new WLANs is 802.1X with dynamic keys enabled. To maintain robust Layer 2 security, leave 802.1X configured on your WLANs.

- Disable or enable the 802.1X authentication by entering this command:

config wlan security 802.1X {**enable** | **disable**} *wlan_id*

After you enable 802.1X authentication, the controller sends EAP authentication packets between the wireless client and the authentication server. This command allows all EAP-type packets to be sent to and from the controller.

- Change the 802.1X encryption level for a WLAN by entering this command:

  config wlan security 802.1X encryption *wlan_id* [**0** | **40** | **104**]

  - Use the **0** option to specify no 802.1X encryption.
  - Use the **40** option to specify 40/64-bit encryption.
  - Use the **104** option to specify 104/128-bit encryption. (This is the default encryption setting.)

Configuring a WLAN for Both Static and Dynamic WEP

You can configure up to four WLANs to support static WEP keys, and you can also configure dynamic WEP on any of these static-WEP WLANs. Follow these guidelines when configuring a WLAN for both static and dynamic WEP:

- The static WEP key and the dynamic WEP key must be the same length.
- When you configure both static and dynamic WEP as the Layer 2 security policy, no other security policies can be specified. That is, you cannot configure web authentication. However, when you configure either static or dynamic WEP as the Layer 2 security policy, you can configure web authentication.

WPA1 and WPA2

Wi-Fi Protected Access (WPA or WPA1) and WPA2 are standards-based security solutions from the Wi-Fi Alliance that provide data protection and access control for wireless LAN systems. WPA1 is compatible with the IEEE 802.11i standard but was implemented prior to the standard's ratification; WPA2 is the Wi-Fi Alliance's implementation of the ratified IEEE 802.11i standard.

By default, WPA1 uses Temporal Key Integrity Protocol (TKIP) and message integrity check (MIC) for data protection while WPA2 uses the stronger Advanced Encryption Standard encryption algorithm using Counter Mode with Cipher Block Chaining Message Authentication Code Protocol (AES-CCMP). Both WPA1 and WPA2 use 802.1X for authenticated key management by default. However, these options are also available:

- 802.1X—The standard for wireless LAN security, as defined by IEEE, is called *802.1X for 802.11*, or simply *802.1X*. An access point that supports 802.1X acts as the interface between a wireless client and an authentication server, such as a RADIUS server, to which the access point communicates over the wired network. If 802.1X is selected, only 802.1X clients are supported.
- PSK—When you choose PSK (also known as *WPA preshared key* or *WPA passphrase*), you need to configure a preshared key (or a passphrase). This key is used as the pairwise master key (PMK) between the clients and the authentication server.
- CCKM—Cisco Centralized Key Management (CCKM) uses a fast rekeying technique that enables clients to roam from one access point to another without going through the controller, typically in under 150 milliseconds (ms). CCKM reduces the time required by the client to mutually authenticate with the new access point and derive a new session key during reassociation. CCKM fast secure roaming ensures that there is no perceptible delay in time-sensitive applications such as wireless Voice over IP (VoIP), enterprise resource planning (ERP), or Citrix-based solutions. CCKM is a CCXv4-compliant feature. If CCKM is selected, only CCKM clients are supported.

When CCKM is enabled, the behavior of access points differs from the controller's for fast roaming in the following ways:

- If an association request sent by a client has CCKM enabled in a Robust Secure Network Information Element (RSN IE) but CCKM IE is not encoded and only PMKID is encoded in RSN IE, then the controller does not do a full authentication. Instead, the controller validates the PMKID and does a four-way handshake.
- If an association request sent by a client has CCKM enabled in RSN IE but CCKM IE is not encoded and only PMKID is encoded in RSN IE, then AP does a full authentication. The access point does not use PMKID sent with the association request when CCKM is enabled in RSN IE.

Note The OEAP 600 series does not support fast roaming for clients. Dual mode voice clients will experience reduced call quality when they roam between the two spectrums on OEAP602 access point. We recommend that you configure voice devices to only connect on one band, either 2.4 GHz or 5.0 GHz.

Note The 4.2 or later release of controller software supports CCX versions 1 through 5. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. The controller stores the CCX version of the client in its client database and uses it to limit client functionality. Clients must support CCXv4 or v5 in order to use CCKM. See the "Configuring Cisco Client Extensions" section on page 7-52 for more information on CCX.

- 802.1X+CCKM—During normal operation, 802.1X-enabled clients mutually authenticate with a new access point by performing a complete 802.1X authentication, including communication with the main RADIUS server. However, when you configure your WLAN for 802.1X and CCKM fast secure roaming, CCKM-enabled clients securely roam from one access point to another without the need to reauthenticate to the RADIUS server. 802.1X+CCKM is considered optional CCKM because both CCKM and non-CCKM clients are supported when this option is selected.

On a single WLAN, you can allow WPA1, WPA2, and 802.1X/PSK/CCKM/802.1X+CCKM clients to join. All of the access points on such a WLAN advertise WPA1, WPA2, and 802.1X/PSK/CCKM/802.1X+CCKM information elements in their beacons and probe responses. When you enable WPA1 and/or WPA2, you can also enable one or two *ciphers*, or cryptographic algorithms, designed to protect data traffic. Specifically, you can enable AES and/or TKIP data encryption for WPA1 and/or WPA2. TKIP is the default value for WPA1, and AES is the default value for WPA2.

You can configure WPA1+WPA2 through either the GUI or the CLI.

Using the GUI to Configure WPA1+WPA2

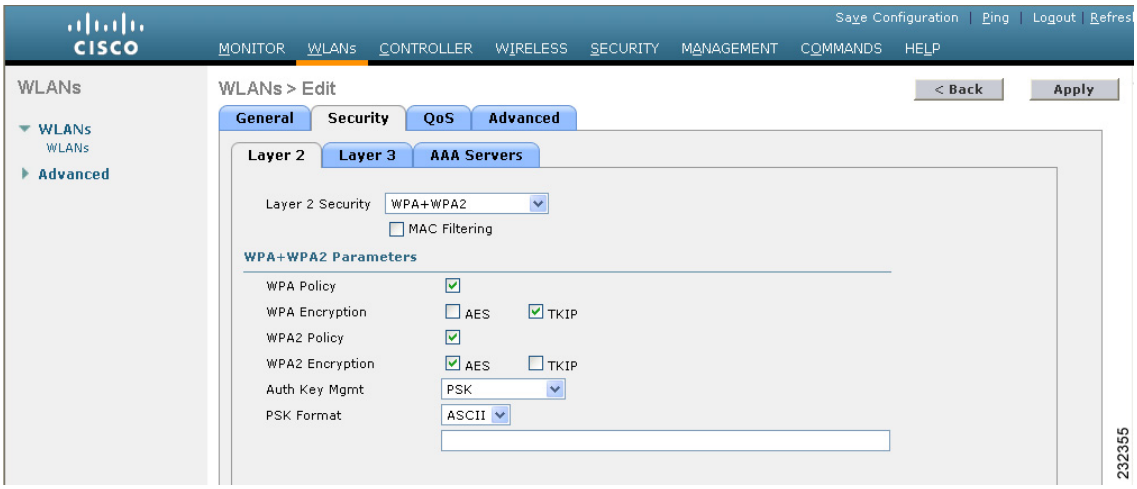
To configure a WLAN for WPA1+WPA2 using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Security** and **Layer 2** tabs to open the WLANs > Edit (Security > Layer 2) page (see Figure 7-11).

Figure 7-11 WLANs > Edit (Security > Layer 2) Page



Step 4 Choose **WPA+WPA2** from the Layer 2 Security drop-down list.

Step 5 Under WPA+WPA2 Parameters, select the **WPA Policy** check box to enable WPA1, select the **WPA2 Policy** check box to enable WPA2, or select both check boxes to enable both WPA1 and WPA2.

Note The default value is disabled for both WPA1 and WPA2. If you leave both WPA1 and WPA2 disabled, the access points advertise in their beacons and probe responses information elements only for the authentication key management method that you choose in Step 7.

Step 6 Select the **AES** check box to enable AES data encryption or the **TKIP** check box to enable TKIP data encryption for WPA1, WPA2, or both. The default values are TKIP for WPA1 and AES for WPA2.

Step 7 Choose one of the following key management methods from the Auth Key Mgmt drop-down list: **802.1X**, **CCKM**, **PSK**, or **802.1X+CCKM**.

Note Cisco OEAP 600 does not support CCKM. You must choose either 802.1X or PSK.

Note For Cisco OEAP 600, the TKIP and AES security encryption settings must be identical for WPA and WPA2.

Step 8 If you chose PSK in Step 7, choose **ASCII** or **HEX** from the PSK Format drop-down list and then enter a preshared key in the blank text box. WPA preshared keys must contain 8 to 63 ASCII text characters or 64 hexadecimal characters.

Step 9 Click **Apply** to commit your changes.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Configure WPA1+WPA2

To configure a WLAN for WPA1+WPA2 using the controller CLI, follow these steps:

Step 1 Disable the WLAN by entering this command:

config wlan disable *wlan_id*

Step 2 Enable or disable WPA for the WLAN by entering this command:

config wlan security wpa {**enable** | **disable**} *wlan_id*

Step 3 Enable or disable WPA1 for the WLAN by entering this command:

config wlan security wpa wpa1 {**enable** | **disable**} *wlan_id*

Step 4 Enable or disable WPA2 for the WLAN by entering this command:

config wlan security wpa wpa2 {**enable** | **disable**} *wlan_id*

Step 5 Enable or disable AES or TKIP data encryption for WPA1 or WPA2 by entering one of these commands:

- **config wlan security wpa wpa1 ciphers** {**aes** | **tkip**} {**enable** | **disable**} *wlan_id*
- **config wlan security wpa wpa2 ciphers** {**aes** | **tkip**} {**enable** | **disable**} *wlan_id*

The default values are TKIP for WPA1 and AES for WPA2.

Step 6 Enable or disable 802.1X, PSK, or CCKM authenticated key management by entering this command:

config wlan security wpa akm {**802.1X** | **psk** | **cckm**} {**enable** | **disable**} *wlan_id*

The default value is 802.1X.

Step 7 If you enabled PSK in Step 6, enter this command to specify a preshared key:

config wlan security wpa akm psk set-key {**ascii** | **hex**} *psk-key wlan_id*

WPA preshared keys must contain 8 to 63 ASCII text characters or 64 hexadecimal characters.

Step 8 If you enabled WPA2 with 802.1X authenticated key management or WPA1 or WPA2 with CCKM authenticated key management, the PMK cache lifetime timer is used to trigger reauthentication with the client when necessary. The timer is based on the timeout value received from the AAA server or the WLAN session timeout setting. To see the amount of time remaining before the timer expires, enter this command:

show pmk-cache all

Information similar to the following appears:

```
PMK-CCKM Cache
                          Entry
Type        Station       Lifetime   VLAN Override        IP Override
------  ------------------ --------   ------------------   ---------------
CCKM    00:07:0e:b9:3a:1b  150                        0.0.0.0
```

If you enabled WPA2 with 802.1X authenticated key management, the controller supports opportunistic PMKID caching but not sticky (or non-opportunistic) PMKID caching. In sticky PMKID caching, the client stores multiple PMKIDs. This approach is not practical because it requires full authentication for each new access point and is not guaranteed to work in all conditions. In contrast, opportunistic PMKID caching stores only one PMKID per client and is not subject to the limitations of sticky PMK caching.

Step 9 Enable the WLAN by entering this command:

config wlan enable *wlan_id*

Step 10 Save your settings by entering this command:

save config

CKIP

Cisco Key Integrity Protocol (CKIP) is a Cisco-proprietary security protocol for encrypting 802.11 media. CKIP improves 802.11 security in infrastructure mode using key permutation, a message integrity check (MIC), and a message sequence number. Software release 4.0 or later releases support CKIP with a static key. For this feature to operate correctly, you must enable Aironet information elements (IEs) for the WLAN.

A lightweight access point advertises support for CKIP in beacon and probe response packets by adding an Aironet IE and setting one or both of the CKIP negotiation bits (key permutation and multi-modular hash message integrity check [MMH MIC]). Key permutation is a data encryption technique that uses the basic encryption key and the current initialization vector (IV) to create a new key. MMH MIC prevents bit-flip attacks on encrypted packets by using a hash function to compute message integrity code.

The CKIP settings specified in a WLAN are mandatory for any client attempting to associate. If the WLAN is configured for both CKIP key permutation and MMH MIC, the client must support both. If the WLAN is configured for only one of these features, the client must support only the CKIP feature.

CKIP requires that 5-byte and 13-byte encryption keys be expanded to 16-byte keys. The algorithm to perform key expansion occurs at the access point. The key is appended to itself repeatedly until the length reaches 16 bytes. All lightweight access points support CKIP.

You can configure CKIP through either the GUI or the CLI.

Using the GUI to Configure CKIP

To configure a WLAN for CKIP using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Advanced** tab.

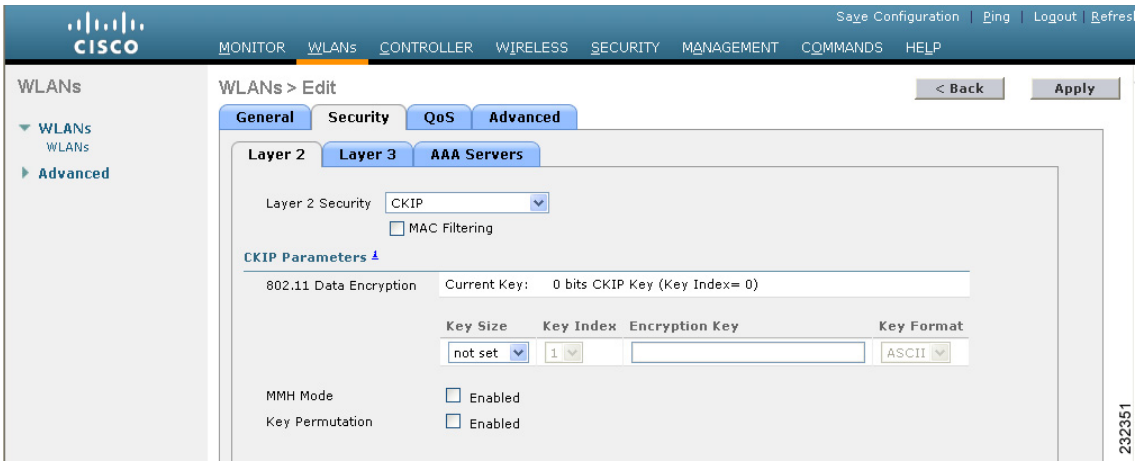
Step 4 Select the **Aironet IE** check box to enable Aironet IEs for this WLAN and click **Apply**.

Step 5 Choose the **General** tab.

Step 6 Unselect the **Status** check box, if selected, to disable this WLAN and click **Apply**.

Step 7 Choose the **Security** and **Layer 2** tabs to open the WLANs > Edit (Security > Layer 2) page (see Figure 7-12).

Figure 7-12 WLANs > Edit (Security > Layer 2) Page



Step 8 Choose **CKIP** from the Layer 2 Security drop-down list.

Step 9 Under CKIP Parameters, choose the length of the CKIP encryption key from the Key Size drop-down list.The range is Not Set, 40 bits, or 104 bits and the default is Not Set.

Step 10 Choose the number to be assigned to this key from the Key Index drop-down list. You can configure up to four keys.

Step 11 From the Key Format drop-down list, choose **ASCII** or **HEX** and then enter an encryption key in the Encryption Key text box. 40-bit keys must contain 5 ASCII text characters or 10 hexadecimal characters. 104-bit keys must contain 13 ASCII text characters or 26 hexadecimal characters.

Step 12 Select the **MMH Mode** check box to enable MMH MIC data protection for this WLAN. The default value is disabled (or unselected).

Step 13 Select the **Key Permutation** check box to enable this form of CKIP data protection. The default value is disabled (or unselected).

Step 14 Click **Apply** to commit your changes.

Step 15 Choose the **General** tab.

Step 16 Select the **Status** check box to enable this WLAN.

Step 17 Click **Apply** to commit your changes.

Step 18 Click **Save Configuration** to save your changes.

Using the CLI to Configure CKIP

To configure a WLAN for CKIP using the controller CLI, follow these steps:

Step 1 Disable the WLAN by entering this command:

config wlan disable *wlan_id*

Step 2 Enable Aironet IEs for this WLAN by entering this command:

config wlan ccx aironet-ie enable *wlan_id*

Step 3 Enable or disable CKIP for the WLAN by entering this command:

config wlan security ckip {**enable** | **disable**} *wlan_id*

Step 4 Specify a CKIP encryption key for the WLAN by entering this command:

config wlan security ckip akm psk set-key *wlan_id* {**40** | **104**} {**hex** | **ascii**} *key key_index*

Step 5 Enable or disable CKIP MMH MIC for the WLAN by entering this command:

config wlan security ckip mmh-mic {**enable** | **disable**} *wlan_id*

Step 6 Enable or disable CKIP key permutation for the WLAN by entering this command:

config wlan security ckip kp {**enable** | **disable**} *wlan_id*

Step 7 Enable the WLAN by entering this command:

config wlan enable *wlan_id*

Step 8 Save your settings by entering this command:

save config

Configuring a Session Timeout

Using the controller GUI or CLI, you can configure a session timeout for wireless clients on a WLAN. The session timeout is the maximum time for a client session to remain active before requiring reauthorization.

Using the GUI to Configure a Session Timeout

To configure a session timeout for wireless clients on a WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to assign a session timeout.

Step 3 When the WLANs > Edit page appears, choose the **Advanced** tab. The WLANs > Edit (Advanced) page appears.

Step 4 Select the **Enable Session Timeout** check box to configure a session timeout for this WLAN. Otherwise, unselect the check box. The default value is selected.

In the Session Timeout text box, enter a value between 300 and 86400 seconds to specify the duration of the client session. The default value is 1800 seconds for the following Layer 2 security types: 802.1X, Static WEP+802.1X, WPA+WPA2 with 802.1X, CCKM, or 802.1X+CCKM authentication key management and 0 seconds for all other Layer 2 security types (Open WLAN/CKIP/Static WEP). A value of 0 is equivalent to no timeout.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure a Session Timeout

To configure a session timeout for wireless clients on a WLAN using the controller CLI, follow these steps:

Step 1 Configure a session timeout for wireless clients on a WLAN by entering this command:

config wlan session-timeout *wlan_id timeout*

The default value is 1800 seconds for the following Layer 2 security types: 802.1X, Static WEP+802.1X, WPA+WPA2 with 802.1X, CCKM, or 802.1X+CCKM authentication key management and 0 seconds for all other Layer 2 security types (Open WLAN/CKIP/Static WEP). A value of 0 is equivalent to no timeout.

Step 2 Save your changes by entering this command:

save config

Step 3 See the current session timeout value for a WLAN by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 9
Profile Name..................................... test12
Network Name (SSID).............................. test12
...
Number of Active Clients......................... 0
Exclusionlist Timeout............................ 60 seconds
Session Timeout.................................. 1800 seconds
...
```

Configuring Layer 3 Security

This section describes how to configure Layer 3 security settings for a WLAN on the controller.

Note
- Layer 2 Tunnel Protocol (L2TP) and IPsec are not supported on controllers that run software release 4.0 or later releases.
- Layer 3 security settings are not supported when you disable the client IP address on a WLAN.

VPN Passthrough

The controller supports VPN passthrough or the “passing through” of packets that originate from VPN clients. An example of VPN passthrough is your laptop trying to connect to the VPN server at your corporate office.

Note The VPN Passthrough option is not available on Cisco 5500 Series and Cisco 2100 Series Controllers. However, you can replicate this functionality on a Cisco 5500 or 2100 Series Controller by creating an open WLAN using an ACL.

Using the GUI to Configure VPN Passthrough

To configure a WLAN for VPN passthrough using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure VPN passthrough. The WLANs > Edit page appears.

Step 3 Choose the **Security** and **Layer 3** tabs to open the WLANs > Edit (Security > Layer 3) page.

Step 4 From the Layer 3 Security drop-down list, choose **VPN Pass-Through**.

Step 5 In the VPN Gateway Address text box, enter the IP address of the gateway router that is terminating the VPN tunnels initiated by the client and passed through the controller.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your settings.

Using the CLI to Configure VPN Passthrough

Configure a WLAN for VPN passthrough using the controller CLI by entering this command:

- **config wlan security passthru** {**enable** | **disable**} *wlan_id gateway*

  For *gateway*, enter the IP address of the router that is terminating the VPN tunnel.

Verify that the passthrough is enabled by entering this command:

- **show wlan**

Web Authentication

WLANs can use web authentication only if VPN passthrough is not enabled on the controller. Web authentication is simple to set up and use and can be used with SSL to improve the overall security of the WLAN.

Note Web authentication is supported only with these Layer 2 security policies: open authentication, open authentication+WEP, and WPA-PSK. It is not supported for use with 802.1X.

Note The controller supports web authentication redirects only to HTTP (HTTP over TCP) servers. It does not support web authentication redirects to HTTPS (HTTP over SSL) servers.

Note If the CPU ACL's are configured to block HTTP / HTTPS traffic, after the successful web login authentication, there could be a failure in the redirection page.

Note Before enabling web authentication, make sure that all proxy servers are configured for ports other than port 53.

Note When you enable web authentication for a WLAN, a message appears indicating that the controller forwards DNS traffic to and from wireless clients prior to authentication. We recommend that you have a firewall or intrusion detection system (IDS) behind your guest VLAN to regulate DNS traffic and to prevent and detect any DNS tunneling attacks.

If the web authentication is enabled on the WLAN and you also have the CPU ACL rules, the client-based web authentication rules take higher precedence as long as the client is unauthenticated (in the webAuth_Reqd state). Once the client goes to the RUN state, the CPU ACL rules get applied. Therefore, if the CPU ACL rules are enabled in the controller, an allow rule for the virtual interface IP is required (in any direction) with the following conditions:

- When the CPU ACL does not have an allow ACL rule for both directions.
- When an allow ALL rule exists, but also a DENY rule for port 443 or 80 of higher precedence.

The allow rule for the virtual IP should be for TCP protocol and port 80 (if secureweb is disabled) or port 443 (if secureweb is enabled). This process is required to allow client's access to the virtual interface IP address, post successful authentication when the CPU ACL rules are in place.

Note When clients connect to a WebAuth SSID and a preauthorization ACL configured to allow VPN users, the clients will get disconnected from the SSID every few minutes. Webauth SSIDs must not connect without authenticating on the web page.

Using the GUI to Configure Web Authentication

To configure a WLAN for web authentication using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure web authentication. The WLANs > Edit page appears.

Step 3 Choose the **Security** and **Layer 3** tabs to open the WLANs > Edit (Security > Layer 3) page.

Step 4 Select the **Web Policy** check box.

Step 5 Make sure that the **Authentication** option is selected.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your settings.

Step 8 See Chapter 11, "Managing User Accounts," for more information on using web authentication.

Using the CLI to Configure Web Authentication

To configure a WLAN for web authentication using the controller CLI, follow these steps:

Step 1 Enable or disable web authentication on a particular WLAN by entering this command:

config wlan security web-auth {**enable** | **disable**} *wlan_id*

Step 2 Release the guest user IP address when the web authentication policy timer expires and prevent the guest user from acquiring an IP address for 3 minutes by entering this command:

config wlan webauth-exclude *wlan_id* {**enable** | **disable**}

The default value is disabled. This command is applicable when you configure the internal DHCP scope on the controller. By default, when the web authentication timer expires for a guest user, the user can immediately reassociate to the same IP address before another guest user can acquire it. If there are many guest users or limited IP addresses in the DHCP pool, some guest users might not be able to acquire an IP address.

When you enable this feature on the guest WLAN, the guest user's IP address is released when the web authentication policy timer expires and the guest user is excluded from acquiring an IP address for 3 minutes. The IP address is available for another guest user to use. After 3 minutes, the excluded guest user can reassociate and acquire an IP address, if available.

Step 3 See the status of web authentication by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... cj
Network Name (SSID).............................. cj
Status........................................... Disabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Network Admission Control

  NAC-State...................................... Disabled
  Quarantine VLAN................................ 0
Number of Active Clients......................... 0
Exclusionlist Timeout............................ 60 seconds
Session Timeout.................................. 1800 seconds
CHD per WLAN..................................... Enabled
Webauth DHCP exclusion........................... Disabled
Interface........................................ management
WLAN ACL......................................... unconfigured
DHCP Server...................................... Default
DHCP Address Assignment Required................. Disabled
...
Web Based Authentication......................... Disabled
Web-Passthrough.................................. Disabled
...
```

Step 4 For more information on using web authentication, see Chapter 11, "Managing User Accounts."

Configuring a Fallback Policy with MAC Filtering and Web Authentication

You can configure a fallback policy mechanism that combines Layer 2 and Layer 3 security. In a scenario where you have both MAC filtering and web authentication implemented, when a client tries to connect to a WLAN using the MAC filter (RADIUS server), if the client fails the authentication, you can configure the authentication to fall back to web authentication. When a client passes the MAC filter authentication, the web authentication is skipped and the client is connected to the WLAN. With this feature, you can avoid disassociations based on only a MAC filter authentication failure.

Using the GUI to Configure a Fallback Policy with MAC Filtering and Web Authentication

To configure a fallback policy with MAC filtering and web authentication on a WLAN using the controller GUI, follow these steps:

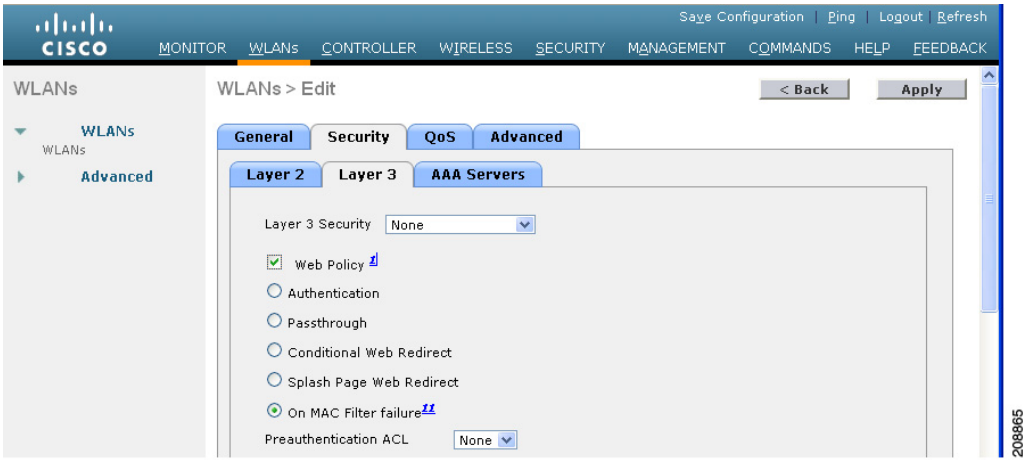
Note Before configuring a fallback policy, you must have MAC filtering enabled. To know more about how to enable MAC filtering, see the "Configuring MAC Filtering for WLANs" section on page 7-17.

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure the fallback policy for web authentication. The WLANs > Edit page appears.

Step 3 Choose the **Security** and **Layer 3** tabs to open the WLANs > Edit (Security > Layer 3) page (see Figure 7-13).

Figure 7-13 WLANs > Edit (Security > Layer 3) Page



Step 4 From the Layer 3 Security drop-down list, choose **None**.

Step 5 Select the **Web Policy** check box.

Note The controller forwards DNS traffic to and from wireless clients prior to authentication.

The following options are displayed:

- Authentication
- Passthrough
- Conditional Web Redirect
- Splash Page Web Redirect
- On MAC Filter Failure

Step 6 Click **On MAC Filter Failure**.

Step 7 Click **Apply** to commit your changes.

Step 8 Click **Save Configuration** to save your settings.

Using the CLI to Configure a Fallback Policy with MAC Filtering and Web Authentication

To configure a fallback policy with MAC filtering and web authentication on a WLAN using the controller CLI, follow these steps:

Note Before configuring a fallback policy , you must have MAC filtering enabled. To know more about how to enable MAC filtering, see the "Configuring MAC Filtering for WLANs" section on page 7-17

Step 1 Enable or disable web authentication on a particular WLAN by entering this command:

config wlan security web-auth on-macfilter-failure *wlan-id*

Step 2 See the web authentication status by entering this command:

show wlan *wlan_id*

```
FT Over-The-Ds mode.............................. Enabled
CKIP ..................................... Disabled
   IP Security.................................. Disabled
   IP Security Passthru......................... Disabled
   Web Based Authentication..................... Enabled-On-MACFilter-Failure
        ACL..................................... Unconfigured
        Web Authentication server precedence:
        1....................................... local
        2....................................... radius
        3....................................... ldap
```

Assigning a QoS Profile to a WLAN

Cisco UWN solution WLANs support four levels of QoS: Platinum/Voice, Gold/Video, Silver/Best Effort (default), and Bronze/Background. You can configure the voice traffic WLAN to use Platinum QoS, assign the low-bandwidth WLAN to use Bronze QoS, and assign all other traffic between the remaining QoS levels.

The WLAN QoS level defines a specific 802.11e user priority (UP) for over-the-air traffic. This UP is used to derive the over-the-wire priorities for non-WMM traffic, and it also acts as the ceiling when managing WMM traffic with various levels of priorities. The access point uses this QoS-profile-specific UP in accordance with the values in Table 7-2 to derive the IP DSCP value that is visible on the wired LAN.

Table 7-2 Access Point QoS Translation Values

AVVID Traffic Type	AVVID IP DSCP	QoS Profile	AVVID 802.1p	IEEE 802.11e UP
Network control	56 (CS7)	Platinum	7	7
Inter-network control (CAPWAP control, 802.11 management)	48 (CS6)	Platinum	6	7
Voice	46 (EF)	Platinum	5	6

Table 7-2 Access Point QoS Translation Values (continued)

AVVID Traffic Type	AVVID IP DSCP	QoS Profile	AVVID 802.1p	IEEE 802.11e UP
Interactive video	34 (AF41)	Gold	4	5
Mission critical	26 (AF31)	Gold	3	4
Transactional	18 (AF21)	Silver	2	3
Bulk data	10 (AF11)	Bronze	1	2
Best effort	0 (BE)	Silver	0	0
Scavenger	2	Bronze	0	1

You can assign a QoS profile to a WLAN using the controller GUI or CLI.

Using the GUI to Assign a QoS Profile to a WLAN

To assign a QoS profile to a WLAN using the controller GUI, follow these steps:

Step 1 If you have not already done so, configure one or more QoS profiles using the instructions in the "Using the GUI to Configure QoS Profiles" section on page 4-68.

Step 2 Choose **WLANs** to open the WLANs page.

Step 3 Click the ID number of the WLAN to which you want to assign a QoS profile.

Step 4 When the WLANs > Edit page appears, choose the **QoS** tab.

Step 5 From the Quality of Service (QoS) drop-down list, choose one of the following:

- **Platinum** (**voice**)
- **Gold** (**video**)
- **Silver** (**best effort**)
- **Bronze** (**background**)

Note Silver (best effort) is the default value.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Assign a QoS Profile to a WLAN

To assign a QoS profile to a WLAN using the controller CLI, follow these steps:

Step 1 If you have not already done so, configure one or more QoS profiles using the instructions in the "Using the CLI to Configure QoS Profiles" section on page 4-70.

Step 2 Assign a QoS profile to a WLAN by entering this command:

config wlan qos *wlan_id* {**bronze** | **silver** | **gold** | **platinum**}

Silver is the default value.

Step 3 Save your changes by entering this command:

save config

Step 4 Verify that you have properly assigned the QoS profile to the WLAN by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... test
Network Name (SSID).............................. test
Status........................................... Enabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Number of Active Clients......................... 0
Exclusionlist.................................... Disabled
Session Timeout.................................. 0
Interface........................................ management
WLAN ACL......................................... unconfigured
DHCP Server...................................... 1.100.163.24
DHCP Address Assignment Required................. Disabled
Quality of Service.............................. Silver (best effort)
WMM.............................................. Disabled
...
```

Configuring QoS Enhanced BSS

The QoS Enhanced Basis Service Set (QBSS) information element (IE) enables the access points to communicate their channel usage to wireless devices. Because access points with high channel usage might not be able to handle real-time traffic effectively, the 7921 or 7920 phone uses the QBSS value to determine if they should associate to another access point. You can enable QBSS in these two modes:

- Wi-Fi Multimedia (WMM) mode, which supports devices that meet the 802.11E QBSS standard (such as Cisco 7921 IP Phones)
- 7920 support mode, which supports Cisco 7920 IP Phones on your 802.11b/g network

  The 7920 support mode has two options:

  - Support for 7920 phones that require call admission control (CAC) to be configured on and advertised by the client device (these are typically older 7920 phones)
  - Support for 7920 phones that require CAC to be configured on and advertised by the access point (these are typically newer 7920 phones)

    When access point-controlled CAC is enabled, the access point sends out a Cisco proprietary CAC Information Element (IE) and does not send out the standard QBSS IE.

Note The OEAP 600 Series access points do not support CAC.

You can use the controller GUI or CLI to configure QBSS. QBSS is disabled by default.

Guidelines for Configuring QBSS

Follow these guidelines when configuring QBSS on a WLAN:

- 7920 phones are non-WMM phones with limited CAC functionality. The phones look at the channel utilization of the access point to which they are associated and compare that to a threshold that is beaconed by the access point. If the channel utilization is less than the threshold, the 7920 places a call. In contrast, 7921 phones are full-fledged WMM phones that use traffic specifications (TSPECs) to gain access to the voice queue before placing a phone call. The 7921 phones work well with load-based CAC, which uses the percentage of the channel set aside for voice and tries to limit the calls accordingly.

  Because 7921 phones support WMM and 7920 phones do not, capacity and voice quality problems can arise if you do not properly configure both phones when they are used in a mixed environment. To enable both 7921 and 7920 phones to co-exist on the same network, make sure that load-based CAC and 7920 AP CAC are both enabled on the controller and the WMM Policy is set to Allowed. These settings become particularly important if you have many more 7920 users than 7921 users.

Note See Chapter 4, "Configuring Controller Settings," for more information and configuration instructions for load-based CAC.

Additional Guidelines for Using Cisco 7921 and 7920 Wireless IP Phones

Follow these guidelines to use Cisco 7921 and 7920 Wireless IP Phones with controllers:

- Aggressive load balancing must be disabled for each controller. Otherwise, the initial roam attempt by the phone may fail, causing a disruption in the audio path.
- The Dynamic Transmit Power Control (DTPC) information element (IE) must be enabled using the **config 802.11b dtpc enable** command. The DTPC IE is a beacon and probe information element that allows the access point to broadcast information on its transmit power. The 7921 or 7920 phone uses this information to automatically adjust its transmit power to the same level as the access point to which it is associated. In this manner, both devices are transmitting at the same level.
- Both the 7921 and 7920 phones and the controllers support Cisco Centralized Key Management (CCKM) fast roaming.
- When configuring WEP, there is a difference in nomenclature for the controller and the 7921 or 7920 phone. Configure the controller for 104 bits when using 128-bit WEP for the 7921 or 7920.
- For standalone 7921 phones, load-based CAC must be enabled, and the WMM Policy must be set to Required on the WLAN.
- The controller supports traffic classification (TCLAS) coming from 7921 phones using firmware version 1.1.1. This feature ensures proper classification of voice streams to the 7921 phones.
- When using a 7921 phone with the 802.11a radio of a 1242 series access point, set the 24-Mbps data rate to Supported and choose a lower Mandatory data rate (such as 12 Mbps). Otherwise, the phone might experience poor voice quality.

Using the GUI to Configure QBSS

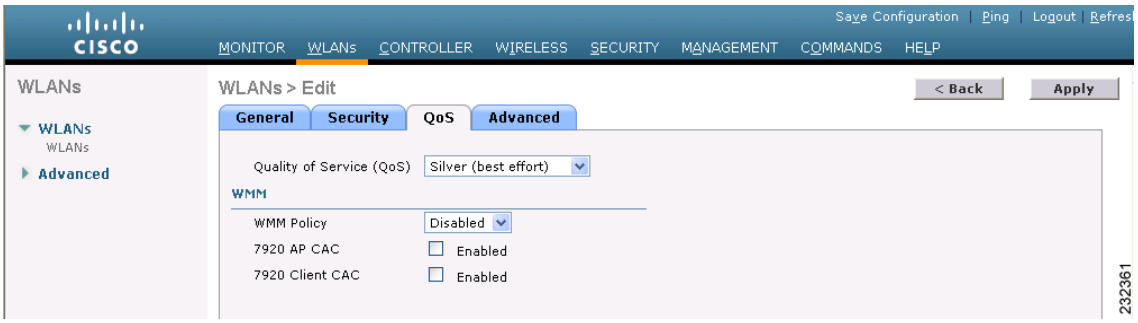
To configure QBSS using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure WMM mode.

Step 3 When the WLANs > Edit page appears, choose the **QoS** tab to open the WLANs > Edit (Qos) page (see Figure 7-14).

Figure 7-14 WLANs > Edit (QoS) Page



Step 4 From the WMM Policy drop-down list, choose one of the following options, depending on whether you want to enable WMM mode for 7921 phones and other devices that meet the WMM standard:

- **Disabled**—Disables WMM on the WLAN. This is the default value.
- **Allowed**—Allows client devices to use WMM on the WLAN.
- **Required**—Requires client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

Step 5 Select the **7920 AP CAC** check box if you want to enable 7920 support mode for phones that require access point-controlled CAC. The default value is unselected.

Step 6 Select the **7920 Client CAC** check box if you want to enable 7920 support mode for phones that require client-controlled CAC. The default value is unselected.

Note You cannot enable both WMM mode and client-controlled CAC mode on the same WLAN.

Step 7 Click **Apply** to commit your changes.

Step 8 Click **Save Configuration** to save your changes.

Using the CLI to Configure QBSS

To configure QBSS using the controller CLI, follow these steps:

Step 1 Determine the ID number of the WLAN to which you want to add QBSS support by entering this command:

show wlan summary

Step 2 Disable the WLAN by entering this command:

config wlan disable *wlan_id*

Step 3 Configure WMM mode for 7921 phones and other devices that meet the WMM standard by entering this command:

config wlan wmm {**disabled** | **allowed** | **required**} *wlan_id*

where

- **disabled** disables WMM mode on the WLAN.
- **allowed** allows client devices to use WMM on the WLAN.
- **required** requires client devices to use WMM. Devices that do not support WMM cannot join the WLAN.

Step 4 Enable or disable 7920 support mode for phones that require client-controlled CAC by entering this command:

config wlan 7920-support client-cac-limit {**enable** | **disable**} *wlan_id*

Note You cannot enable both WMM mode and client-controlled CAC mode on the same WLAN.

Step 5 Enable or disable 7920 support mode for phones that require access point-controlled CAC by entering this command:

config wlan 7920-support ap-cac-limit {**enable** | **disable**} *wlan_id*

Step 6 Reenable the WLAN by entering this command:

config wlan enable *wlan_id*

Step 7 Save your changes by entering this command:

save config

Step 8 Verify that the WLAN is enabled and the Dot11-Phone Mode (7920) text box is configured for compact mode by entering this command:

show wlan *wlan_id*

Configuring Media Session Snooping and Reporting

Controller software release 6.0 or later releases support Voice over IP (VoIP) Media Session Aware (MSA) snooping and reporting. This feature enables access points to detect the establishment, termination, and failure of Session Initiation Protocol (SIP) voice calls and then report them to the controller and WCS. VoIP snooping and reporting can be enabled or disabled for each WLAN.

When VoIP MSA snooping is enabled, the access point radios that advertise this WLAN look for SIP voice packets that comply with SIP RFC 3261. They do not look for non-RFC 3261-compliant SIP voice packets or Skinny Call Control Protocol (SCCP) voice packets. Any SIP packets destined to or originating from port number 5060 (the standard SIP signaling port) are considered for further inspection. The access points track when Wi-Fi Multimedia (WMM) and non-WMM clients are establishing a call, are already on an active call, or are in the process of ending a call. Upstream packet classification for both client types occurs at the access point. Downstream packet classification occurs at the controller for WMM clients and at the access point for non-WMM clients. The access points notify the controller and WCS of any major call events, such as call establishment, termination, and failure.

The controller provides detailed information for VoIP MSA calls. For failed calls, the controller generates a trap log with a timestamp and the reason for failure (in the GUI) and an error code (in the CLI) to aid in troubleshooting. For successful calls, the controller shows the number and duration of calls for usage tracking purposes. WCS displays failed VoIP call information in the Events page.

Using the GUI to Configure Media Session Snooping

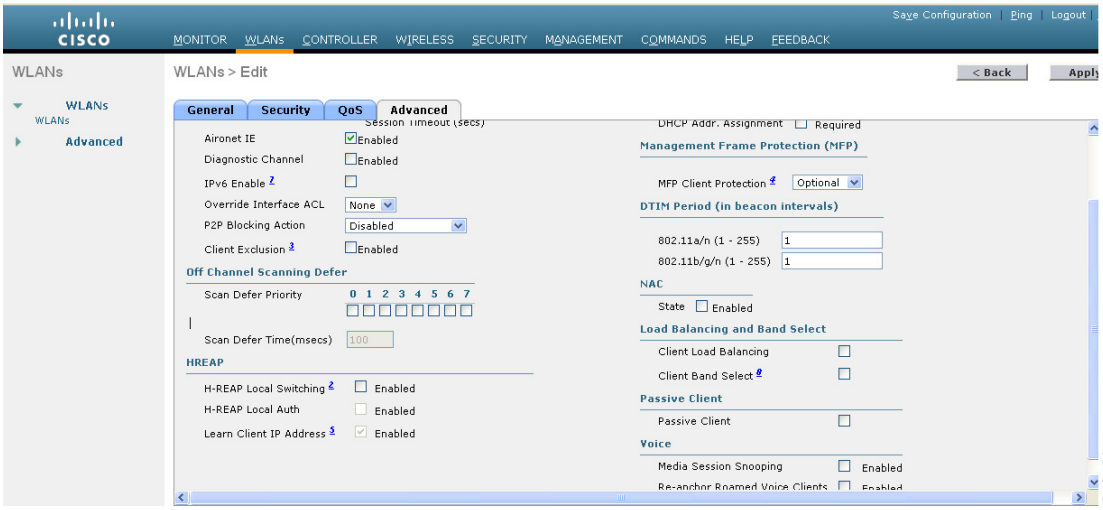
To configure media session snooping using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure media session snooping.

Step 3 When the WLANs > Edit page appears, choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 7-15).

Figure 7-15 WLANs > Edit (Advanced) Page



Step 4 Under the Voice, select the **Media Session Snooping** check box to enable media session snooping or unselect it to disable this feature. The default value is unselected.

Step 5 Click **Apply** to commit your changes.

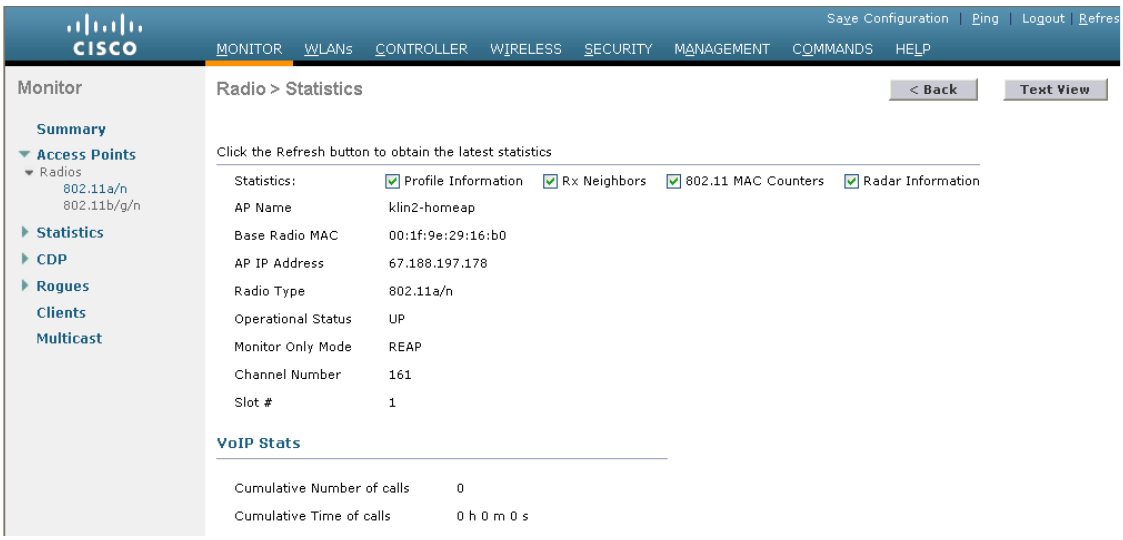
Step 6 Click **Save Configuration** to save your changes.

Step 7 See the VoIP statistics for your access point radios as follows:

a. Choose **Monitor > Access Points > Radios > 802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

b. Scroll to the right and click the **Detail** link for the access point for which you want to view VoIP statistics. The Radio > Statistics page appears (see Figure 7-16).

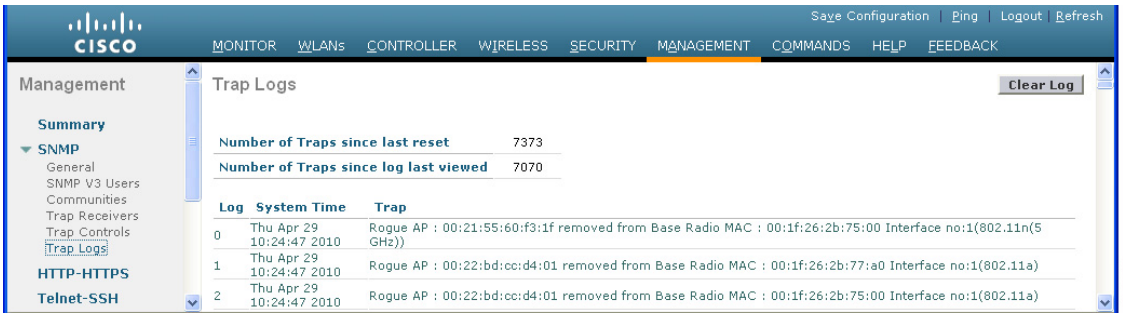
Figure 7-16 Radio > Statistics Page



The VoIP Stats section shows the cumulative number and length of voice calls for this access point radio. Entries are added automatically when voice calls are successfully placed and deleted when the access point disassociates from the controller.

Step 8 Choose **Management > SNMP > Trap Logs** to see the traps generated for failed calls. The Trap Logs page appears (Figure 7-17).

Figure 7-17 Trap Logs Page



For example, log 0 in Figure 7-17 shows that a call failed. The log provides the date and time of the call, a description of the failure, and the reason why the failure occurred.

Using the CLI to Configure Media Session Snooping

To configure VoIP snooping using the controller CLI, follow these steps:

Step 1 Enable or disable VoIP snooping for a particular WLAN by entering this command:

config wlan call-snoop {**enable** | **disable**} *wlan_id*

Step 2 Save your changes by entering this command:

save config

Step 3 See the status of media session snooping on a particular WLAN by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... wpa2-psk
Network Name (SSID).............................. wpa2-psk
Status........................................... Enabled
...
    H-REAP Local Switching....................... Disabled
    H-REAP Learn IP Address...................... Enabled
    Infrastructure MFP protection.............. Enabled (Global Infrastructure MFP
Disabled)
    Client MFP................................... Optional
    Tkip MIC Countermeasure Hold-down Timer..... 60
Call Snooping.................................... Enabled
```

Step 4 See the call information for an MSA client when media session snooping is enabled and the call is active by entering this command:

show call-control client callInfo *client_MAC_address*

Information similar to the following appears:

```
Uplink IP/port..................................... 192.11.1.71 / 23870
Downlonk IP/port................................... 192.12.1.47 / 2070
UP................................................. 6
Calling Party...................................... sip:1054
Called Party....................................... sip:1000
Call ID............................................ 58635b00-850161b7-14853-1501a8
Number of calls for given client is.............. 1
```

Step 5 See the metrics for successful calls or the traps generated for failed calls by entering this command:

show call-control ap {**802.11a** | **802.11b**} *Cisco_AP* {**metrics** | **traps**}

Information similar to the following appears when you enter **show call-control ap** {**802.11a** | **802.11b**} *Cisco_AP* **metrics**:

```
Total Call Duration in Seconds................... 120
Number of Calls.................................. 10
```

Information similar to the following appears when you enter **show call-control ap** {**802.11a** | **802.11b**} *Cisco_AP* **traps**:

```
Number of traps sent in one min.................. 2
Last SIP error code.............................. 404
Last sent trap timestamp..................... Jun 20 10:05:06
```

To aid in troubleshooting, the output of this command shows an error code for any failed calls. Table 7-3 explains the possible error codes for failed calls.

Table 7-3 Error Codes for Failed VoIP Calls

Error Code	Integer	Description
1	unknown	Unknown error.
400	badRequest	The request could not be understood because of malformed syntax.
401	unauthorized	The request requires user authentication.

Table 7-3 Error Codes for Failed VoIP Calls (continued)

Error Code	Integer	Description
402	paymentRequired	Reserved for future use.
403	forbidden	The server understood the request but refuses to fulfill it.
404	notFound	The server has information that the user does not exist at the domain specified in the Request-URI.
405	methodNotallowed	The method specified in the Request-Line is understood but not allowed for the address identified by the Request-URI.
406	notAcceptabl	The resource identified by the request is only capable of generating response entities with content characteristics that are not acceptable according to the Accept header text box sent in the request.
407	proxyAuthenticationRequired	The client must first authenticate with the proxy.
408	requestTimeout	The server could not produce a response within a suitable amount of time, if it could not determine the location of the user in time.
409	conflict	The request could not be completed due to a conflict with the current state of the resource.
410	gone	The requested resource is no longer available at the server, and no forwarding address is known.
411	lengthRequired	The server is refusing to process a request because the request entity-body is larger than the server is willing or able to process.
413	requestEntityTooLarge	The server is refusing to process a request because the request entity-body is larger than the server is willing or able to process.
414	requestURITooLarge	The server is refusing to service the request because the Request-URI is longer than the server is willing to interpret.
415	unsupportedMediaType	The server is refusing to service the request because the message body of the request is in a format not supported by the server for the requested method.
420	badExtension	The server did not understand the protocol extension specified in a Proxy-Require or Require header text box.
480	temporarilyNotAvailable	The callee's end system was contacted successfully, but the callee is currently unavailable.
481	callLegDoesNotExist	The UAS received a request that does not match any existing dialog or transaction.
482	loopDetected	The server has detected a loop.
483	tooManyHops	The server received a request that contains a Max-Forwards header text box with the value zero.
484	addressIncomplete	The server received a request with a Request-URI that was incomplete.

Table 7-3 Error Codes for Failed VoIP Calls (continued)

Error Code	Integer	Description
485	ambiguous	The Request-URI was ambiguous.
486	busy	The callee's end system was contacted successfully, but the callee is currently not willing or able to take additional calls at this end system.
500	internalServerError	The server encountered an unexpected condition that prevented it from fulfilling the request.
501	notImplemented	The server does not support the functionality required to fulfill the request.
502	badGateway	The server, while acting as a gateway or proxy, received an invalid response from the downstream server it accessed in attempting to fulfill the request.
503	serviceUnavailable	The server is temporarily unable to process the request because of a temporary overloading or maintenance of the server.
504	serverTimeout	The server did not receive a timely response from an external server it accessed in attempting to process the request.
505	versionNotSupported	The server does not support or refuses to support the SIP protocol version that was used in the request.
600	busyEverywhere	The callee's end system was contacted successfully, but the callee is busy or does not want to take the call at this time.
603	decline	The callee's machine was contacted successfully, but the user does not want to or cannot participate.
604	doesNotExistAnywhere	The server has information that the user indicated in the Request-URI does not exist anywhere.
606	notAcceptable	The user's agent was contacted successfully, but some aspects of the session description (such as the requested media, bandwidth, or addressing style) were not acceptable.

Note If you experience any problems with media session snooping, enter the **debug call-control** {**all** | **event**} {**enable** | **disable**} command to debug all media session snooping messages or events.

Configuring Reanchoring of Roaming Voice Clients

You can allow voice clients to get anchored on the best suited and nearest available controller, which is useful when intercontroller roaming occurs. By using this feature, you can avoid the use of tunnels to carry traffic between the foreign controller and the anchor controller and remove unnecessary traffic from the network.

The ongoing call during roaming is not affected and can continue without any problem. The traffic passes through proper tunnels that are established between the foreign controller and the anchor controller. Disassociation occurs only after the call ends , and then the client then gets reassociated to a new controller.

Note The ongoing data session might be affected due to disassociation and then reassociation.

Note This feature is supported for TSPEC-based calls and non-TSPEC SIP-based calls only when you enable the admission control.

Note You can reanchor roaming of voice clients for each WLAN.

Note This feature is not recommended for use on Cisco 792x phones.

Using the GUI to Configure Reanchoring of Roaming Voice Clients

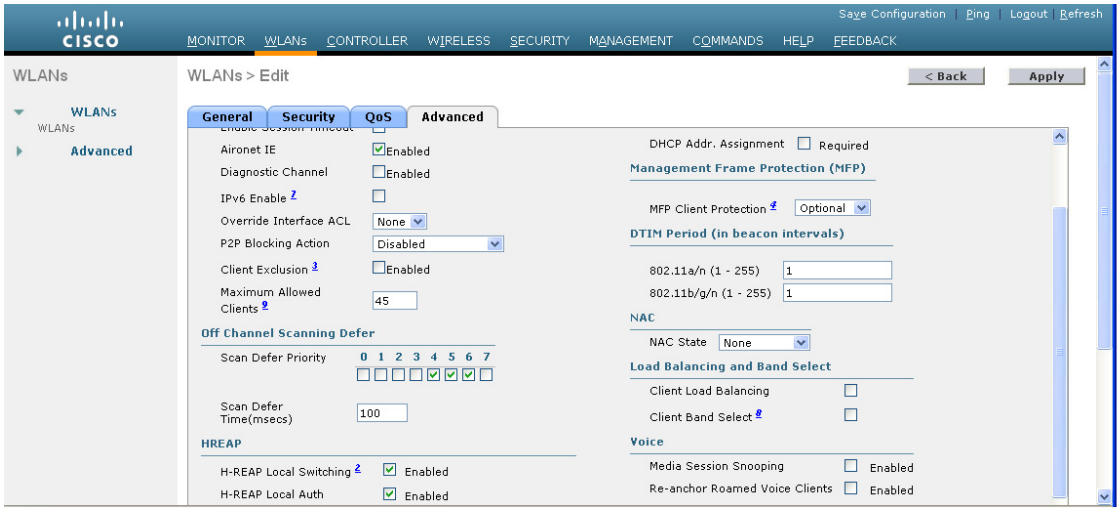
To configure reanchoring of roaming clients using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN for which you want to configure reanchoring of roaming voice clients.

Step 3 When the WLANs > Edit page appears, choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 7-18).

Figure 7-18 WLANs > Edit (Advanced) Page



Step 4 In the Voice area select the **Re-anchor Roamed Clients** check box.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure Reanchoring of Roaming Voice Clients

To configure reanchoring of roaming voice clients using the controller CLI, follow these steps:

Step 1 Enable or disable reanchoring of roaming voice clients for a particular WLAN by entering this command:

config wlan roamed-voice-client re-anchor {enable | disable} *wlan id*

Step 2 Save your changes by entering this command:

save config

Step 3 See the status of reanchoring roaming voice client on a particular WLAN by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.............................. 1
Profile Name................................. wpa2-psk
Network Name (SSID).......................... wpa2-psk
Status....................................... Enabled
...
Call Snooping................................ Enabled
Roamed Call Re-Anchor Policy................. Enabled
Band Select.................................. Disabled
Load Balancing............................... Disabled
```

Step 4 Save your changes by entering this command:

save config

Configuring IPv6 Bridging

Internet Protocol version 6 (IPv6) is the next-generation network layer Internet protocol intended to replace version 4 (IPv4) in the TCP/IP suite of protocols. This new version increases Internet global address space to accommodate users and applications that require unique global IP addresses. IPv6 incorporates 128-bit source and destination addresses, providing significantly more addresses than the 32-bit IPv4 addresses. Follow the instructions in this section to configure a WLAN for IPv6 bridging using either the controller GUI or CLI.

Guidelines for Using IPv6 Bridging

Follow these guidelines when using IPv6 bridging:

- To use IPv6 bridging, multicast must be enabled on the controller.
- Hybrid-REAP with central switching is supported for use with IPv6 bridging. Hybrid-REAP with local switching is not supported.
- Auto-anchor mobility is not supported for use with IPv6 bridging.

- If symmetric mobility tunneling is enabled, all IPv4 traffic is bidirectionally tunneled to and from the client, but the IPv6 client traffic is bridged locally.
- Clients must support IPv6 with either static stateless autoconfiguration (such as Windows XP clients) or stateful DHCPv6 IP addressing (such as Windows Vista clients).

Note Currently, DHCPv6 is supported for use only with Windows Vista clients. For these clients, you must manually renew the DHCPv6 IP address after the client changes VLANs.

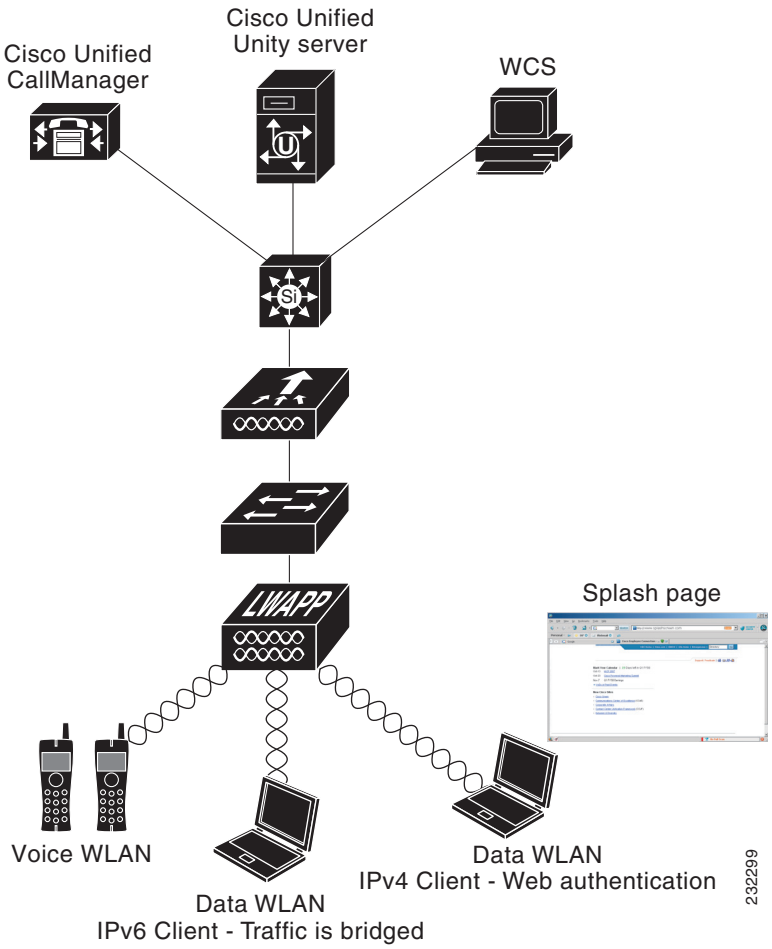
Note Dynamic VLAN function on IPV6 bridging environment is not supported on the Controller software release 6.0 and 7.0.

- For stateful DHCPv6 IP addressing to operate properly, you need a switch or router that supports the DHCP for IPv6 feature (such as the Catalyst 3750 switch) and is configured to act like a DHCPv6 server, or you need a dedicated server such as a Windows 2008 server with a built-in DHCPv6 server.

Note To load the SDM IPv6 template in the Catalyst 3750 switch, enter the **sdm prefer dual-ipv4-and-v6 default** command and then reset the switch. For more information, see *Catalyst 3750 Switch Configuration Guide for Cisco IOS Release 12.2(46)SE.*

- In controller software release 4.2 or later releases, you can enable IPv6 bridging and IPv4 web authentication on the same WLAN, a combination that previously was not supported. The controller bridges IPv6 traffic from all clients on the WLAN while IPv4 traffic goes through the normal web authentication process. The controller begins bridging IPv6 as soon as the client associates and even before web authentication for IPv4 clients is complete. No other Layer 2 or Layer 3 security policy configuration is supported on the WLAN when both IPv6 bridging and web authentication are enabled. Figure 7-19 shows how IPv6 bridging and IPv4 web authentication can be used on the same WLAN.
- In controller software release 6.0 or later releases, all Layer 2 security policies are supported and can be configured when you enable IPv6 bridging on a WLAN.

Figure 7-19 IPv6 Bridging and IPv4 Web Authentication



Note The Security Policy Completed text box in both the controller GUI and CLI shows "No for IPv4 (bridging allowed for IPv6)" until web authentication is completed. You can view this text box from the Clients > Detail page on the GUI or from the **show client detail** CLI command.

Using the GUI to Configure IPv6 Bridging

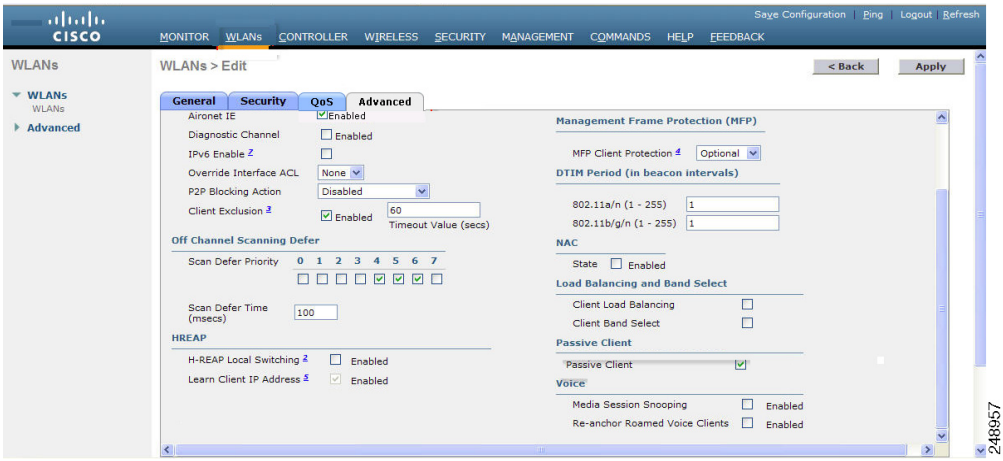
To configure a WLAN for IPv6 bridging using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced tab) page (see Figure 7-20).

Figure 7-20 WLANs > Edit (Advanced) Page



Step 4 Select the **IPv6 Enable** check box if you want to enable clients that connect to this WLAN to accept IPv6 packets. Otherwise, leave the check box unselected, which is the default value.

Note If you disable (or uncheck) the IPv6 check box, IPv6 will only be allowed after authentication.

Note Enabling IPv6 means that the controller can pass IPv6 traffic without client authentication.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure IPv6 Bridging

Configure a WLAN for IPv6 bridging using the controller CLI by entering this command:

config wlan IPv6support {**enable** | **disable**} *wlan_id*

The default value is disabled.

Configuring Cisco Client Extensions

Cisco Client Extensions (CCX) software is licensed to manufacturers and vendors of third-party client devices. The CCX code resident on these clients enables them to communicate wirelessly with Cisco access points and to support Cisco features that other client devices do not, including those features related to increased security, enhanced performance, fast roaming, and superior power management.

The 4.2 or later releases of controller software support CCX versions 1 through 5, which enables controllers and their access points to communicate wirelessly with third-party client devices that support CCX. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. However, you can configure a specific CCX feature per WLAN. This feature is Aironet information elements (IEs).

If Aironet IE support is enabled, the access point sends an Aironet IE 0x85 (which contains the access point name, load, number of associated clients, and so on) in the beacon and probe responses of this WLAN, and the controller sends Aironet IEs 0x85 and 0x95 (which contains the management IP address of the controller and the IP address of the access point) in the reassociation response if it receives Aironet IE 0x85 in the reassociation request.

Follow the instructions in this section to configure a WLAN for the CCX Aironet IE feature and to see the CCX version supported by specific client devices using either the GUI or the CLI.

Note CCX is not supported on Cisco OEAP 600 access points and all elements related to CCX are not supported.

Note Cisco OEAP 600 do not support Aeronet IEs.

Using the GUI to Configure CCX Aironet IEs

To configure a WLAN for CCX Aironet IEs using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN to open the WLANs > Edit page.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced tab) page (see Figure 7-20).

Step 4 Select the **Aironet IE** check box if you want to enable support for Aironet IEs for this WLAN. Otherwise, unselect this check box. The default value is enabled (or selected).

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the GUI to View a Client's CCX Version

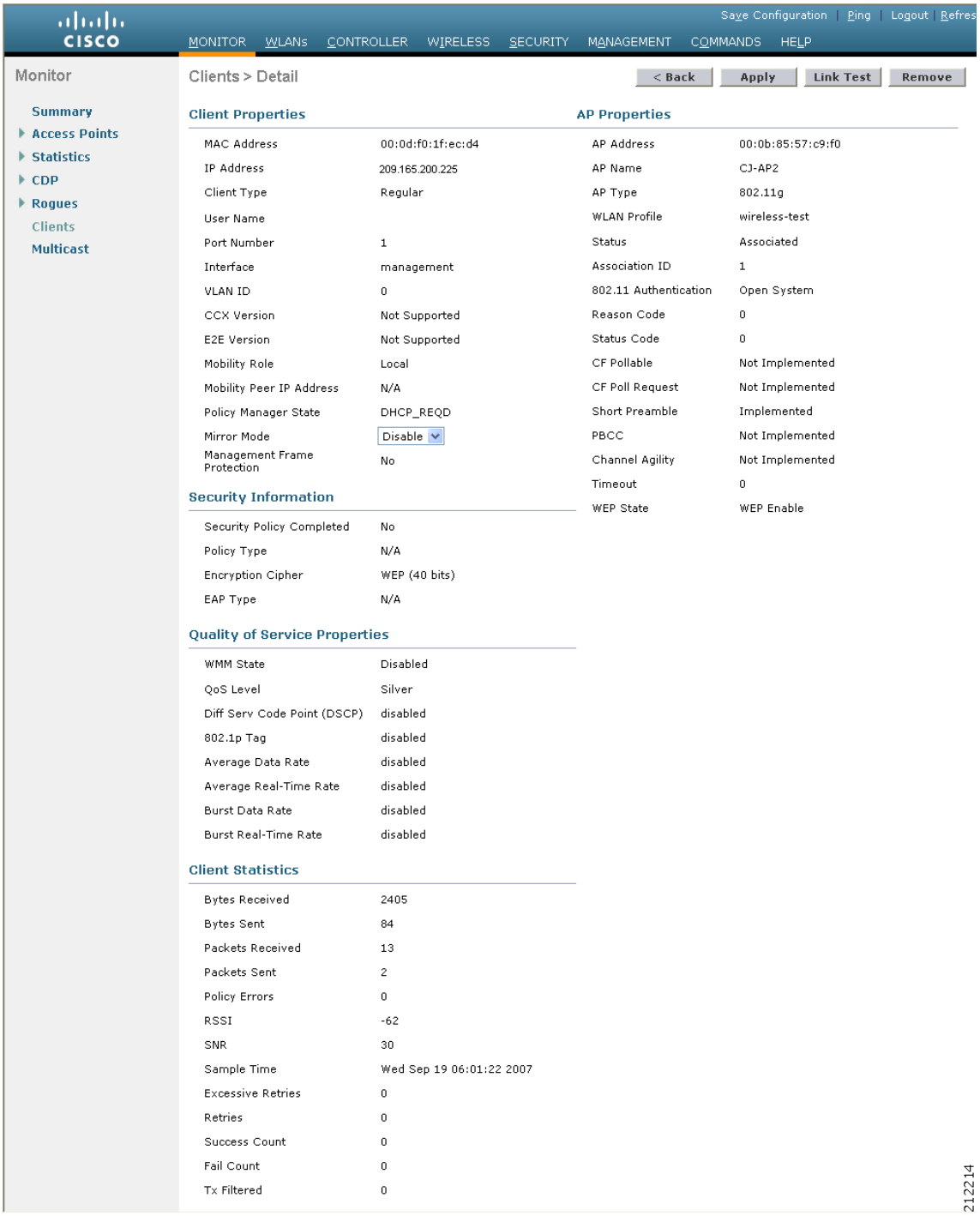
A client device sends its CCX version in association request packets to the access point. The controller then stores the client's CCX version in its database and uses it to limit the features for this client. For example, if a client supports CCX version 2, the controller does not allow the client to use CCX version 4 features.

To see the CCX version supported by a particular client device using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Clients** to open the Clients page.

Step 2 Click the MAC address of the desired client device to open the Clients > Detail page (see Figure 7-21).

Figure 7-21 Clients > Detail Page



The CCX Version text box shows the CCX version supported by this client device. *Not Supported* appears if the client does not support CCX.

Step 3 Click **Back** to return to the previous screen.

Step 4 Repeat this procedure to view the CCX version supported by any other client devices.

Using the CLI to Configure CCX Aironet IEs

Enable or disable support for Aironet IEs for a particular WLAN using the controller CLI, by entering this command:

config wlan ccx aironet-ie {**enable** | **disable**} *wlan_id*

The default value is enabled.

Using the CLI to View a Client's CCX Version

See the CCX version supported by a particular client device using the controller CLI by entering this command:

show client detail *client_mac*

Configuring Access Point Groups

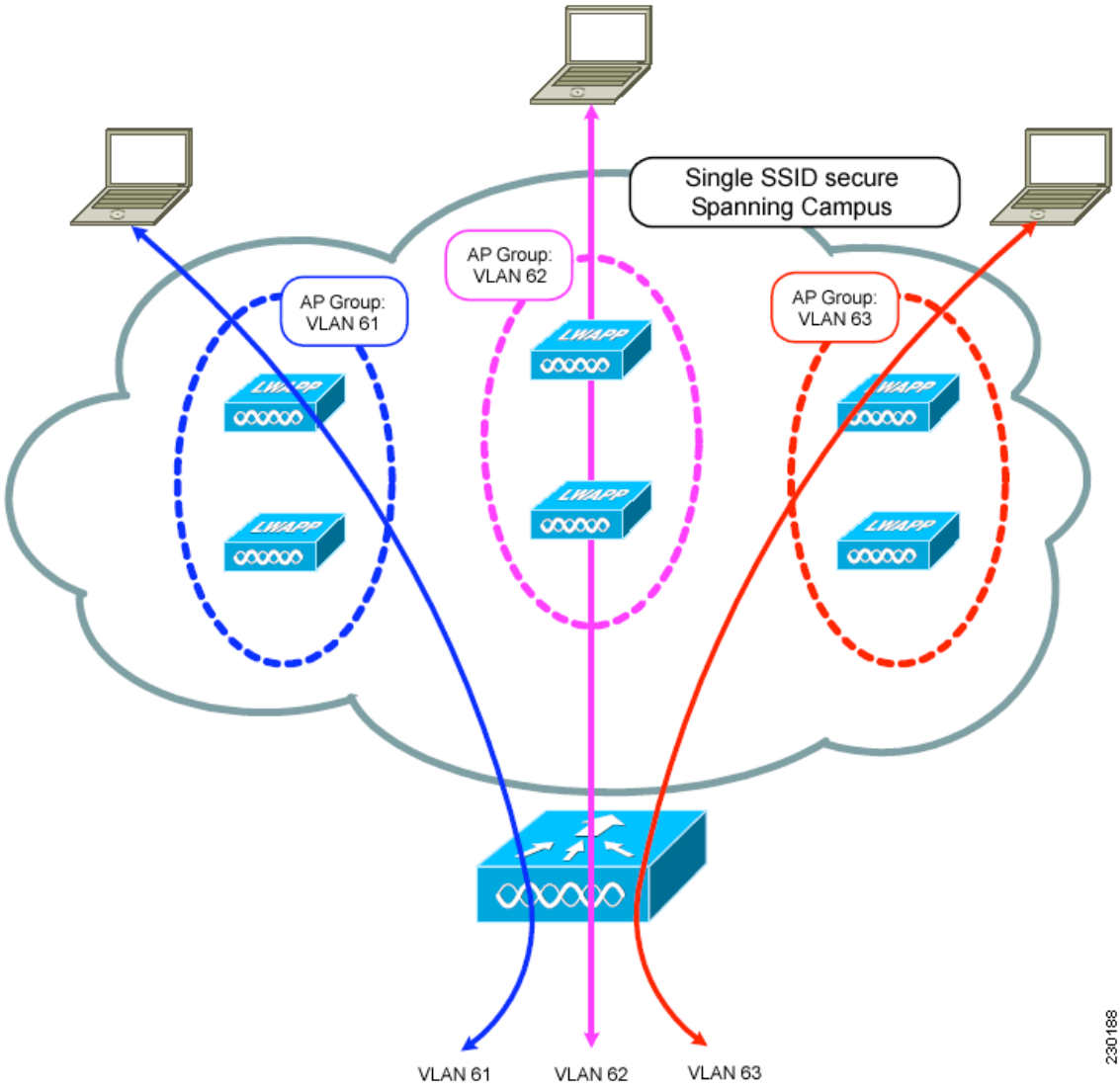
After you create up to 512 WLANs on the controller, you can selectively publish them (using access point groups) to different access points to better manage your wireless network. In a typical deployment, all users on a WLAN are mapped to a single interface on the controller. Therefore, all users associated with that WLAN are on the same subnet or VLAN. However, you can choose to distribute the load among several interfaces or to a group of users based on specific criteria such as individual departments (such as Marketing) by creating access point groups. Additionally, these access point groups can be configured in separate VLANs to simplify network administration, as shown in Figure 7-22.

Note The required access control list (ACL) must be defined on the router that serves the VLAN or subnet.

Note Multicast traffic is supported with access point group VLANs. However, if the client roams from one access point to another, the client might stop receiving multicast traffic, unless IGMP snooping is enabled.

Note The OEAP 600 Series access point supports a maximum of two WLANs and one remote LAN. If you have configured more than two WLANs and one remote LAN, you can assign the 600 Series access point to an AP group. The support for two WLANs and one remote LAN still applies to the AP group If the 600 Series OEAP is in the default group, the WLAN/remote LAN ids must be lower than 8.

Figure 7-22 Access Point Groups



In Figure 7-22, three configured dynamic interfaces are mapped to three different VLANs (VLAN 61, VLAN 62, and VLAN 63). Three access point groups are defined, and each is a member of a different VLAN, but all are members of the same SSID. A client within the wireless SSID is assigned an IP address from the VLAN subnet on which its access point is a member. For example, any user that associates with an access point that is a member of access point group VLAN 61 is assigned an IP address from that subnet.

In the example in Figure 7-22, the controller internally treats roaming between access points as a Layer 3 roaming event. In this way, WLAN clients maintain their original IP addresses.

Note Suppose that the interface mapping for a WLAN in the AP group table is the same as the WLAN interface. If the WLAN interface is changed, the interface mapping for the WLAN in the AP group table also changes to the new WLAN interface.

Suppose that the interface mapping for a WLAN in the AP group table is different from the one defined for the WLAN. If the WLAN interface is changed, then the interface mapping for the WLAN in the AP group table does not change to the new WLAN interface.

Note A controller with OfficeExtend access points in an access point group publishes upto 15 WLANs to each connected OfficeExtend access point because it reserves one WLAN for the personal SSID.

To configure access point groups, follow these steps:

1. Configure the appropriate dynamic interfaces and map them to the desired VLANs.

   For example, to implement the network in Figure 7-22, create dynamic interfaces for VLANs 61, 62, and 63 on the controller. See Chapter 3, "Configuring Ports and Interfaces," for information on how to configure dynamic interfaces.

2. Create the access point groups. See the "Creating Access Point Groups" section on page 7-57.

3. Assign access points to the appropriate access point groups. See the "Creating Access Point Groups" section on page 7-57.

Creating Access Point Groups

After all access points have joined the controller, you can create access point groups and assign up to 16 WLANs to each group. Each access point advertises only the enabled WLANs that belong to its access point group. The access point does not advertise disabled WLANs in its access point group or WLANs that belong to another group.

You can create up to 50 access point groups for Cisco 2100 Series Controller and controller network modules; up to 300 access point groups for Cisco 4400 Series Controllers, Cisco WiSM, and 3750G wireless LAN controller switch; and up to 500 access point groups for Cisco 5500 Series Controllers.

Note All OfficeExtend access points should be in the same access point group, and that group should contain no more than 15 WLANs. A controller with OfficeExtend access points in an access point group publishes only up to 15 WLANs to each connected OfficeExtend access point because it reserves one WLAN for the personal SSID.

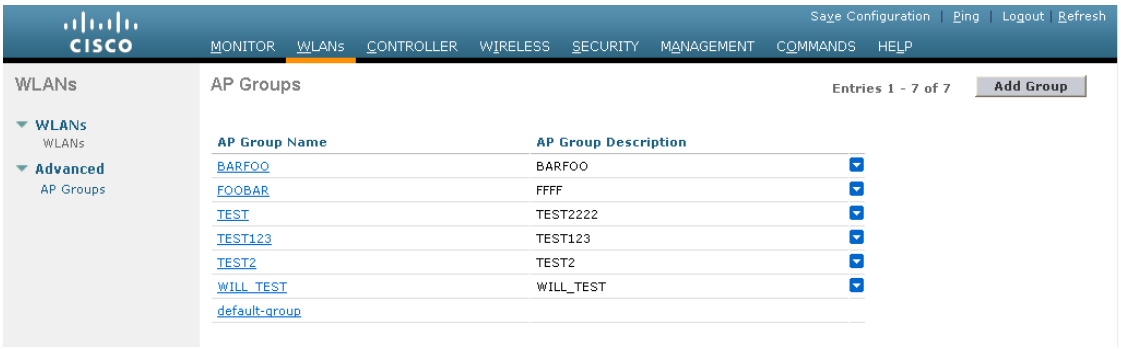
Note If you clear the configuration on the controller, all of the access point groups disappear except for the default access point group "default-group," which is created automatically.

Using the GUI to Create Access Point Groups

To create an access point group using the controller GUI, follow these steps:

Step 1 Choose **WLANs > Advanced > AP Groups** to open the AP Groups page (see Figure 7-23).

Figure 7-23 AP Groups Page



This page lists all the access point groups currently created on the controller. By default, all access points belong to the default access point group "default-group," unless you assign them to other access point groups.

Note When you upgrade to controller software release 5.2 or later releases, the controller creates the default-group access point group and automatically populates it with the first 16 WLANs (WLANs with IDs 1 through 16, or fewer if 16 WLANs are not configured). This default group cannot be modified (you cannot add WLANs to it nor delete WLANs from it). It is dynamically updated whenever the first 16 WLANs are added or deleted. If an access point does not belong to an access point group, it is assigned to the default group and uses the WLANs in that group. If an access point joins the controller with an undefined access point group name, the access point keeps its group name but uses the WLANs in the default-group access point group.

Step 2 Click **Add Group** to create a new access point group. The Add New AP Group section appears at the top of the page.

Step 3 In the AP Group Name text box, enter the group's name.

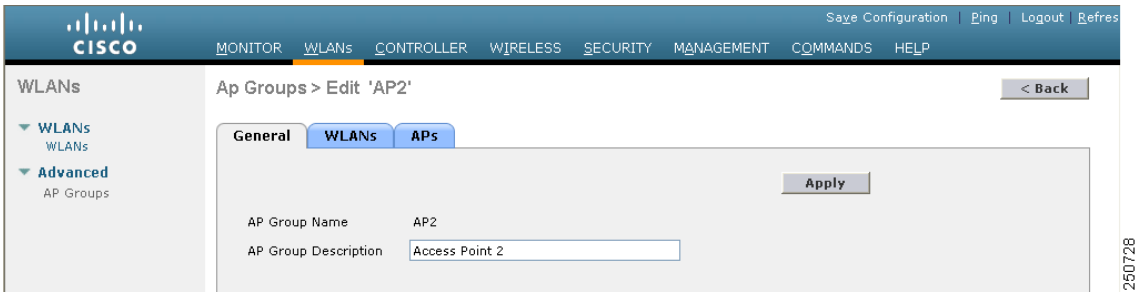
Step 4 In the Description text box, enter the group's description.

Step 5 Click **Add**. The newly created access point group appears in the list of access point groups on the AP Groups page.

Note If you ever want to delete this group, hover your cursor over the blue drop-down arrow for the group and choose **Remove**. An error message appears if you try to delete an access point group that is used by at least one access point. Before deleting an access point group in controller software release 6.0 or later releases, move all access points in the group to another group. The access points are not moved to the default-group access point group as in previous releases.

Step 6 Click the name of the group to edit this new group. The AP Groups > Edit (General) page appears (see Figure 7-24).

Figure 7-24 AP Groups > Edit (General) Page

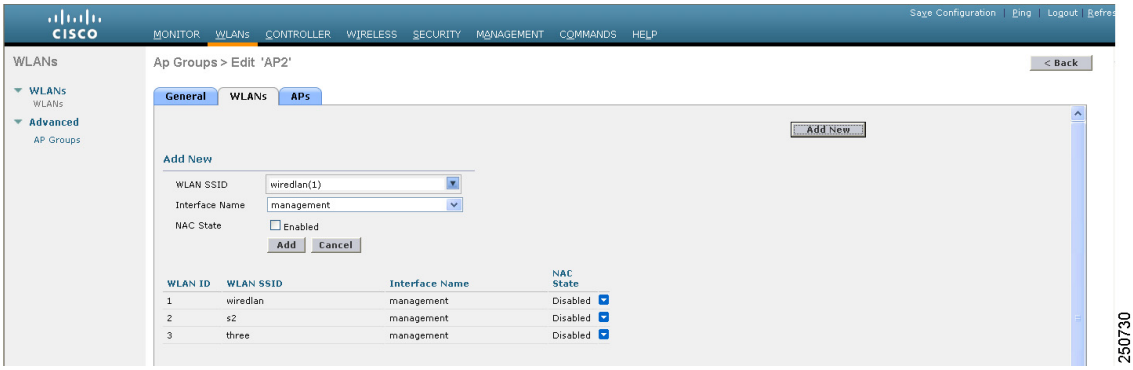


Step 7 Change the description of this access point group by entering the new text in the AP Group Description text box and click **Apply**.

Step 8 Choose the **WLANs** tab to open the AP Groups > Edit (WLANs) page. This page lists the WLANs that are currently assigned to this access point group.

Step 9 Click **Add New** to assign a WLAN to this access point group. The Add New section appears at the top of the page (see Figure 7-25).

Figure 7-25 AP Groups > Edit (WLANs) Page



Step 10 From the WLAN SSID drop-down list, choose the SSID of the WLAN.

Step 11 From the Interface Name drop-down list, choose the interface to which you want to map the access point group. Choose the quarantine VLAN if you plan to enable network admission control (NAC) out-of-band support.

Note The interface name in the default-group access point group matches the WLAN interface.

Step 12 Select the **NAC State** check box to enable NAC out-of-band support for this access point group. To disable NAC out-of-band support, leave the check box unselected, which is the default value. See the "Configuring NAC Out-of-Band Integration" section on page 7-68 for more information on NAC.

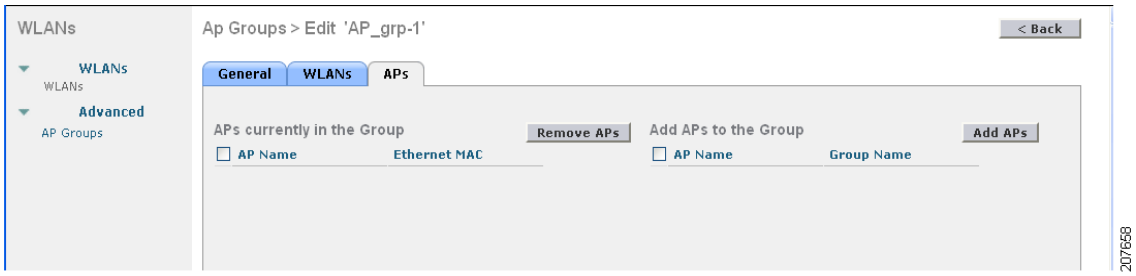
Step 13 Click **Add** to add this WLAN to the access point group. This WLAN appears in the list of WLANs that are assigned to this access point group.

Note If you ever want to remove this WLAN from the access point group, hover your cursor over the blue drop-down arrow for the WLAN and choose **Remove**.

Step 14 Repeat Step 9 through Step 13 to add any additional WLANs to this access point group.

Step 15 Choose the **APs** tab to assign access points to this access point group. The AP Groups > Edit (APs) page lists the access points that are currently assigned to this group as well as any access points that are available to be added to the group. If an access point is not currently assigned to a group, its group name appears as "default-group" (see Figure 7-26).

Figure 7-26 AP Groups > Edit (APs) Page



Step 16 Select the check box to the left of the access point name and click **Add APs** to add an access point to this access point group. The access point now appears in the list of access points currently in this access point group.

Note To select all of the available access points at once, select the **AP Name** check box. All of the access points are then selected.

Note If you ever want to remove an access point from the group, select the check box to the left of the access point name and click **Remove APs**. To select all of the access points at once, select the **AP Name** check box. All of the access points are then removed from this group.

Note If you ever want to change the access point group to which an access point belongs, choose **Wireless** > **Access Points** > **All APs** > *ap_name* > **Advanced** tab, choose the name of another access point group from the **AP Group Name** drop-down list, and click **Apply**.

Step 17 Click **Save Configuration** to save your changes.

Using the CLI to Create Access Point Groups

To create access point groups using the controller CLI, follow these steps:

Step 1 Create an access point group by entering this command:

config wlan apgroup add *group_name*

Note To delete an access point group, enter the **config wlan apgroup delete** *group_name* command. An error message appears if you try to delete an access point group that is used by at least one access point. Before deleting an access point group in controller software release 6.0 or later releases, move all access points in the group to another group. The access points are not moved to the default-group access point group as in previous releases. To see the access points in a group, enter the **show wlan apgroups** command. To move the access points to another group, enter the **config ap group-name** *group_name Cisco_AP* command.

Step 2 Add a description to an access point group by entering this command:

config wlan apgroup description *group_name description*

Step 3 Assign a WLAN to an access point group by entering this command:

config wlan apgroup interface-mapping add *group_name wlan_id interface_name*

Note To remove a WLAN from an access point group, enter the **config wlan apgroup interface-mapping delete** *group_name wlan_id* command.

Step 4 Enable or disable NAC out-of-band support for this access point group by entering this command:

config wlan apgroup nac {**enable** | **disable**} *group_name wlan_id*

Step 5 Assign an access point to an access point group by entering this command:

config ap group-name *group_name Cisco_AP*

Note To remove an access point from an access point group, reenter this command and assign the access point to another group.

Step 6 Save your changes by entering this command:

save config

Using the CLI to View Access Point Groups

To view information about or to troubleshoot access point groups, use these commands:

- See a list of all access point groups on the controller by entering this command:

  show wlan apgroups

  Information similar to the following appears:

```
Site Name..................................... AP2
Site Description.............................. Access Point 2

WLAN ID          Interface          Network Admission Control
-------         -----------        --------------------------
 1              management           Disabled
 2              management           Disabled
 3              management           Disabled
 4              management           Disabled
 9              management           Disabled
 10             management           Disabled
 11             management           Disabled
```

```
 12              management            Disabled
 13              management            Disabled
 14              management            Disabled
 15              management            Disabled
 16              management            Disabled
 18              management            Disabled

AP Name Slots AP Model     Ethernet MAC   Location Port Country Priority GroupName
------- ---- -------------- ----------------- ------- ---- ------- -------- ---------
AP1242   2   AP1242AG-A-K9 00:14:1c:ed:23:9a default  1    US       1       AP2
...
```

- See the BSSIDs for each WLAN assigned to an access point group by entering this command:

  show ap wlan {**802.11a** | **802.11b**} *Cisco_AP*

  Information similar to the following appears:

```
Site Name..................................... AP3
Site Description.............................. Access Point 3

WLAN ID          Interface          BSSID
-------         ------------  -------------------
 10             management     00:14:1b:58:14:df
```

- See the number of WLANs enabled for an access point group by entering this command:

  show ap config {**802.11a** | **802.11b**} *Cisco_AP*

  Information similar to the following appears:

```
Cisco AP Identifier.............................. 166
Cisco AP Name.................................. AP2
...
Station Configuration
      Configuration ............................. AUTOMATIC
      Number Of WLANs ........................... 2
...
```

- Enable or disable debugging of access point groups by entering this command:

  debug group {**enable** | **disable**}

Configuring Web Redirect with 802.1X Authentication

You can configure a WLAN to redirect a user to a particular web page after 802.1X authentication has completed successfully. You can configure the web redirect to give the user partial or full access to the network.

Conditional Web Redirect

If you enable conditional web redirect, the user can be conditionally redirected to a particular web page after 802.1X authentication has completed successfully. You can specify the redirect page and the conditions under which the redirect occurs on your RADIUS server. Conditions might include the user's password reaching expiration or the user needing to pay his or her bill for continued usage.

If the RADIUS server returns the Cisco AV-pair "url-redirect," then the user is redirected to the specified URL upon opening a browser. If the server also returns the Cisco AV-pair "url-redirect-acl," the specified access control list (ACL) is installed as a preauthentication ACL for this client. The client is not considered fully authorized at this point and can only pass traffic allowed by the preauthentication ACL.

After the client completes a particular operation at the specified URL (for example, changing a password or paying a bill), the client must reauthenticate. When the RADIUS server does not return a "url-redirect," the client is considered fully authorized and allowed to pass traffic.

Note The conditional web redirect feature is available only for WLANs that are configured for 802.1X or WPA+WPA2 Layer 2 security.

After you configure the RADIUS server, you can then configure the conditional web redirect on the controller using either the controller GUI or CLI.

Splash Page Web Redirect

If you enable splash page web redirect, the user is redirected to a particular web page after 802.1X authentication has completed successfully. After the redirect, the user has full access to the network. You can specify the redirect page on your RADIUS server. If the RADIUS server returns the Cisco AV-pair "url-redirect," then the user is redirected to the specified URL upon opening a browser. The client is considered fully authorized at this point and is allowed to pass traffic, even if the RADIUS server does not return a "url-redirect."

Note The splash page web redirect feature is available only for WLANs that are configured for 802.1X or WPA+WPA2 Layer 2 security with 802.1x key management. Preshared key management is not supported with any Layer 2 security method.

After you configure the RADIUS server, you can then configure the splash page web redirect on the controller using either the controller GUI or CLI.

Using the GUI to Configure the RADIUS Server

To configure your RADIUS server using the controller GUI, follow these steps:

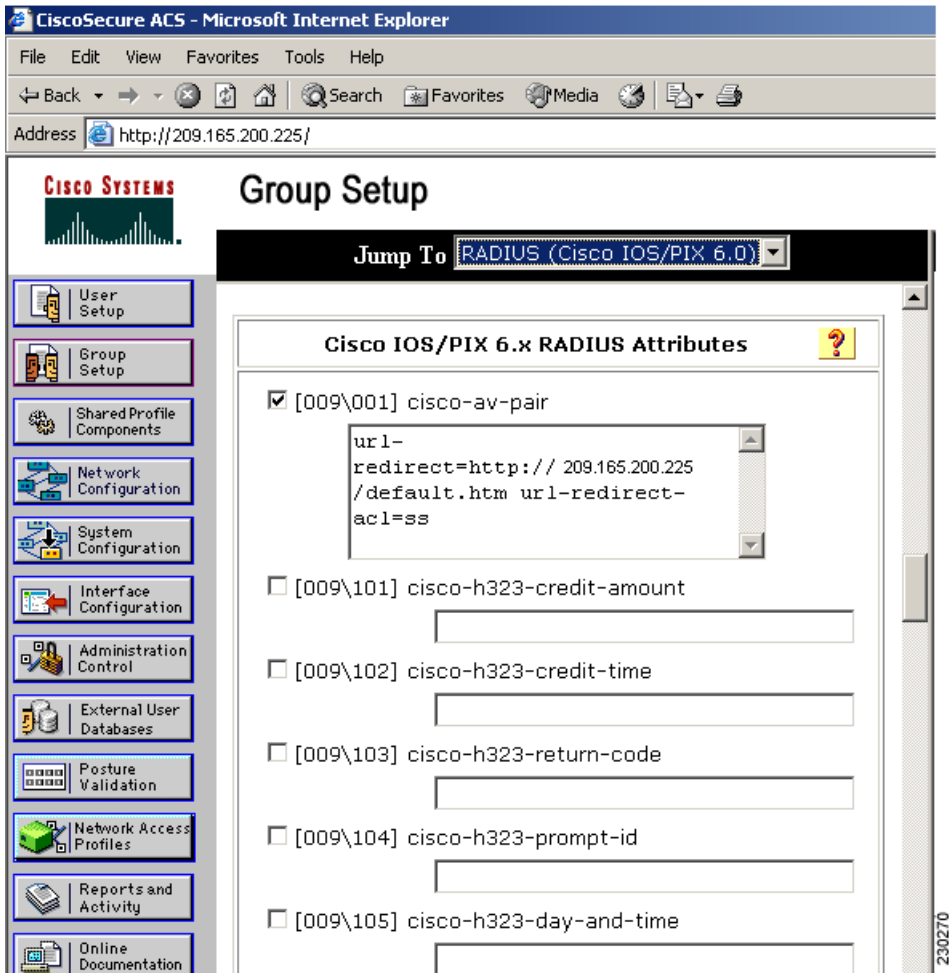
Note These instructions are specific to the CiscoSecure ACS; however, they should be similar to those for other RADIUS servers.

Step 1 From the CiscoSecure ACS main menu, choose **Group Setup**.

Step 2 Click **Edit Settings**.

Step 3 From the Jump To drop-down list, choose **RADIUS (Cisco IOS/PIX 6.0)**. The dialog box shown in Figure 7-27 appears.

Figure 7-27 ACS Server Configuration



Step 4 Select the **[009\001] cisco-av-pair** check box.

Step 5 Enter the following Cisco AV-pairs in the [009\001] cisco-av-pair edit box to specify the URL to which the user is redirected and, if configuring conditional web redirect, the conditions under which the redirect takes place, respectively:

url-redirect=http://*url*

url-redirect-acl=*acl_name*

Using the GUI to Configure Web Redirect

To configure conditional or splash page web redirect using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN. The WLANs > Edit page appears.

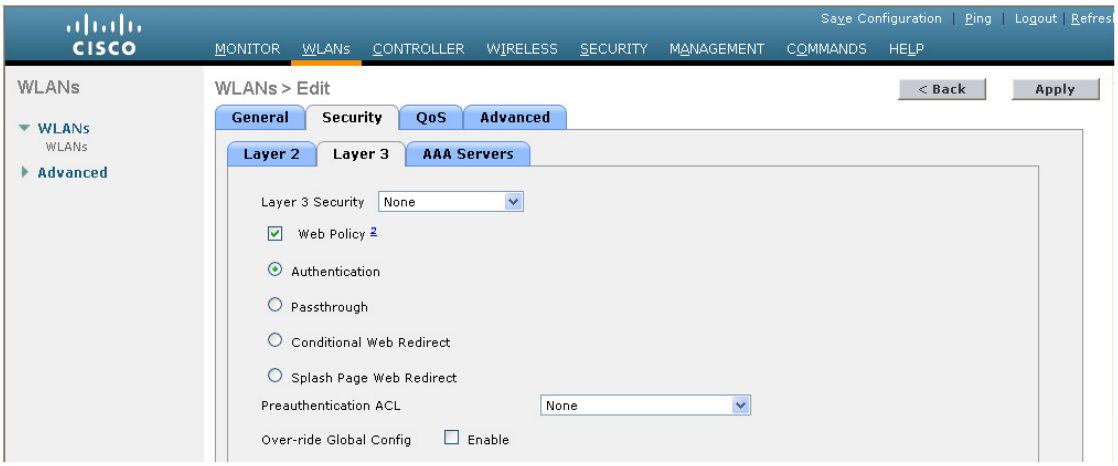
Step 3 Choose the **Security** and **Layer 2** tabs to open the WLANs > Edit (Security > Layer 2) page.

Step 4 From the Layer 2 Security drop-down list, choose **802.1X** or **WPA+WPA2**.

Step 5 Set any additional parameters for 802.1X or WPA+WPA2.

Step 6 Choose the **Layer 3** tab to open the WLANs > Edit (Security > Layer 3) page (see Figure 7-28).

Figure 7-28 WLANs > Edit (Security > Layer 3) Page



Step 7 From the Layer 3 Security drop-down list, choose **None**.

Step 8 Check the **Web Policy** check box.

Step 9 Choose one of the following options to enable conditional or splash page web redirect: **Conditional Web Redirect** or **Splash Page Web Redirect**. The default value is disabled for both parameters.

Step 10 If the user is to be redirected to a site external to the controller, choose the ACL that was configured on your RADIUS server from the Preauthentication ACL drop-down list.

Step 11 Click **Apply** to commit your changes.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure Web Redirect

To configure conditional or splash page web redirect using the controller CLI, follow these steps:

Step 1 Enable or disable conditional web redirect by entering this command:

config wlan security cond-web-redir {**enable** | **disable**} *wlan_id*

Step 2 Enable or disable splash page web redirect by entering this command:

config wlan security splash-page-web-redir {**enable** | **disable**} *wlan_id*

Step 3 Save your settings by entering this command:

save config

Step 4 See the status of the web redirect features for a particular WLAN by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... test
Network Name (SSID).............................. test
...
Web Based Authentication......................... Disabled
Web-Passthrough.................................. Disabled
Conditional Web Redirect......................... Disabled
Splash-Page Web Redirect......................... Enabled
...
```

Using the GUI to Disable the Accounting Servers per WLAN

This section provides instructions for disabling all accounting servers on a WLAN. Disabling accounting servers disables all accounting operations and prevents the controller from falling back to the default RADIUS server for the WLAN.

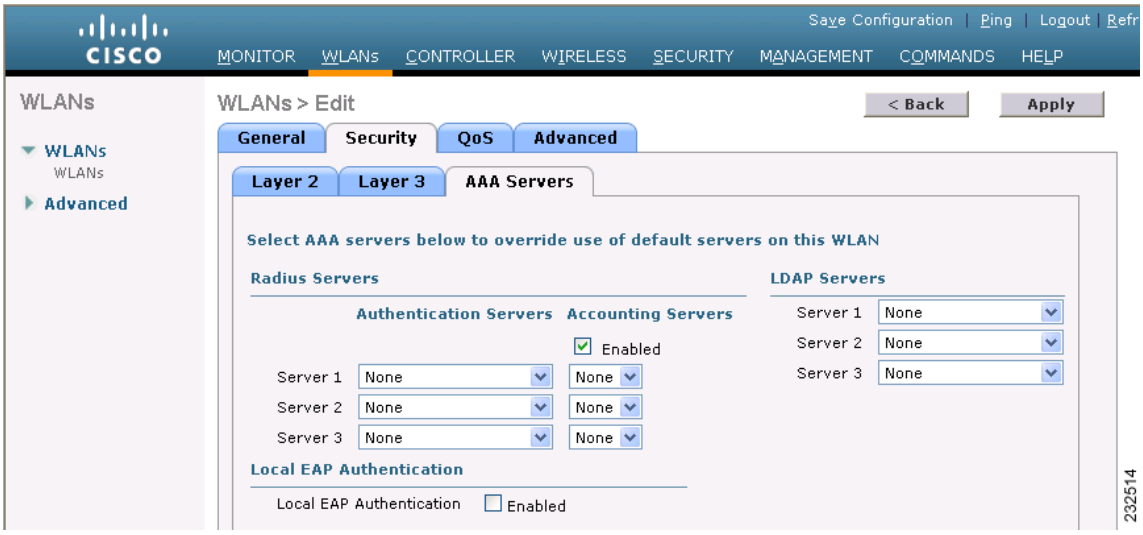
To disable all accounting servers for a RADIUS authentication server using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN to be modified. The WLANs > Edit page appears.

Step 3 Choose the **Security** and **AAA Servers** tabs to open the WLANs > Edit (Security > AAA Servers) page (see Figure 7-29).

Figure 7-29 WLANs > Edit (Security > AAA Servers) Page



Step 4 Unselect the **Enabled** check box for the Accounting Servers.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Disabling Coverage Hole Detection per WLAN

This section provides instructions for disabling coverage hole detection on a WLAN.

Coverage hole detection is enabled globally on the controller. See the "Coverage Hole Detection and Correction" section on page 13-4 and the "Using the GUI to Configure Coverage Hole Detection" section on page 13-20 for more information.

In software release 5.2 or later releases, you can disable coverage hole detection on a per-WLAN basis. When you disable coverage hole detection on a WLAN, a coverage hole alert is still sent to the controller, but no other processing is done to mitigate the coverage hole. This feature is useful for guest WLANs where guests are connected to your network for short periods of time and are likely to be highly mobile.

Using the GUI to Disable Coverage Hole Detection on a WLAN

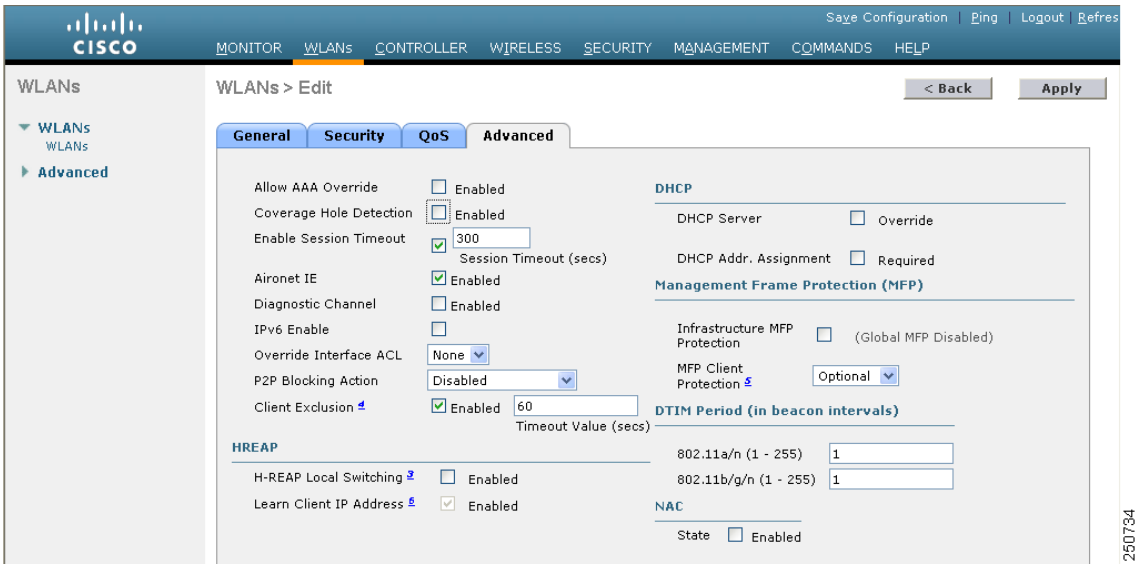
To disable coverage hole detection on a WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the profile name of the WLAN to be modified. The WLANs > Edit page appears.

Step 3 Choose the **Advanced** tab to display the WLANs > Edit (Advanced) page (see Figure 7-30).

Figure 7-30 WLANs > Edit (Advanced) Page



Step 4 Unselect the **Coverage Hole Detection Enabled** check box.

Note OEAP 600 Series Access Points do not support coverage hole detection.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Disable Coverage Hole Detection on a WLAN

To disable coverage hole detection on a WLAN using the controller CLI, follow these steps:

Step 1 Disable coverage hole detection on a by entering this command:

config wlan chd *wlan_id* **disable**

Note OEAP 600 Series Access Points do not support Coverage Hole detection.

Step 2 Save your settings by entering this command:

save config

Step 3 See the coverage hole detection status for a particular WLAN by entering this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 2
Profile Name..................................... wlan2
Network Name (SSID).............................. 2
. . .
CHD per WLAN..................................... Disabled
```

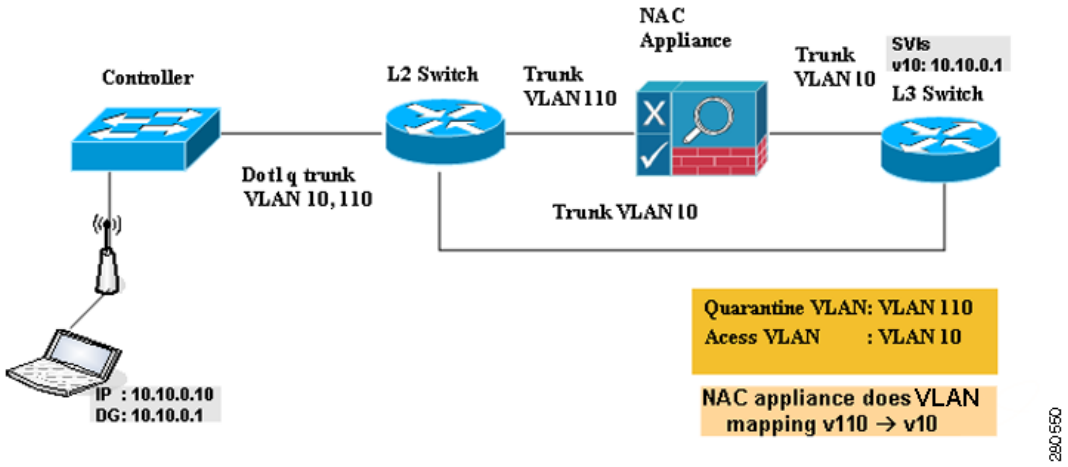
Configuring NAC Out-of-Band Integration

The Cisco NAC Appliance, also known as Cisco Clean Access (CCA), is a network admission control (NAC) product that allows network administrators to authenticate, authorize, evaluate, and remediate wired, wireless, and remote users and their machines prior to allowing users onto the network. It identifies whether machines are compliant with security policies and repairs vulnerabilities before permitting access to the network. The NAC appliance is available in two modes: in-band and out-of-band. Customers can deploy both modes if desired, each geared toward certain types of access (in-band for supporting wireless users and out-of-band for supporting wired users, for example).

In controller software releases prior to 5.1, the controller integrates with the NAC appliance only in in-band mode, where the NAC appliance must remain in the data path. For in-band mode, a NAC appliance is required at each authentication location (such as at each branch or for each controller), and all traffic must traverse the NAC enforcement point. In controller software release 5.1 or later releases, the controller can integrate with the NAC appliance in out-of-band mode, where the NAC appliance remains in the data path only until clients have been analyzed and cleaned. Out-of-band mode reduces the traffic load on the NAC appliance and enables centralized NAC processing.

To implement the NAC out-of-band feature on the controller, you must enable NAC support on the WLAN or guest LAN and then map this WLAN or guest LAN to an interface that is configured with a quarantine VLAN (untrusted VLAN) and an access VLAN (trusted VLAN). When a client associates and completes Layer 2 authentication, the client obtains an IP address from the access VLAN subnet, but the client state is Quarantine. While deploying the NAC out-of-band feature, be sure that the quarantine VLAN is allowed only between the Layer 2 switch on which the controller is connected and the NAC appliance and that the NAC appliance is configured with a unique quarantine-to-access VLAN mapping. Client traffic passes into the quarantine VLAN, which is trunked to the NAC appliance. After posture validation is completed, the client is prompted to take action for remediation. After cleaning is completed, the NAC appliance updates the controller to change the client state from Quarantine to Access. Figure 7-31 provides an example of NAC out-of-band integration.

Figure 7-31 NAC Out-of-Band Integration



In Figure 7-31, the link between the controller and the switch is configured as a trunk, enabling the quarantine VLAN (110) and the access VLAN (10). On the Layer 2 switch, the quarantine traffic is trunked to the NAC appliance while the access VLAN traffic goes directly to the Layer 3 switch. Traffic that reaches the quarantine VLAN on the NAC appliance is mapped to the access VLAN based on a static mapping configuration.

Follow the instructions in this section to configure NAC out-of-band integration using either the controller GUI or CLI.

Guidelines for Using NAC Out-of-Band Integration

Follow these guidelines when using NAC out-of-band integration:

- The NAC appliance supports up to 3500 users, and the controller supports up to 5000 users. Multiple NAC appliances might need to be deployed.
- CCA software release 4.5 or later releases is required for NAC out-of-band integration.
- Because the NAC appliance supports static VLAN mapping, you must configure a unique quarantine VLAN for each interface configured on the controller. For example, you might configure a quarantine VLAN of 110 on controller 1 and a quarantine VLAN of 120 on controller 2. However, if two WLANs or guest LANs use the same distribution system interface, they must use the same quarantine VLAN, provided they have one NAC appliance deployed in the network. The NAC appliance supports unique quarantine-to-access VLAN mapping.

- For posture reassessment based on session expiry, you must configure the session timeout on both the NAC appliance and the WLAN, making sure that the session expiry on the WLAN is greater than that on the NAC appliance.
- When a session timeout is configured on an open WLAN, the timing out of clients in the Quarantine state is determined by the timer on the NAC appliance. Once the session timeout expires for WLANs using web authentication, clients deauthenticate from the controller and must perform posture validation again.
- NAC out-of-band integration is supported only on WLANs configured for hybrid-REAP central switching. It is not supported for use on WLANs configured for hybrid-REAP local switching.

Note See Chapter 15, "Configuring Hybrid REAP," for more information on hybrid REAP.

- If you want to enable NAC on an access point group VLAN, you must first enable NAC on the WLAN. Then you can enable or disable NAC on the access point group VLAN. If you ever decide to disable NAC on the WLAN, be sure to disable it on the access point group VLAN as well.
- NAC out-of-band integration is not supported for use with the WLAN AAA override feature.
- All Layer 2 and Layer 3 authentication occurs in the quarantine VLAN. To use external web authentication, you must configure the NAC appliance to allow HTTP traffic to and from external web servers and to allow the redirect URL in the quarantine VLAN.

Note See the Cisco NAC appliance configuration guides for configuration instructions: http://www.cisco.com/en/US/products/ps6128/products_installation_and_configuration_guides_list.html

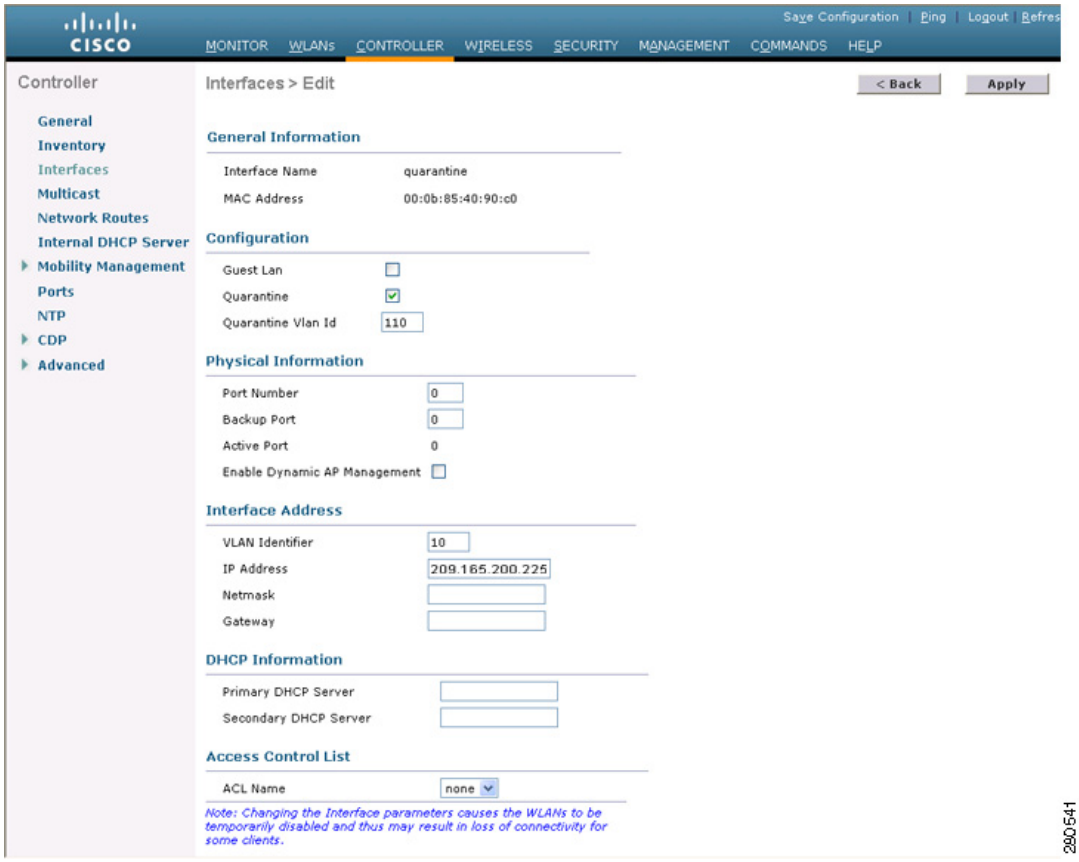
Using the GUI to Configure NAC Out-of-Band Integration

To configure NAC out-of-band integration using the controller GUI, follow these steps:

Step 1 Configure the quarantine VLAN for a dynamic interface as follows:

a. Choose **Controller** > **Interfaces** to open the Interfaces page.
b. Click **New** to create a new dynamic interface.
c. In the Interface Name text box, enter a name for this interface, such as "quarantine."
d. In the VLAN ID text box, enter a nonzero value for the access VLAN ID, such as "10."
e. Click **Apply** to commit your changes. The Interfaces > Edit page appears (see Figure 7-32).

Figure 7-32 Interfaces > Edit Page



f. Select the **Quarantine** check box and enter a nonzero value for the quarantine VLAN ID, such as "110."

Note We recommend that you configure unique quarantine VLANs throughout your network. If multiple controllers are configured in the same mobility group and access interfaces on all controllers are in the same subnet, it is mandatory to have the same quarantine VLAN if there is only one NAC appliance in the network. If multiple controllers are configured in the same mobility group and access interfaces on all controllers are in different subnets, it is mandatory to have different quarantine VLANs if there is only one NAC appliance in the network.

g. Configure any remaining text boxes for this interface, such as the IP address, netmask, and default gateway.

h. Click **Apply** to save your changes.

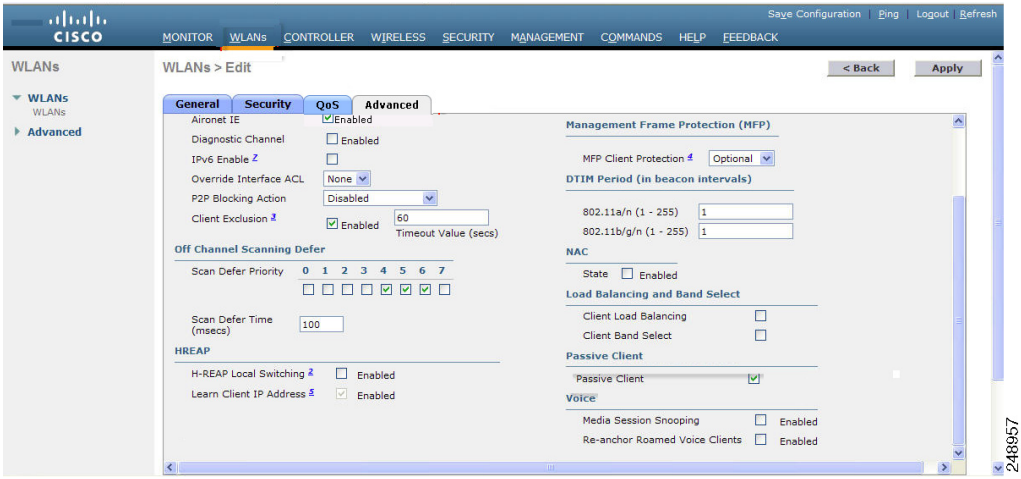
Step 2 Configure NAC out-of-band support on a WLAN or guest LAN as follows:

a. Choose **WLANs** to open the WLANs page.

b. Click the ID number of the desired WLAN or guest LAN. The WLANs > Edit page appears.

c. Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure 7-33).

Figure 7-33 WLANs > Edit (Advanced) Page



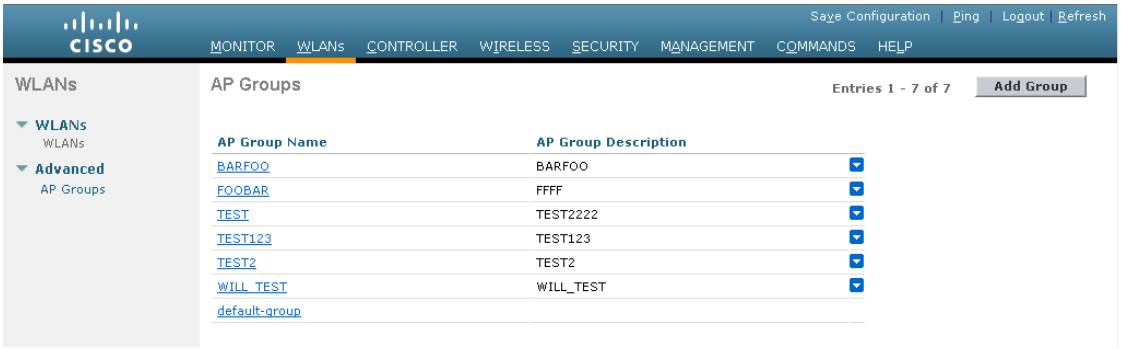
d. Configure NAC out-of-band support for this WLAN or guest LAN by selecting the **NAC State** check box. To disable NAC out-of-band support, leave the check box unselected, which is the default value.

e. Click **Apply** to commit your changes.

Step 3 Configure NAC out-of-band support for a specific access point group as follows:

a. Choose **WLANs > Advanced > AP Groups** to open the AP Groups page (see Figure 7-34).

Figure 7-34 AP Groups Page

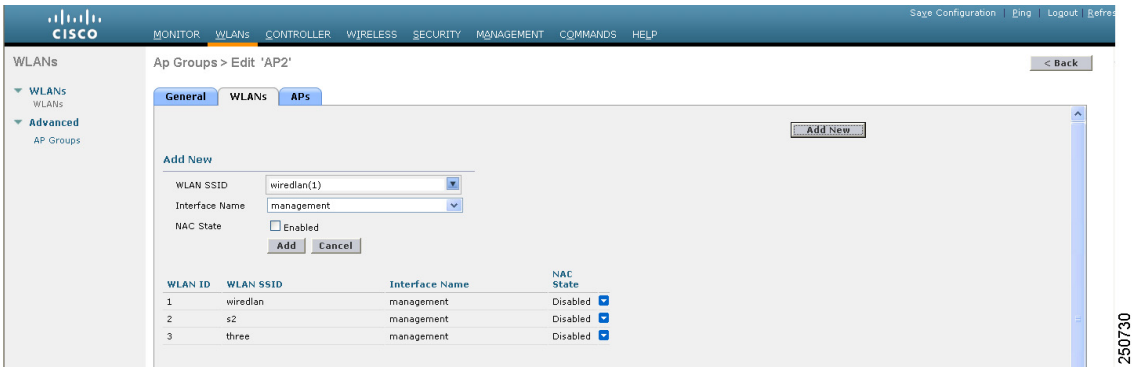


b. Click the name of the desired access point group.

c. Choose the **WLANs** tab to open the AP Groups > Edit (WLANs) page.

d. Click **Add New** to assign a WLAN to this access point group. The Add New section appears at the top of the page (see Figure 7-35).

Figure 7-35 AP Groups > Edit (WLANs) Page



e. From the WLAN SSID drop-down list, choose the SSID of the WLAN.

f. From the Interface Name drop-down list, choose the interface to which you want to map the access point group. Choose the quarantine VLAN if you plan to enable NAC out-of-band support.

g. To enable NAC out-of-band support for this access point group, select the **NAC State** check box. To disable NAC out-of-band support, leave the check box unselected, which is the default value.

h. Click **Add** to add this WLAN to the access point group. This WLAN appears in the list of WLANs assigned to this access point group.

Note If you ever want to remove this WLAN from the access point group, hover your cursor over the blue drop-down arrow for the WLAN and choose **Remove**.

Step 4 Click **Save Configuration** to save your changes.

Step 5 See the current state of the client (Quarantine or Access) as follows:

a. Choose **Monitor > Clients** to open the Clients page.

b. Click the MAC address of the desired client to open the Clients > Detail page. The NAC state appears under the Security Information section.

Note The client state appears as “Invalid” if the client is probing, has not yet associated to a WLAN, or cannot complete Layer 2 authentication.

Using the CLI to Configure NAC Out-of-Band Integration

To configure NAC out-of-band integration using the controller CLI, follow these steps:

Step 1 Configure the quarantine VLAN for a dynamic interface by entering this command:

config interface quarantine vlan *interface_name vlan_id*

Note You must configure a unique quarantine VLAN for each interface on the controller.

Note To disable the quarantine VLAN on an interface, enter **0** for the VLAN ID.

Step 2 Enable or disable NAC out-of-band support for a WLAN or guest LAN by entering this command:

config {**wlan** | **guest-lan**} **nac** {**enable** | **disable**} {*wlan_id* | *guest_lan_id*}

Step 3 Enable or disable NAC out-of-band support for a specific access point group by entering this command:

config wlan apgroup nac {**enable** | **disable**} *group_name wlan_id*

Step 4 Save your changes by entering this command:

save config

Step 5 See the configuration of a WLAN or guest LAN, including the NAC state by entering this command:

show {**wlan** *wlan_ id* | **guest-lan** *guest_lan_id*}

Information similar to the following appears:

```
WLAN Identifier.............................. 1
Profile Name................................. wlan
Network Name (SSID).......................... wlan
Status....................................... Disabled
MAC Filtering................................ Disabled
Broadcast SSID............................... Enabled
AAA Policy Override.......................... Disabled
Network Admission Control

  NAC-State.................................. Enabled
  Quarantine VLAN............................ 110
...
```

Step 6 See the current state of the client (either Quarantine or Access) by entering this command:

show client detailed *client_mac*

Information similar to the following appears:

```
Client's NAC state.............................. QUARANTINE
```

Note The client state appears as "Invalid" if the client is probing, has not yet associated to a WLAN, or cannot complete Layer 2 authentication.

Configuring Passive Client

Note The passive client feature is supported on Cisco 5500 and Cisco 2100 Series Controllers.

Note The passive client feature is not supported with the AP groups and hybrid REAP centrally switched WLANs.

Note The passive client feature works in multicast-multicast and multicast-unicast mode. The controller sources the multicast packets using its management IP address.

Passive clients are wireless devices, such as scales and printers that are configured with a static IP address. These clients do not transmit any IP information such as IP address, subnet mask, and gateway information when they associate with an access point. As a result, when passive clients are used, the controller never knows the IP address unless they use the DHCP.

Wireless LAN controllers currently act as a proxy for ARP requests. Upon receiving an ARP request, the controller responds with an ARP response instead of passing the request directly to the client. This scenario has two advantages:

- The upstream device that sends out the ARP request to the client will not know where the client is located.
- Power for battery-operated devices such as mobile phones and printers is preserved because they do not have to respond to every ARP requests.

Since the wireless controller does not have any IP related information about passive clients, it cannot respond to any ARP requests. The current behavior does not allow the transfer of ARP requests to passive clients. Any application that tries to access a passive client will fail.

The passive client feature enables the ARP requests and responses to be exchanged between wired and wireless clients. This feature when enabled, allows the controller to pass ARP requests from wired to wireless clients until the desired wireless client gets to the RUN state.

Using the GUI to Configure Passive Client

This section describes how to configure passive client using the controller GUI.

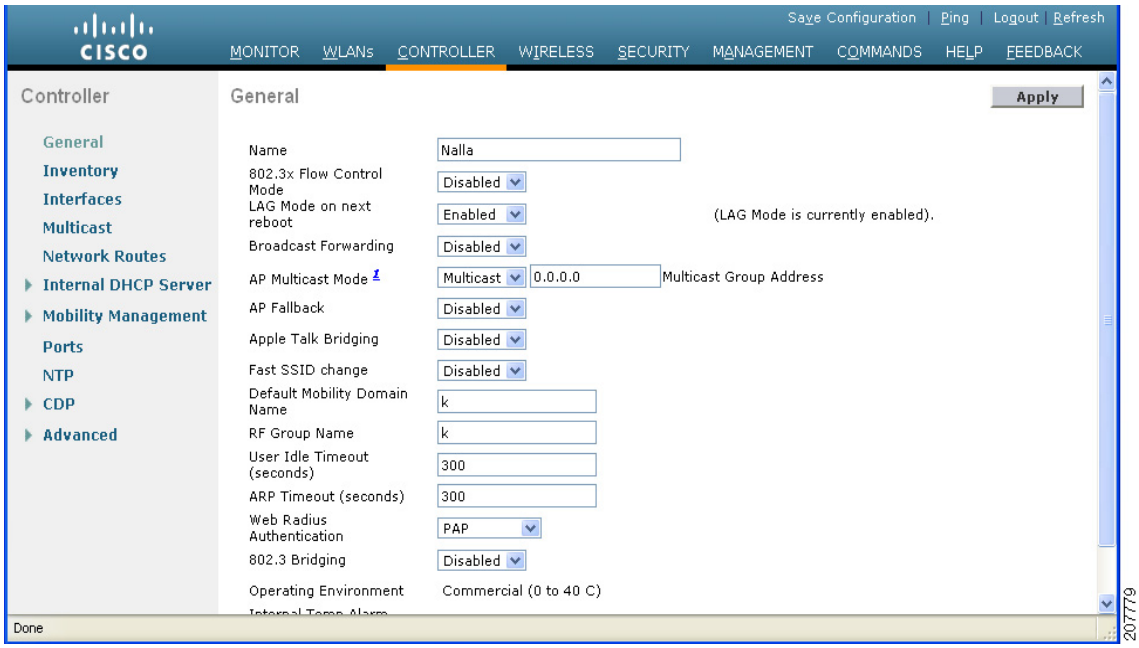
Note You can configure passive clients in multicast-multicast or multicast-unicast mode.

Enabling the Multicast-Multicast Mode

To enable the multicast-multicast mode, follow these steps:

Step 1 Choose **Controller** > **General** to open the General page. See Figure 7-36.

Figure 7-36 Controller > General Page



Step 2 Choose one of the following options from the AP Multicast Mode drop-down list:

- **Unicast**—Configures the controller to use the unicast method to send multicast packets. This is the default value.
- **Multicast**—Configures the controller to use the multicast method to send multicast packets to a CAPWAP multicast group.

Step 3 Select Multicast from the **AP Multicast Mode** drop-down list. The Multicast Group Address text box is displayed.

Step 4 In the Multicast Group Address text box, enter the IP address of the multicast group.

Step 5 Click **Apply** to commit your changes.

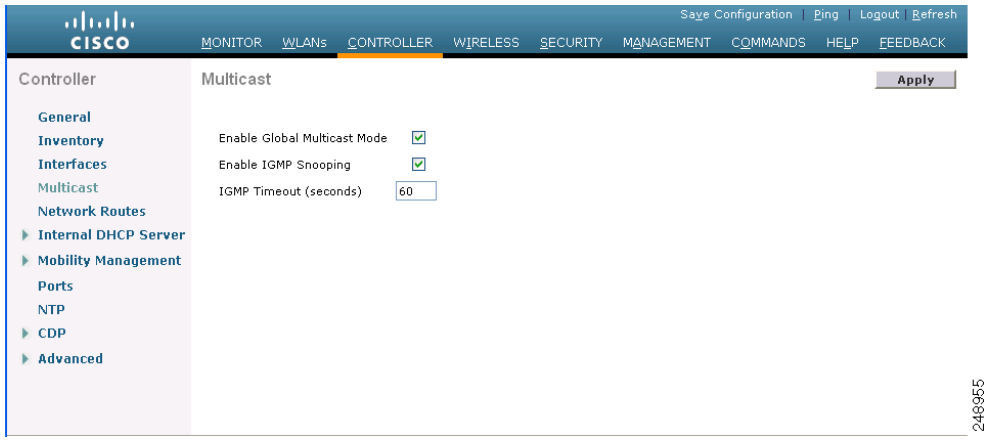
Step 6 Click Multicast to enable the global multicast mode (see Figure 7-37).

Enabling the Global Multicast Mode on Controllers

To enable the global multicast mode, follow these steps:

Step 1 Choose Controller > **Multicast** to open the Multicast page (see Figure 7-37.)

Figure 7-37 Multicast Page



Note The Enable IGMP Snooping text box is highlighted only when you enable the Enable Global Multicast mode. The IGMP Timeout (seconds) text box is highlighted only when you enable the Enable IGMP Snooping text box.

Step 2 Select the **Enable Global Multicast Mode** check box to enable the multicast mode. This step configures the controller to use the multicast method to send multicast packets to a CAPWAP multicast group.

Step 3 Select the **Enable IGMP Snooping** check box to enable the IGMP snooping. The default value is disabled.

Step 4 In the IGMP Timeout text box to set the IGMP timeout, enter a value between 30 and 7200 seconds.

Step 5 Click **Apply** to commit your changes.

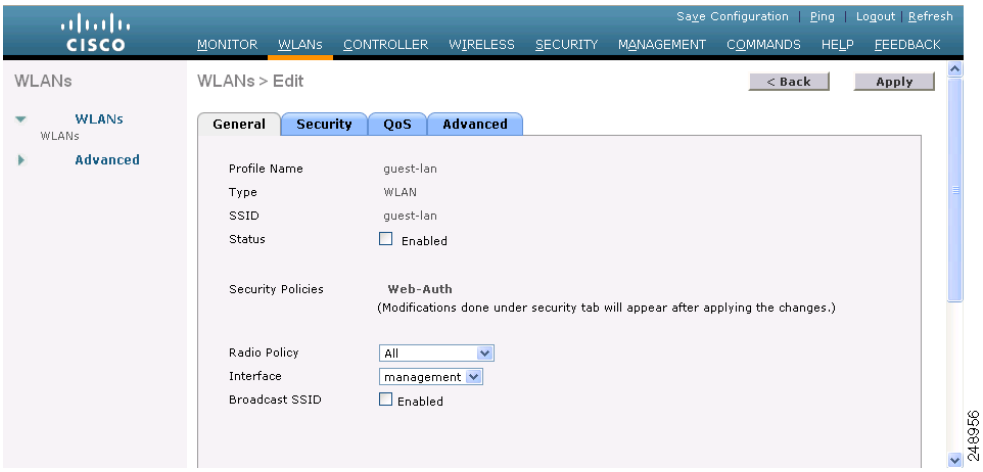
Enabling the Passive Client Feature on the Controller

To enable the passive client feature on the controller, follow these steps:

Step 1 Choose **WLANs > WLANs > WLAN ID** to open the WLANs > Edit page (see Figure 7-38). By default, the General tab is displayed.

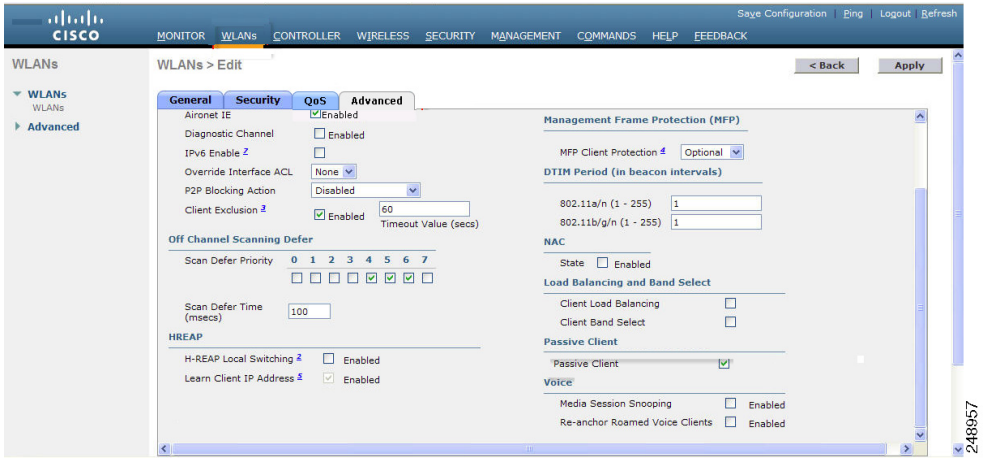
Step 2 Choose the **Advanced** tab.

Figure 7-38 WLAN > Edit Page



Step 3 Select the **Passive Client** check box (see Figure 7-39) to enable the passive client feature.

Figure 7-39 WLAN > Edit > Advanced Tab Page



Step 4 Click **Apply** to commit your changes.

Using the CLI to Configure Passive Client

To configure passive client using the controller CLI, follow these steps:

Note Make sure that you enable the multicast mode before you configure the passive client feature.

Step 1 Enable or disable multicasting on the controller by entering this command:

config network multicast global {**enable** | **disable**}

The default value is disabled.

Step 2 Configure the controller to use multicast to send multicast to an access point by entering this command:

config network multicast mode multicast *multicast_group_IP_address*

Step 3 Configure passive client on a wireless LAN by entering this command:

config wlan passive-client {**enable** | **disable**} *wlan_id*

Step 4 Configure a WLAN by entering this command:

config *wlan*

Step 5 Save your changes by entering this command:

save config

Step 6 Display the passive client information on a particular WLAN by entering this command:

show wlan *2*

Information similar to the following appears:

```
WLAN Identifier.................................. 2
Profile Name..................................... passive
Network Name (SSID).............................. passive
Status........................................... Enabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Network Admission Control
  NAC-State.............................Disabled
  Quarantine VLAN.......................0
Number of Active Clients.............1
Exclusionlist Timeout...................60 seconds
Session Timeout.........................1800 seconds
CHD per WLAN............................Enabled
Webauth DHCP exclusion..................Disabled
Interface...............................management
WLAN ACL................................unconfigured
DHCP Server.............................Default
DHCP Address Assignment Required......Disabled
--More-- or (q)uit
Quality of Service............................... Silver (best effort)
WMM.............................................. Allowed
CCX - AironetIe Support.......................... Enabled
CCX - Gratuitous ProbeResponse (GPR)............. Disabled
CCX - Diagnostics Channel Capability............. Disabled
Dot11-Phone Mode (7920).......................... Disabled
Wired Protocol................................... None
IPv6 Support..................................... Disabled
Passive Client Feature........................... Enabled
Peer-to-Peer Blocking Action..................... Disabled
Radio Policy..................................... All
DTIM period for 802.11a radio.................... 1
DTIM period for 802.11b radio.................... 1
Radius Servers
   Authentication................................ Global Servers
   Accounting.................................... Global Servers
Local EAP Authentication......................... Disabled
Security
   802.11 Authentication:........................ Open System
   Static WEP Keys............................... Disabled
   802.1X........................................ Disabled
   Wi-Fi Protected Access (WPA/WPA2)............. Disabled
--More-- or (q)uit
   CKIP ......................................... Disabled
   Web Based Authentication...................... Disabled
   Web-Passthrough............................... Disabled
   Conditional Web Redirect...................... Disabled
```

```
   Splash-Page Web Redirect..................... Disabled
   Auto Anchor.................................. Disabled
   H-REAP Local Switching....................... Disabled
   H-REAP Learn IP Address...................... Enabled
   Infrastructure MFP protection................ Enabled (Global Infrastructure MFP
Disabled)
   Client MFP................................... Optional but inactive (WPA2 not
configured)
   Tkip MIC Countermeasure Hold-down Timer..... 60
Call Snooping.................................. Disabled
Band Select.................................... Enabled
Load Balancing................................. Enabled
```

Step 7 Verify if the passive client is associated correctly with the AP and if the passive client has moved into the DHCP required state at the controller by entering this command:

debug client *mac_address*

Step 8 Display the detailed information for a client by entering this command:

show client detail *mac_address*

Information similar to the following appears:

```
Client MAC Address............................. 00:0d:28:f4:c0:45
Client Username ............................... N/A
AP MAC Address................................. 00:14:1b:58:19:00
Client State................................... Associated
Client NAC OOB State........................... Access
Wireless LAN Id................................ 1
BSSID.......................................... 00:14:1b:58:19:00
Connected For ................................. 8 secs
Channel........................................ 11
IP Address..................................... Unknown
.....

Security Policy Completed...................... No
Policy Manager State........................... DHCP_REQD
Policy Manager Rule Created.................... Yes
ACL Name....................................... none
ACL Applied Status............................. Unavailable
```

Step 9 Check if the client moves into the run state, when a wired client tries to contact the client by entering this command:

debug client *mac_address*

Step 10 Configure and check if the arp request is forwarded from the wired side to the wireless side by entering this command:

debug arp all enable

Information similar to the following appears:

```
*dtlArpTask: Apr 15 10:54:26.161: Received dtlArpRequest
   sha: 00:19:06:61:b1:c3 spa: 80.4.1.1
   tha: 00:00:00:00:00:00 tpa: 80.4.0.50
   intf: 1, vlan: 71, node type: 1, mscb: not found, isFromSta: 0^M^M
*dtlArpTask: Apr 15 10:54:26.161: dtlArpFindClient:ARP look-up for 80.4.0.50 failed (not a
client).

*dtlArpTask: Apr 15 10:54:26.161: Dropping ARP to DS (mscb (nil), port 65535)
   sha 0019.0661.b1c3 spa: 80.4.1.1
   tha 0000.0000.0000 tpa: 80.4.0.50
*dtlArpTask: Apr 15 10:54:26.161: Arp from Wired side to passive client
```

```
*dtlArpTask: Apr 15 10:54:27.465: dtlArpBcastRecv: received packet (rxTunType 1, dataLen
122)
```

Per-WLAN RADIUS Source Support

By default, the controller sources all RADIUS traffic from the IP address on its management interface. This means that even if a WLAN has specific RADIUS servers configured instead of the global list, the identity used is the management interface IP address.

If you want to do a per-user WLAN filtering, you can use the callStationID set by RFC 3580 to be in the APMAC:SSID format. You can also extend the filtering on the authentication server to be on a per-WLAN source interface by using the NAS-IP-Address attribute.

When the per-WLAN RADIUS source support is enabled, the controller sources all RADIUS traffic for a particular WLAN using the dynamic interface that is configured. Also, RADIUS attributes are modified accordingly to match the identity. This feature effectively virtualizes the controller on the per-WLAN RADIUS traffic, where each WLAN can have a separate L3 identity. This feature is useful in ACS Network Access Restrictions, Network Access Profiles, and so on.

This feature can be combined with normal RADIUS traffic source, with some WLANs using the management interface and others using the per-WLAN dynamic interface as the address source.

Configuring Per-WLAN RADIUS Source Support

You can configure the per-WLAN RADIUS source support using only the controller CLI:

Step 1 Enter the **config wlan disable** *wlan-id* command to disable the WLAN.

Step 2 Enter the following command to enable or disable the per-WLAN RADIUS source support:

config wlan radius_server overwrite-interface {**enable** | **disable**} *wlan-id*

Note When enabled, the controller uses the interface specified on the WLAN configuration as identity and source for all RADIUS related traffic on that WLAN.

When disabled, the controller uses the management interface as the identity in the NAS-IP-Address attribute. If the RADIUS server is on a directly connected dynamic interface, the RADIUS traffic will be sourced from that interface. Otherwise, the management IP address is used. In all cases, the NAS-IP-Address attribute remains the management interface, unless the feature is enabled.

Step 3 Enter the **config wlan enable** *wlan-id* command to enable the WLAN.

Note You can filter requests on the RADIUS server side using CiscoSecure ACS. You can filter (accept or reject) a request depending on the NAS-IP-Address attribute through a Network Access Restrictions rule. The filtering to be used is the CLI/DNIS filtering.

Monitoring the Status of Per-WLAN RADIUS Source Support

To see if the feature is enabled or disabled, enter the following command:

show wlan *wlan-id*

Example

The following example shows that the per-WLAN RADIUS source support is enabled on WLAN 1.

show wlan *1*

Information similar to the following is displayed:

```
WLAN Identifier.................................. 4
Profile Name..................................... 4400-wpa2
Network Name (SSID).............................. 4400-wpa2
Status........................................... Enabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Network Admission Control
...
Radius Servers
   Authentication................................ Global Servers
   Accounting.................................... Global Servers
   Overwrite Sending Interface................... Enabled
Local EAP Authentication......................... Disabled
```

Guidelines and Limitations

- It is up to the authentication server (RADIUS) to implement a proper rule filtering on the new identity because the controller sources traffic only from the selected interface.
- callStationID is always in the APMAC:SSID format to comply with 802.1x over RADIUS RFC. This is also a legacy behavior. Web-auth can use different formats available in the **config radius callStationIDType** command.
- If AP groups or AAA override are used, the source interface remains the WLAN interface, and not what is specified on the new AP group or RADIUS profile configuration.

Configuring Remote LANs

This section describes how to configure remote LANs using the controller GUI and CLI.

Caution You must remove all remote LANs from a controller's configuration before moving to a release that does not support the remote LAN functionality. The remote LAN changes to a WLAN in earlier releases, which could cause an undesirable or unsecured WLAN being broadcast on the wireless network. Remote LAN is only supported in release 7.0.116.0 and later.

Note Only four clients can connect to an OEAP 600 series access point through a remote LAN port. This number does not affect the fifteen WLAN limit imposed for the controller WLANs. The remote LAN client limit supports connecting a switch or hub to the remote LAN port for multiple devices or connecting directly to a Cisco IP phone that is connected to that port. Only the first four devices can connect until one of the devices is idle for more than one minute.

Note Remote LAN can be applied on a dedicated LAN port on an OEAP 600 series access point.

Using the GUI to Configure a Remote LAN

To create remote LANs using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

This page lists all of the WLANs and remote LANs currently configured on the controller. For each WLAN, you can see its WLAN/remote LAN ID, profile name, type, SSID, status, and security policies.

The total number of WLANs/Remote LANs appears in the upper right-hand corner of the page. If the list of WLANs/Remote LANs spans multiple pages, you can access these pages by clicking the page number links.

Note If you want to delete a Remote LAN, hover your cursor over the blue drop-down arrow for that WLAN and choose **Remove**, or select the check box to the left of the row, choose **Remove Selected** from the drop-down list, and click **Go**. A message appears asking you to confirm your decision. If you proceed, the remote LAN is removed from any access point group to which it is assigned and from the access point's radio.

Step 2 Create a new Remote-LAN by choosing **Create New** from the drop-down list and clicking **Go**. The WLANs > New page appears.

Step 3 From the Type drop-down list, choose **Remote LAN** to create a remote LAN.

Step 4 In the Profile Name text box, enter up to 32 alphanumeric characters for the profile name to be assigned to this Remote WLAN. The profile name must be unique.

Step 5 From the WLAN ID drop-down list, choose the ID number for this WLAN.

Step 6 Click **Apply** to commit your changes. The WLANs > Edit page appears (see Figure 7-3).

Note You can also open the WLANs > Edit page from the WLANs page by clicking the ID number of the WLAN that you want to edit.

Step 7 Use the parameters on the General, Security, and Advanced tabs to configure this remote LAN. See the sections in the rest of this chapter for instructions on configuring specific features.

Step 8 On the General tab, select the **Status** check box to enable this remote LAN. Be sure to leave it unselected until you have finished making configuration changes to the remote LAN.

Note You can also enable or disable remote LANs from the WLANs page by selecting the check boxes to the left of the IDs that you want to enable or disable, choosing **Enable Selected** or **Disable Selected** from the drop-down list, and clicking **Go**.

Step 9 Click **Apply** to commit your changes.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Configure a Remote LAN

To configure 802.1X for a remote LAN using the controller CLI, use the following commands:

- See the current configuration of the remote LAN by entering this command:

  show remote-lan *remote-lan-id*

- Enable or disable remote LAN by entering this command:

  config remote-lan {enable | disable} *remote-lan-id*

- Enable or disable 802.1X authentication for remote LAN by entering this command:

  config remote-lan security 802.1X {enable | disable} *remote-lan-id*

Caution The 802.1x authentication settings for a Remote LAN can only be configured or modified using the controller CLI. If a remote LAN is accessed through the controller GUI and any configuration changes are performed; regardless of any modifications from the GUI; the 802.1x settings for that remote LAN will be removed and whatever settings are shown in the GUI will be applied.

Note The encryption on a remote LAN is always “none”.

- Enable or disable local EAP with the controller as an authentication server, by entering this command:

  config remote-lan local-auth enable *profile-name remote-lan-id*

- If you are using an external AAA authentication server, use the following command:

  config remote-lan radius_server auth {add | delete} *remote-lan-id server id*

  config remote-lan radius_server auth {enable | disable} *remote-lan-id*

CHAPTER 8

Controlling Lightweight Access Points

This chapter describes the Cisco lightweight access points and explains how to connect them to the controller and manage access point settings. It contains these sections:

Access Point Communication Protocols

In controller software release 5.2 or later releases, Cisco lightweight access points use the IETF standard Control and Provisioning of Wireless Access Points Protocol (CAPWAP) to communicate with the controller and other lightweight access points on the network. Controller software releases prior to 5.2 use the Lightweight Access Point Protocol (LWAPP) for these communications.

CAPWAP, which is based on LWAPP, is a standard, interoperable protocol that enables a controller to manage a collection of wireless access points. CAPWAP is being implemented in controller software release 5.2 and later releases for these reasons:

- To provide an upgrade path from Cisco products that use LWAPP to next-generation Cisco products that use CAPWAP
- To manage RFID readers and similar devices
- To enable controllers to interoperate with third-party access points in the future

LWAPP-enabled access points can discover and join a CAPWAP controller, and conversion to a CAPWAP controller is seamless. For example, the controller discovery process and the firmware downloading process when using CAPWAP are the same as when using LWAPP. The one exception is for Layer 2 deployments, which are not supported by CAPWAP.

You can deploy CAPWAP controllers and LWAPP controllers on the same network. The CAPWAP-enabled software allows access points to join either a controller running CAPWAP or LWAPP. The only exceptions are that the Cisco Aironet 1260 and 3500 Series Access Points, which support only CAPWAP and join only controllers that run CAPWAP. For example, an 1130 series access point can join a controller running either CAPWAP or LWAPP where an1140 series access point can join only a controller that runs CAPWAP.

Guidelines for Using CAPWAP

Follow these guidelines when using CAPWAP:

- If your firewall is currently configured to allow traffic only from access points using LWAPP, you must change the rules of the firewall to allow traffic from access points using CAPWAP.
- Make sure that the CAPWAP UDP ports 5246 and 5247 (similar to the LWAPP UDP ports 12222 and 12223) are enabled and are not blocked by an intermediate device that could prevent an access point from joining the controller.
- If access control lists (ACLs) are in the control path between the controller and its access points, you need to open new protocol ports to prevent access points from being stranded.

Configuring Data Encryption

Cisco 5500 Series Controllers enable you to encrypt CAPWAP control packets (and optionally, CAPWAP data packets) that are sent between the access point and the controller using Datagram Transport Layer Security (DTLS). DTLS is a standards-track Internet Engineering Task Force (IETF) protocol based on TLS. CAPWAP control packets are management packets exchanged between a controller and an access point while CAPWAP data packets encapsulate forwarded wireless frames. CAPWAP control and data packets are sent over separate UDP ports: 5246 (control) and 5247 (data). If an access point does not support DTLS data encryption, DTLS is enabled only for the control plane, and a DTLS session for the data plane is not established.

Note Cisco 1130 and 1240 series access points support DTLS data encryption with software-based encryption, and 1040, 1140, 1250, 1260, and 3500 series access points support DTLS data encryption with hardware-based encryption.

DTLS data encryption is enabled automatically for OfficeExtend access points but disabled by default for all other access points. Most access points are deployed in a secure network within a company building, so data encryption is not necessary. In contrast, the traffic between an OfficeExtend access point and the controller travels through an unsecure public network, so data encryption is more important for these access points. When data encryption is enabled, traffic is encrypted at the access point before it is sent to the controller and at the controller before it is sent to the client.

Note Encryption limits throughput at both the controller and the access point, and maximum throughput is desired for most enterprise networks.

Caution In a Cisco unified local wireless network environment, do not enable DTLS on the Cisco 1130 and 1240 access points, as it may result in severe throughput degradation and may render the APs unusable.

Note See the"OfficeExtend Access Points" section on page 8-69 for more information on OfficeExtend access points.

You can use the controller GUI or CLI to enable or disable DTLS data encryption for a specific access point or for all access points.

The availability of data DTLS for the 7.0.116.0 release is as follows:

- The Cisco 5500 Series Controller will be available with two licenses options: One that allows data DTLS without any license requirements and another image that requires a license to use data DTLS. See "Upgrading or Downgrading DTLS Images for Cisco 5500 Series Controllers" section on page 8-4. The images for the DTLS and licensed DTLS images are as follows:
  - Licensed DTLS—AS_5500_LDPE_x_x_x_x.aes
  - Non licensed DTLS—AS_5500_x_x_x_x.aes
- Cisco 2500, WiSM2, WLC2—By default, these platforms do not contain DTLS. To turn on data DTLS, you must install a license. These platforms have a single image with data DTLS turned off. To use data DTLS you will need to have a license.

Note If your controller does not have a data DTLS license and if the access point associated with the controller has DTLS enabled, the data path will be unencrypted.

Note Non Russian customers using Cisco 5508 Series Controller do not need data DTLS license. However all customers using WISM2 and Cisco 2500 Series Controllers must enable data DTLS.

Upgrading or Downgrading DTLS Images for Cisco 5500 Series Controllers

A regular image (DTLS enabled) can be upgraded or downgraded to a licensed DTLS image using the following two step process:

Step 1 The upgrade operation fails on first attempt with a warning indicating that the upgrade to a licensed DTLS image is irreversible.

Step 2 On a subsequent attempt, the license is applied and the image is successfully updated.

Note The controller must not be rebooted after step 1.

The following are some of the guidelines when upgrading to or from a DTLS image:

- You cannot install a regular image (non-Licensed data DTLS) once a licensed data DTLS image is installed.
- You can upgrade from one licensed DTLS image to another licensed DTLS image.
- You can upgrade from a regular image (DTLS) to a licensed DTLS image in a two step process.

Using the GUI to Configure Data Encryption

To enable DTLS data encryption for access points on the controller using the controller GUI, follow these steps:

Step 1 Make sure that the base license is installed on the Cisco 5500 Series Controller. Once the license is installed, you can enable data encryption for the access points.

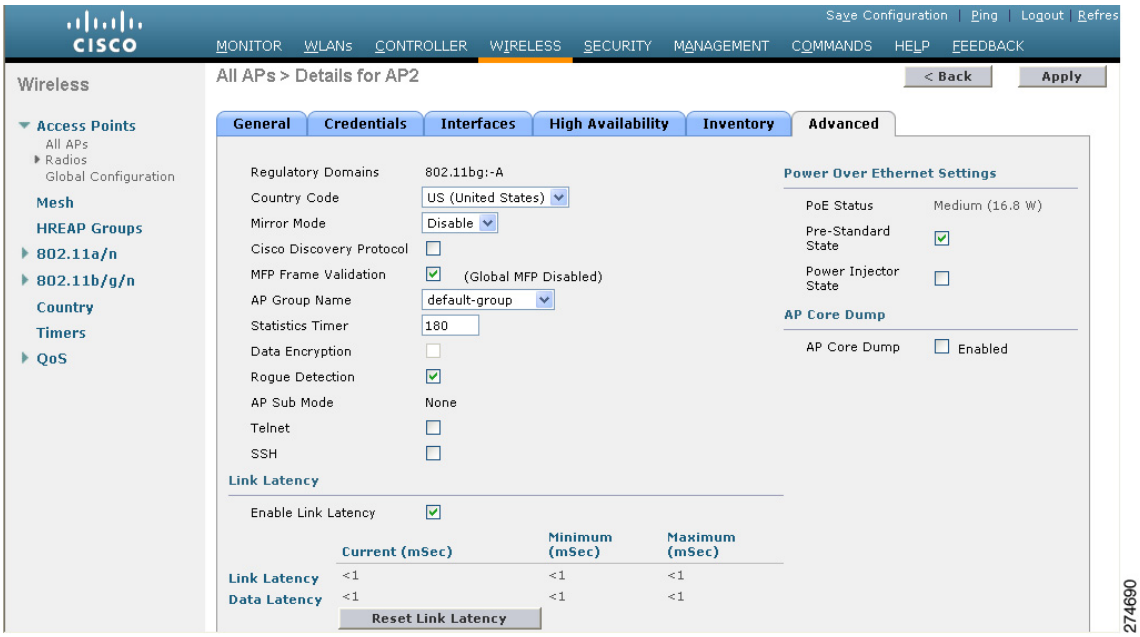
Note See Chapter 4, "Configuring Controller Settings," for information on obtaining and installing licenses.

Step 2 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 3 Click the name of the access point for which you want to enable data encryption.

Step 4 Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 8-1).

Figure 8-1 All APs > Details for (Advanced) Page



Step 5 Select the **Data Encryption** check box to enable data encryption for this access point or unselect it to disable this feature. The default value is unselected.

Note Changing the data encryption mode requires the access points to rejoin the controller.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Configure Data Encryption

Note In images without a DTLS license, the **config** or **show** commands are not available.

To enable DTLS data encryption for access points on the controller using the controller CLI, follow these steps:

Step 1 Enable or disable data encryption for all access points or a specific access point by entering this command:

config ap link-encryption {**enable** | **disable**} {**all** | *Cisco_AP*}

The default value is disabled.

Note Changing the data encryption mode requires the access points to rejoin the controller.

Step 2 When prompted to confirm that you want to disconnect the access point(s) and attached client(s), enter **Y**.

Step 3 Save your changes by entering this command:

save config

Step 4 See the encryption state of all access points or a specific access point by entering this command:

show ap link-encryption {**all** | *Cisco_AP*}

Information similar to the following appears:

```
                Encryption Dnstream  Upstream Last
AP Name         State      Count     Count    Update
--------------  ---------- --------  --------  --------
AP1130          En         112       1303      23:49
AP1140          En         232      2146      23:49
             auth err: 198 replay err: 0
AP1250          En         0         0         Never
AP1240          En         6191    15011      22:13
```

This command also shows authentication errors, which tracks the number of integrity check failures, and replay errors, which tracks the number of times that the access point receives the same packet.

Step 5 See a summary of all active DTLS connections by entering this command:

show dtls connections

Information similar to the following appears:

```
AP Name         Local Port        Peer IP        Peer Port               Ciphersuite
------------- ------------- ----------------  ------------ ----------------------------
AP1130          Capwap_Ctrl    172.20.225.163      62369     TLS_RSA_WITH_AES_128_CBC_SHA
AP1250          Capwap_Ctrl    172.20.225.166      19917     TLS_RSA_WITH_AES_128_CBC_SHA
AP1140          Capwap_Ctrl    172.20.225.165       1904     TLS_RSA_WITH_AES_128_CBC_SHA
AP1140          Capwap_Data    172.20.225.165       1904     TLS_RSA_WITH_AES_128_CBC_SHA
AP1130          Capwap_Data    172.20.225.163      62369     TLS_RSA_WITH_AES_128_CBC_SHA
AP1250          Capwap_Data   172.20.225.166     19917    TLS_RSA_WITH_AES_128_CBC_SHA
```

Note If you experience any problems with DTLS data encryption, enter the **debug dtls** {**all** | **event** | **trace** | **packet**} {**enable** | **disable**} command to debug all DTLS messages, events, traces, or packets.

Viewing CAPWAP MTU Information

See the maximum transmission unit (MTU) for the CAPWAP path on the controller by entering this command:

show ap config general *Cisco_AP*

The MTU specifies the maximum size of any packet (in bytes) in a transmission.

Information similar to the following appears:

```
Cisco AP Identifier.............................. 9
Cisco AP Name.................................... Maria-1250
Country code..................................... US  - United States
Regulatory Domain allowed by Country.............. 802.11bg:-A     802.11a:-A
AP Country code.................................. US  - United States
AP Regulatory Domain............................. 802.11bg:-A    802.11a:-A
Switch Port Number .............................. 1
```

```
MAC Address..................................... 00:1f:ca:bd:bc:7c
IP Address Configuration........................ DHCP
IP Address...................................... 1.100.163.193
IP NetMask...................................... 255.255.255.0
CAPWAP Path MTU............................... 1485
...
```

Debugging CAPWAP

Use these CLI commands to obtain CAPWAP debug information:

- **debug capwap events** {**enable** | **disable**}—Enables or disables debugging of CAPWAP events.
- **debug capwap errors** {**enable** | **disable**}—Enables or disables debugging of CAPWAP errors.
- **debug capwap detail** {**enable** | **disable**}—Enables or disables debugging of CAPWAP details.
- **debug capwap info** {**enable** | **disable**}—Enables or disables debugging of CAPWAP information.
- **debug capwap packet** {**enable** | **disable**}—Enables or disables debugging of CAPWAP packets.
- **debug capwap payload** {**enable** | **disable**}—Enables or disables debugging of CAPWAP payloads.
- **debug capwap hexdump** {**enable** | **disable**}—Enables or disables debugging of the CAPWAP hexadecimal dump.
- **debug capwap dtls-keepalive** {**enable** | **disable**}—Enables or disables debugging of CAPWAP DTLS data keepalive packets.

Controller Discovery Process

In a CAPWAP environment, a lightweight access point discovers a controller by using CAPWAP discovery mechanisms and then sends the controller a CAPWAP join request. The controller sends the access point a CAPWAP join response allowing the access point to join the controller. When the access point joins the controller, the controller manages its configuration, firmware, control transactions, and data transactions.

Upgrade and downgrade paths from LWAPP to CAPWAP or from CAPWAP to LWAPP are supported. An access point with an LWAPP image starts the discovery process in LWAPP. If it finds an LWAPP controller, it starts the LWAPP discovery process to join the controller. If it does not find a LWAPP controller, it starts the discovery in CAPWAP. If the number of times that the discovery process starts with one discovery type (CAPWAP or LWAPP) exceeds the maximum discovery count and the access point does not receive a discovery response, the discovery type changes to the other type. For example, if the access point does not discover the controller in LWAPP, it starts the discovery process in CAPWAP.

Note If an access point is in the UP state and its IP address changes, the access point tears down the existing CAPWAP tunnel and rejoins the controller. In previous software releases, the access point notifies the controller, and the session continues with the changed IP address without tearing down the session.

Note You must install software release 4.0.155.0 or later releases on the controller before connecting 1100 and 1300 series access points to the controller. The 1120 and 1310 access points were not supported prior to software release 4.0.155.0.

Note During the discovery process, the 1140 and 3500 series access points will only query for Cisco CAPWAP Controllers. It will not query for LWAPP controllers. If you want these access points to query for both LWAPP and CAPWAP controllers then you need to update the DNS.

Note Make sure that the controller is set to the current time. If the controller is set to a time that has already occurred, the access point might not join the controller because its certificate may not be valid for that time.

Access points must be discovered by a controller before they can become an active part of the network. The lightweight access points support these controller discovery processes:

- Layer 3 CAPWAP or LWAPP discovery—This feature can be enabled on different subnets from the access point and uses IP addresses and UDP packets rather the MAC addresses used by Layer 2 discovery.
- Over-the-air provisioning (OTAP)—This feature is supported by Cisco 5500 and 4400 Series Controllers. If this feature is enabled on the controller (on the controller General page or through the **config network otap-mode** {**enable** | **disable**} CLI command), all associated access points transmit wireless CAPWAP or LWAPP neighbor messages, and new access points receive the controller IP address from these messages. This feature is disabled by default and should remain disabled when all access points are installed.

  Note Disabling OTAP on the controller does not disable it on the access point. OTAP cannot be disabled on the access point.

  Note You can find additional information about OTAP at this URL: http://www.ciscosystems.com/en/US/products/ps6366/products_tech_note09186a008093d74a.shtml

- Locally stored controller IP address discovery—If the access point was previously associated to a controller, the IP addresses of the primary, secondary, and tertiary controllers are stored in the access point's nonvolatile memory. This process of storing controller IP addresses on an access point for later deployment is called *priming the access point*.
- DHCP server discovery—This feature uses DHCP option 43 to provide controller IP addresses to the access points. Cisco switches support a DHCP server option that is typically used for this capability. For more information about DHCP option 43, see the "Using DHCP Option 43 and DHCP Option 60" section on page 8-52.
- DNS discovery—The access point can discover controllers through your domain name server (DNS). For the access point to do so, you must configure your DNS to return controller IP addresses in response to CISCO-LWAPP-CONTROLLER.*localdomain*, where *localdomain* is the access point domain name. When an access point receives an IP address and DNS information from a DHCP server, it contacts the DNS to resolve CISCO-LWAPP-CONTROLLER.*localdomain*. When the DNS sends a list of controller IP addresses, the access point sends discovery requests to the controllers.

Verifying that Access Points Join the Controller

When replacing a controller, you need to make sure that access points join the new controller.

Using the GUI to Verify that Access Points Join the Controller

To ensure that access points join the new controller using the controller GUI, follow these steps:

Step 1 Configure the new controller as a master controller as follows:

a. Choose **Controller > Advanced > Master Controller Mode** to open the Master Controller Configuration page.

b. Select the **Master Controller Mode** check box.

c. Click **Apply** to commit your changes.

d. Click **Save Configuration** to save your changes.

Step 2 (Optional) Flush the ARP and MAC address tables within the network infrastructure.

Step 3 Restart the access points.

Step 4 Once all the access points have joined the new controller, configure the controller not to be a master controller by unselecting the **Master Controller Mode** check box on the Master Controller Configuration page.

Using the CLI to Verify that Access Points Join the Controller

To ensure that access points join the new controller using the controller CLI, follow these steps:

Step 1 Configure the new controller as a master controller by entering this command:

config network master-base enable

Step 2 (Optional) Flush the ARP and MAC address tables within the network infrastructure.

Step 3 Restart the access points.

Step 4 Configure the controller not to be a master controller once all the access points have joined the new controller by entering this command:

config network master-base disable

All APs

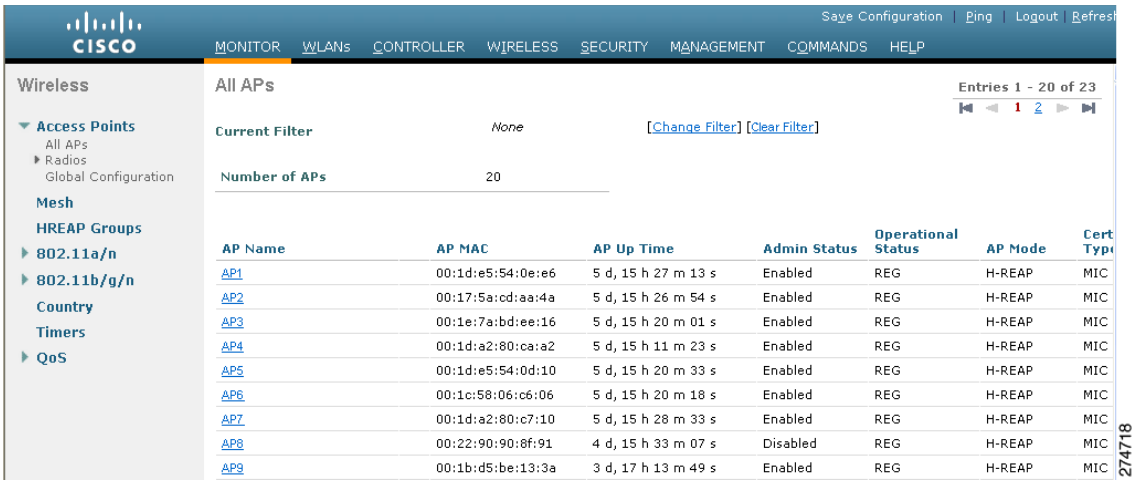
You can search for specific access points in the list of access points on the All APs page. To do so, you create a filter to display only access points that meet certain criteria (such as MAC address, status, access point mode, and certificate type). This feature is especially useful if your list of access points spans multiple pages, preventing you from viewing them all at once.

Using the GUI to Search the AP Filter

To search for access points using the controller GUI, follow these steps:

Step 1 Choose **Monitor > Access Point Summary> All APs > Details** to open the All APs page (see Figure 8-2).

Figure 8-2 All APs Page

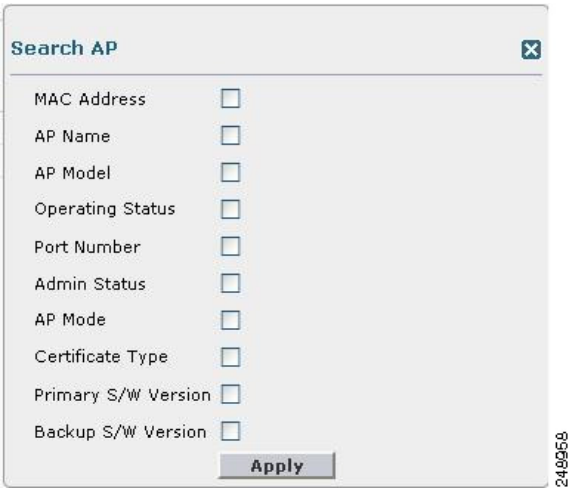


This page lists all of the access points joined to the controller. For each access point, you can see its name, MAC address, uptime, status, operating mode, certificates, OfficeExtend access point status, and access point submode.

The total number of access points appears in the upper right-hand corner of the page. If the list of access points spans multiple pages, you can access these pages by clicking the page number links. Each page shows up to 20 access points.

Step 2 Click **Change Filter** to open the Search AP dialog box (see Figure 8-3).

Figure 8-3 Search AP Dialog Box



Step 3 Select one or more of the following check boxes to specify the criteria used when displaying access points:

- **MAC Address**—Enter the MAC address of an access point.

  Note When you enable the MAC Address filter, the other filters are disabled automatically. When you enable any of the other filters, the MAC Address filter is disabled automatically.

- **AP Name**—Enter the name of an access point.
- **AP Model**—Enter the model name of an access point.
- **Operating Status**—Select one or more of the following check boxes to specify the operating status of the access points:
  - **UP**—The access point is up and running.
  - **DOWN**—The access point is not operational.
  - **REG**—The access point is registered to the controller.
  - **DEREG**—The access point is not registered to the controller.
  - **DOWNLOAD**—The controller is downloading its software image to the access point.
- **Port Number**—Enter the controller port number to which the access point is connected.
- **Admin Status**—Choose **Enabled** or **Disabled** to specify whether the access points are enabled or disabled on the controller.
- **AP Mode**—Select one or more of the following options to specify the operating mode of the access points:
  - **Local**—The default option.

    Note The 600 OEAP series access point uses only local mode.

    When an access point in local mode connects to a Cisco Flex 7500 Series Controller, it does not serve clients. The access point details are available in the controller. To enable an access point to serve clients or perform monitoring-related tasks when connected to the Cisco Flex 7500 Series Controller, the access point mode must be in hybrid-REAP or monitor mode. Use the following command to automatically convert access points to a hybrid-REAP mode or monitor mode on joining the controller:

    config ap autoconvert {hreap | monitor | disable}

    All access points that connect to the controller will either be converted to hybrid-REAP mode or monitor mode depending on the configuration provided.
  - **HREAP (hybrid Remote Edge lightweight Access Point)**—This mode is used for 1040, 1130AG, 1140, 1240AG, 1250, 1260, 3500, AP801, and AP802 access points.
  - **REAP**—This mode is the remote edge lightweight access point.
  - **Monitor**—This mode is the monitor-only mode.
  - **Rogue Detector**—This mode monitors the rogue APs on wire. It does not transmit or receive frames over the air or contain rogue AP**s.**

- **Sniffer**—The access point starts sniffing the air on a given channel. It captures and forwards all the packets from the clients on that channel to a remote machine that runs Airopeek or Wireshark (packet analyzers for IEEE 802.11 wireless LANs). It includes information on the time stamp, signal strength, packet size, and so on.

Note The Bridge option is displayed only if the AP is bridge capable.

Note If the AP mode is set to "Bridge" and the AP is not REAP capable, an error appears.

- **Bridge**—This mode sets the AP mode to "Bridge" if you are connecting a Root AP.
- **SE-Connect**—This mode allows you to connect to spectrum expert and it allows the access point to perform spectrum intelligence.

Note The AP3500 supports the spectrum intelligence and AP1260 does not support the spectrum intelligence.

Note When an access point is configured in SE-Connect mode, the access point reboots and rejoins the controller. Access points that are configured in this mode do not serve the client.

- **Certificate Type**—Select one or more of the following check boxes to specify the types of certificates installed on the access points:
  - **MIC**—Manufactured-installed certificate
  - **SSC**—Self-signed certificate
  - **LSC**—Local significant certificate

Note See the "Authorizing Access Points" section on page 8-45 for more information on these certificate types.

- **Primary S/W Version**—Select this check box to enter the primary software version number
- **Backup S/W Version**—Select this check box to enter the secondary software version number.

Step 4 Click **Apply** to commit your changes. Only the access points that match your search criteria appear on the All APs page, and the Current Filter parameter at the top of the page specifies the filter used to generate the list (for example, MAC Address:00:1d:e5:54:0e:e6, AP Name:pmsk-ap, Operational Status: UP, Status: Enabled, and so on).

Note If you want to remove the filters and display the entire access point list, click **Clear Filter**.

All APs > Details

Choose **WIRELESS > Access Points > All APs** and then click an AP name to navigate to this page. This page shows the details of the selected access point including the hardware, operating system, and boot version details.

General Tab

Table 8-1 describes the parameters that are listed under the General Tab.

Table 8-1 General Tab Parameters

Paramter	Description
AP Name	User-definable name of the access point.
Location	User-definable location name for the access point.
AP MAC Address	MAC address of the access point.
Base Radio MAC	MAC address of the 802.11a/b/g/n radio.
Status	Administration state of the access point: enabled or disabled.

Table 8-1 General Tab Parameters (continued)

Paramter	Description
AP Mode	Access point mode of operation. The options are as follows: • Local—Specifies the default option. **Note** The 600 OEAP series access points uses only local mode. When an access point in local mode connects to a Cisco Flex 7500 Series Controller, it does not serve clients. The access point details are available in the controller. To enable an access point to serve clients or perform monitoring-related tasks when connected to the Cisco Flex 7500 Series Controller, the access point mode must be in hybrid-REAP or monitor mode. All access points that connect to the controller will either be converted to hybrid-REAP mode or monitor mode depending on the configuration provided. • H-REAP (hybrid Remote Edge lightweight Access Point)—Specifies the 1040, 1130AG, 1140, 1240AG, 1250, 1260, 3500, AP801, and AP802 access points. • Monitor—Specifies the monitor-only mode. • Rogue Detector—This mode monitors the rogue APs on wire. It does not transmit or receive frames over the air or contain rogue APs. • Sniffer—Specifies the access point that starts sniffing the air on a given channel. It captures and forwards all the packets from the clients on that channel to a remote machine that runs Airopeek or Wireshark (packet analyzers for IEEE 802.11 wireless LANs). It will include information on time stamps, signal strength, packet sizes and so on. **Note** The Bridge option is displayed only if the AP is bridge capable. **Note** If the AP mode is set to "Bridge" and the AP is not REAP capable, an error appears. • Bridge—Sets the AP mode to "Bridge" if you are connecting a Root AP. **Note** The SE-Connect option is displayed only if the AP is CleanAir capable. **Note** When an access point is configured in SE-Connect mode, the access point will reboot and rejoin the controller. Access points that are configured in this mode do not serve clients. • SE-Connect—Sets the AP mode to SE-Connect if you want the access point to perform spectrum intelligence.
AP Sub Mode	Displays *wIPS* if the access point in is Monitor, Local, or H-REAP modes and the wIPS submode is configured on the access point or *None* if the access point is not in Monitor mode or the access point is in Monitor mode but the wIPS submode is not configured.
Operational Status	Operational status of the access point that comes up as either registered (REG) or not registered (DEREG) automatically by the controller.
Port Number	Access point that is connected to this controller port.

Versions Tab

Table 8-2 describes the parameters that are listed under the Versions Tab.

Table 8-2 Versions Tab Parameters

Parameters	Description
Primary Software Version	Primary software version.
Backup Software Version	Version of the backup software on this access point.
Predownload Status	Predownload status on this access point.
Predownloaded Version	Version of the software that is being predownloaded.
Predownload Next Retry time	Time duration after which this access point will try to perform a predownload operation.
Predownload Retry Count	Count of the number of times this access point has tried to perform the predownload operation.
Boot Version	Boot ROM versions.
IOS Version	Cisco IOS Software version.
Mini IOS Version	Mini-IOS software version.

Table 8-3 lists the IP configuration parameters.

Table 8-3 IP Config Parameters

Parameter	Description
IP Address	IP address of the access point.
Static IP	Static IP address of the access point. When an access point boots up, it tries to determine if its static IP address is configured or not. If an access point has been configured with a static IP address that is not valid on the network, the access point cannot join the controller and cannot communicate with the rest of the network. The only way to recover that access point is to manually open the access point door and connect a serial console for configuration purpose. The access point can be configured in such a way that even if its static IP address is not valid on the network, it initiates a DHCP process to get a new IP address and uses it for communication. This situation allows the access point to join the controllers on the network. **Note** An access point cannot discover the controller using domain name system (DNS) resolution if a static IP address is configured for the access point, unless you specify a DNS server and the domain to which the access point belongs. Options for this parameter are as follows: • Unselected—When the box is unselected, the static IP address is disabled and the access point initiates a DHCP process when it boots up to procure the IP address. • Selected—When the box is selected, you can set the following: – The static IP address of the access point. – The subnet mask assigned to the access point IP address. – The gateway of the access point. Click **Apply** to commit your changes. The access point reboots and rejoins the controller, and the static IP address that you specified is sent to the access point. You can now configure the DNS server IP address and domain name. To do so, follow these steps: – In the DNS IP Address text box, enter the IP address of the DNS server. – In the Domain Name text box, enter the name of the domain to which the access point belongs. Click **Apply** to commit your changes.

Table 8-4 lists the time statistics parameters.

Table 8-4 Time Statistics Parameters

Parameters	Description
UP Time	Amount of time that the access point has been powered up.
Controller Associated Time	Amount of time that the access point has been associated with the controller.
Controller Associated Latency	Amount of time that the access point took to associate with the controller.

Table 8-5 lists the hardware reset parameters.

Table 8-5 Hardware Reset

Button	Description
Reset AP Now	Button that resets the access point.

Table 8-6 lists the set to factory defaults parameters.

Table 8-6 Set to Factory Defaults

Button	Description
Clear All Config	Button that resets the access point parameters to the factory-defaults. **Note** The clear all configuration action does not affect OEAP 600 Series Access Point. The only way to reset the access point to factory defaults is by pressing the reset button on the access point and then power cycling the AP.
Clear Config Except Static IP	Button that resets the access point parameters to the factory defaults but retains the static IP address information.

Credentials Tab

Table 8-7 lists the login parameters under the Credentials Tab.

Table 8-7 Login Credentials

Parameter	Description
Over-ride Global credentials	Credentials that prevent this access point from inheriting the global username, password, and enable password from the controller. The default value is unselected. **Note** The Username, Password, and Enable Password text boxes appears only when you select the **Over-ride Global credentials** check box.
Username	Unique username for this access point.
Password	Unique password for this access point.
Enable Password	Unique enable password for this access point.

Table 8-8 lists the 802.1X supplicant credentials parameters.

Table 8-8 802.1X Supplicant Credentials

Parameter	Description
Over-ride Global credentials	Credentials that prevent this access point from inheriting the global authentication username and password from the controller. The default value is unselected. **Note** The Username, Password, and Confirm Password text boxes are displayed only when you select the Over-ride Global credentials check box.
Username	Unique username for this access point.
Password	Unique password for this access point. **Note** You must enter a strong password. Strong passwords have the following characteristics: • They are at least eight characters long. • They contain a combination of uppercase and lowercase letters, numbers, and symbols. • They are not a word in any language.
Confirm Password	Action to reenter the unique password for this access point.

Interfaces Tab

Note Ethernet Interfaces statistics are displayed only for mesh or bridged access points; statistics are not displayed for nonmesh access points.

Table 8-9 lists the Ethernet interfaces parameters.

Table 8-9 Ethernet Interfaces

Parameter	Description
Interface	Interface name.
Operational Status	Status of the interface.
Tx Unicast Packets	Number of unicast packets transmitted.
Rx Unicast Packets	Number of unicast packets received.
Tx Non-Unicast Packets	Number of nonunicast packets transmitted.
Rx Non-Unicast Packets	Number of nonunicast packets received.

Table 8-10 lists the interface properties parameters.

Table 8-10 Interface Properties Parameters

Parameter	Description
AP Name	Name of the access point.
Link Speed	Speed of the interference in Mbps.
RX Bytes	Total number of bytes in the error-free packets received on the interface.
RX Unicast Packets	Total number of unicast packets received on the interface.
RX Non-Unicast Packets	Total number of nonunicast or multicast packets received on the interface.
Input CRC	Total number of CRC error in packets while receiving on the interface.
Input Errors	Sum of all errors in the packets while receiving on the interface.
Input Overrun	Number of times the receiver hardware was incapable of handling received data to a hardware buffer because the input rate exceeded the receiver's capability to handle the data.
Input Resource	Total number of resource errors in packets received on the interface.
Runts	Number of packets that are discarded because they are similar than the medium's minimum packet size.
Throttle	Total number of times the interface advised a sending NIC that it was overwhelmed by packets being sent and to slow the pace of delivery.
Output Collision	Total number of packet retransmitted due to an Ethernet collision.
Output Resource	Resource errors in packets transmitted on the interface.
Output Errors	Errors that prevented the final transmission of packets out of the interface.
Operational Status	Operational state of the physical ethernet interface on the AP.
Duplex	Interface's duplex mode.
TX Bytes	Number of bytes in the error-free packets transmitted on the interface.
TX Unicast Packets	Total number of unicast packets transmitted on the interface.
TX Non-Unicast Packets	Total number of nonunicast or multicast packets transmitted on the interface.
Input Aborts	Total number of packets aborted while receiving on the interface.
Input Frames	Total number of packets received incorrectly that has a CRD error and a noninteger number of octets on the interface.
Input Drops	Total number of packets dropped while receiving on the interface because the queue was full.
Unknown Protocol	Total number of packets discarded on the interface due to an unknown protocol.
Giants	Number of packets that are discarded because they exceeded the medium's maximum packet size.
Interface Resets	Number of times that an interface has been completely reset.
Output No Buffer	Total number of packets discarded because there was no buffer space.

Table 8-10 Interface Properties Parameters (continued)

Parameter	Description
Output Underrun	Number of times the transmitter has been running faster than the router can handle.
Outout Total Drops	Total number of packets dropped while transmitting from the interface because the queue was full.

Table 8-11 lists the radio interface parameters.

Table 8-11 Radio Interfaces

Parameter	Description
Number of Radio interfaces	Number of radio interfaces.
Radio Slot#	Slot where the radio is installed.
Radio Interface Type	Cisco Radio type: 802.11a/n or 802.11b/g/n.
Sub Band	Cisco Radio sub band, if it is active: 4.9 GHz or 5 GHz.
Admin Status	Cisco Radio interface status: enabled or disabled.
Oper Status	Cisco Radio operational status: UP or DOWN.
CleanAir admin Status	CleanAir admin status.
CleanAir oper status	CleanAir operator status.
Regulatory Domain	Whether the domain is supported or unsupported.

High Availability Tab

Note Entering an IP address for the backup controller is optional. If the backup controller is outside the mobility group to which the access point is connected (the primary controller), then you need to provide the IP address of the primary, secondary, or tertiary controller, respectively. The controller name and IP address must belong to the same primary, secondary, or tertiary controller. Otherwise, the access point cannot join the backup controller.

Table 8-12 lists the high availability tab parameters.

Table 8-12 High Availability Tab Parameters

Parameter	Description
Primary Controller	Name and management IP address of the primary controller.
Secondary Controller	Name and management IP address of the secondary controller.

Table 8-12 High Availability Tab Parameters (continued)

Parameter	Description
Tertiary Controller	Name and management IP address of the tertiary controller.
AP Failover Priority	Priority for the access point: • Low—Assigns the access point to the level 1 priority, which is the lowest priority level. This is the default value. • Medium—Assigns the access point to the level 2 priority. • High—Assigns the access point to the level 3 priority. • Critical—Assigns the access point to the level 4 priority, which is the highest priority level.

Inventory Tab

Table 8-13 lists the inventory tab parameters.

Table 8-13 Inventory Tab Parameters

Parameter	Description
Product ID	Model of the access point.
Version ID	Version of the access point.
Serial Number	Access point's serial number, for example, FTX0916T134.
Entity Name	Access point's entity name.
Entity Description	Access point's entity description.
Certificate Type	Certificate type: Self Signed or Manufacture Installed.
H-REAP Mode Supported	Whether the access point can be configured as a remote edge lightweight access point: Yes or No. H-REAP Mode is supported on the 1130AG, 1140, 1240AG, 1250, 1260, 3500, AP801, and AP802 access points. **Note** By default, VLAN is not enabled on the H-REAP. After it is enabled, H-REAP inherits the VLAN name (interface name) and VLAN-ID associated to WLANs. This configuration is saved in the access point and received after the successful join response. By default, no VLAN is set as a native VLAN. There must be one native VLAN configured per REAP in a VLAN enabled domain. Otherwise, REAP cannot send packets to or receive packets from the controller. When the client gets assigned a VLAN from the RADIUS server for the client, that VLAN is associated to the local switched WLAN. **Note** Black list—H-REAP supports the first 128 entries in the list in the standalone mode.

Mesh Tab

Note This tab appears if you set the AP Mode on the General Tab to Bridge.

Table 8-14 lists the mesh tab parameters.

Table 8-14 Mesh Tab

Parameter	Description
AP Role	Root AP or Mesh AP. Root APs have a wired CAPWAP (Control and Provisioning of Wireless Access Points) protocol connection back to a Cisco controller. This connection uses the backhaul wireless interface to communicate to neighboring Mesh APs. Root APs are the parent node to any bridging or mesh network and connect a bridge or mesh network to the wired network. Only one Root AP can be on for any bridged or mesh network. Mesh APs have no wired connection to a Cisco controller. They can be completely wireless supporting clients, communicating to other Mesh APs and a Root AP to get access to the network, or they can be wired and serve as bridge to a remote wired network.
Bridge Type	*Display only.* Whether the access point is an indoor or outdoor access point.
Bridge Group Name	Bridge group name. Use bridge group names to logically group the access points and avoid two networks on the same channel from communicating with each other. **Note** For the access points to communicate with each other, they must have the same bridge group name.
Ethernet Bridging	Ethernet bridging on the access point. If the AP Mode is Root AP, Ethernet bridging is enabled by default. If the AP Mode is Mesh AP, Ethernet bridging is disabled by default. Enable Ethernet bridging on a Mesh AP if you want to do the following: • Use the mesh nodes as bridges. • Connect an Ethernet device on the Mesh AP using its Ethernet port. **Note** When you enable Ethernet Bridging and click **Apply**, the Table 8-15Ethernet Bridging Parameters area appears and lists the four Ethernet ports of the mesh access point.
Backhaul Interface	*Display only.* Backhaul interface (802.11a, 802.11b or 802.11g).

Table 8-14 Mesh Tab (continued)

Parameter	Description
Bridge Data Rate (Mbps)	Data rate. This is the rate at which data is shared between the access points. The drop-down list displays the data rates depending on the Backhaul Interface set. The correct range of values depend on the backhaul interfaces used by the access points. The data rates (Mbps) are as follows: • 802.11a—auto, 6, 9, 12, 18, 24, 36, 48, 54 **Note** In previous software releases, the default value for bridge data rate for 802.11a was **24 Mbps**. In controller software release 6.0, the default value for bridge data rate is **auto**. If you configured the default bridge data rate value (24 Mbps) in a previous controller software release, the bridge data rate is configured with the new default value (auto) when you upgrade to controller software release 6.0. However, if you configured a non-default value (for example, 18 Mbps) in a previous controller software release, that configuration setting is preserved when you upgrade to software release 6.0. When the bridge data rate is set to **auto**, the mesh backhaul chooses the highest rate where the next higher rate cannot be used due to unsuitable conditions for that specific rate (and not because of conditions that affect all rates). • 802.11b—1, 2, 5.5, 11 • 802.11g—1, 2, 5.5, 11, 6, 9, 12, 18, 24, 36, 48, 54
Ethernet Link Status	Status of the Ethernet (LAP1510) or Gigabit Ethernet (LAP1522) links. For each link, the status can be Up, Dn, or Na.
Heater Status	Status of the heater: ON or OFF.
Internal Temperature	Internal temperature of the access point in Fahrenheit and Celsius.

Table 8-15 lists the Enternet bridging parameters.

Note The following information appears when you enable Ethernet Bridging and click **Apply**.

Table 8-15 Ethernet Bridging Parameters

Parameter	Description
Interface Name	Name of the interface. Click the interface name to open the All APs > ap_name > VLAN Mappings (for mesh access points) page. To configure the access mode on a Mesh access point, click the **gigabitEthernet1** interface. To configure the trunk mode on a Root or Mesh access point, click the **gigabitEthernet0** interface.
Oper Status	Operational status of the interface.

Table 8-15 Ethernet Bridging Parameters (continued)

Parameter	Description
Mode	Mode of the interface: Normal, Access, or Trunk.
VLAN ID	VLAN ID of the interface.

H-REAP Tab

Note This tab appears if you set the AP Mode on the General Tab to H-REAP.

Table 8-16 lists the H-REAP tab parameters.

Table 8-16 H-REAP Tab Parameters

Parameter	Description
VLAN Support	Native VLAN ID. **Note** After you enable VLAN support, click **Apply** to activate the **VLAN Mappings** button.
Native VLAN ID	VLAN ID number.
VLAN Mappings	All APs > ap_name > VLAN Mappings (for H-REAP Access Points) page.
HREAP Group Name	Name of the group if the access point belongs to a hybrid-REAP group.
OfficeExtend AP **Note** Currently, Cisco 1040, 1130, 1140, and 3502I series access points that are joined to a Cisco 5500 Series Controller can be configured to operate as OfficeExtend access points.	
Enable OfficeExtend AP	Mode that you can enable for this access point. The default value is enabled. **Note** Unselecting this check box disables OfficeExtend mode for this access point. It does not undo all of the configuration settings on the access point.
Enable Least Latency Controller Join	Mode that you can enable for the access point to choose the controller with the least latency when joining. The default value is disabled. When you enable this feature, the access point calculates the time between the discovery request and discovery response and joins the Cisco 5500 Series Controller that responds first.
Reset Personal SSID	Mode that allows you to clear only the access point's personal SSID. **Note** If you want to clear the access point's configuration and return it to factory-default settings, enter the **clear ap config** *Cisco_AP* command on the controller CLI.

Advanced Tab

Table 8-17 lists the advanced tab parameters.

Table 8-17 Advanced Tab Parameters

Parameter	Description
Regulatory Domains	Regulatory domain of the AP.
Country Code	Country code.
Mirror Mode	Port Mirroring mode: enabled or disabled.
Cisco Discovery Protocol	Cisco Discovery Protocol.
MFP Frame Validation	Infrastructure Management Frame Protection validation that causes the AP to authenticate all AP-originating frames that are detected on the radio frequency in which it is operating. If Infrastructure MFP is not enabled globally, a "Global MFP Disabled" message appears next to the check box, and management frames are not validated. See the Using the GUI to Configure MFP page for information on enabling MFP globally on the controller.
Cisco Discovery Protocol	Cisco Discovery Protocol.
MFP Frame Validation	Infrastructure Management Frame Protection validation that causes the AP to authenticate all AP-originating frames that are detected on the radio frequency in which it is operating. If Infrastructure MFP is not enabled globally, a "Global MFP Disabled" message appears next to the check box, and management frames are not validated. See the Using the GUI to Configure MFP page for information on enabling MFP globally on the controller.
AP Group Name	Drop-down list that contains the names of AP Group VLANs that you have created. To associate an AP group VLAN with an access point, follow these steps: 1. Choose an AP group VLAN from the drop-down list. 2. Click **Apply**. For more information on creating a new AP Group and mapping it to an interface, see the "Configuring Access Point Groups" section on page 7-55.
Statistics Timer	Counter that sets the time in seconds that the access point sends its DOT11 statistics to the controller.

Table 8-17 Advanced Tab Parameters (continued)

Parameter	Description
Data Encryption	Datagram Transport Layer Security (DTLS) data encryption. Cisco 5500 Series Controllers allow you to encrypt CAPWAP control packets (and optionally, CAPWAP data packets) that are sent between the access point and the controller using Datagram Transport Layer Security (DTLS). DTLS is a standards-track Internet Engineering Task Force (IETF) protocol based on TLS. CAPWAP control packets are management packets exchanged between a controller and an access point while CAPWAP data packets encapsulate forwarded wireless frames. CAPWAP control and data packets are sent over separate UDP ports: 5246 (control) and 5247 (data). If an access point does not support DTLS data encryption, DTLS is enabled only for the control plane, and a DTLS session for the data plane is not established. **Note** Only Cisco 5500 Series Controllers support DTLS data encryption. This feature is not available on other controller platforms. If an access point with data encryption enabled tries to join any other controller, the access point joins the controller, but data packets are sent unencrypted. **Note** Only 1040, 1130, 1140, 1240, 1250, 1260, and 3500 series access points support DTLS data encryption, and data-encrypted access points can join a Cisco 5500 Series Controller only if the base license is installed on the controller. DTLS data encryption is enabled automatically for OfficeExtend access points but disabled by default for all other access points. Most access points are deployed in a secure network within a company building, so data encryption is not necessary. In contrast, the traffic between an OfficeExtend access point and the controller travels through an unsecure public network, so data encryption is more important for these access points. When data encryption is enabled, traffic is encrypted at the access point before it is sent to the controller and at the controller before it is sent to the client. **Note** Encryption limits throughput at both the controller and the access point, and maximum throughput is desired for most enterprise networks.
Rogue Detection	Rogue detection that you can enable or disable for individual access points. Rogue detection is enabled by default for all access points joined to the controller (except for OfficeExtend access points).
Telnet	Telnet or SSH connectivity on this access point. The default values are unselected.
SSH	Protocol that makes debugging the access point easier, especially when the access point is unable to connect to the controller.
TCP Adjust MSS	TCP adjust Maximum Segment Size. The range is 536 to 1336.
Enable Link Latency	Enable link latency feature for this access point. Enable link latency is used to measure the link between an access point and the controller. This feature can be used with all access points joined to the controller but is especially useful for hybrid-REAP access points (in connected mode) and OfficeExtend access points, for which the link could be a slow or unreliable WAN connection. **Note** Hybrid-REAP access points in standalone mode are not supported.

Table 8-17 Advanced Tab Parameters (continued)

Parameter	Description
Current (mSec)	Current round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back.
Minimum (mSec)	Minimum round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back since link latency has been enabled or reset.
Maximum (mSec)	Maximum round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back since link latency has been enabled or reset.
Reset Link Latency	Feature that clears all link latency statistics on the controller for this access point.
AP Image Download	
Perform a primary image pre-download for this AP	Download Primary button that you click to perform a primary image predownload for this access point. An alert box appears displaying the version that is downloaded when the access point boots. Click **OK** to continue.
Perform a interchange of both the images on this AP	Interchange Image button that you click to swap the images on this access point. An alert box appears prompting you to confirm if you want to interchange the images. Click **OK** to continue.
Perform a backup image pre-download for this AP	Download Backup button that you click to predownload a backup image for this access point. An alert box appears displaying the version that is downloaded when the access point boots. Click **OK** to continue.
PoE Status	Text box that applies only to 1250 series access points that are powered using PoE. THe PoE Status text box shows the power level at which the access point is operating: High (20 W), Medium (16.8 W), or Medium (15.4 W). This text box is not configurable. The controller auto-detects the access point's power source and displays the power level here. **Note** There are two other ways to tell if the access point is operating at a lower power level. First, the "Due to low PoE, radio is transmitting at degraded power" message appears under the Tx Power Level Assignment area on the 802.11 a/n APs > Configure page. Second, the "PoE Status: degraded operation" message appears in the controller's trap log on the Trap Logs page.
Pre-standard 802.3af switches	Whether the access point is being powered by a high-power 802.3af Cisco switch or a power injector. This option is disabled by default.
Power Injector State	Whether the attached switch does not support intelligent power management (IPM) and a power injector is being used. If the attached switch supports IPM, you do not need to select this check box.

Table 8-17 Advanced Tab Parameters (continued)

Parameter	Description
Power Injector Selection	Power injector selection options are as follows: • Installed—Allows the access point to examine and remember the MAC address of the currently connected switch port and assumes that a power injector is connected. If you want to configure the switch MAC address, enter the MAC address in the Injector Switch MAC Address text box. • Override—Allows the access point to operate in high-power mode without first verifying a matching MAC address.
Power Over Ethernet Settings	
Injector Switch MAC Address	MAC address of the connected switch port.
AP Core Dump Settings	
AP Core Dump	Upload of the access point core dump.
TFTP Server IP	IP address of the TFTP server.
File name	Name for the access point core dump file (for example, dump.log).
File Compression	File compression of the access point core dump file. When you enable this option, the file is saved with a .gz extension (for example, **dump.log.gz**). This file can be opened with WinZip.

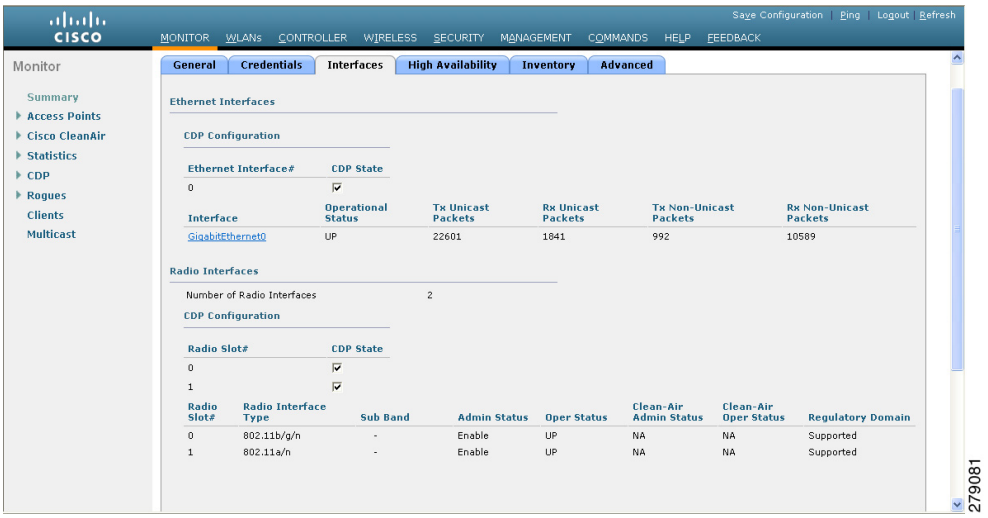
Using the GUI to Monitor the Interface Details

To monitor the interface details using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Summary** > **All APs**. The All APs > Details page appears.

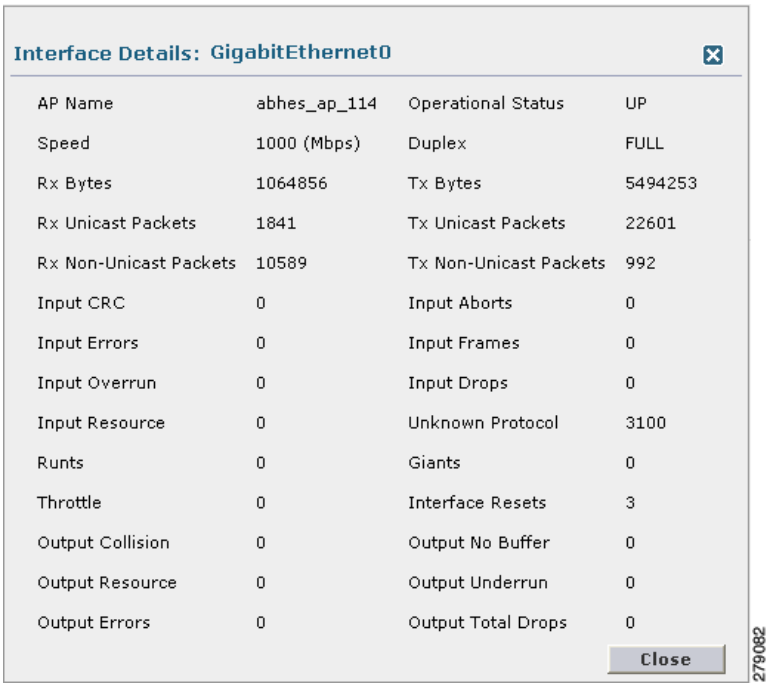
Step 2 Click the **Interfaces** tab. The Interfaces tab is shown in Figure 8-4.

Figure 8-4 Interfaces Tab



Step 3 Click on the available Interface name. The Interface Details page appears. See Figure 8-5.

Figure 8-5 Interfaces Details Page



Step 4 The Interface Details page displays the following parameter details. See Table 8-18.

Table 8-18 Interfaces Parameters Details

Button	Description
AP Name	Name of the access point.
Link Speed	Speed of the interference in Mbps.

Table 8-18 Interfaces Parameters Details (continued)

Button	Description
RX Bytes	Total number of bytes in the error-free packets received on the interface.
RX Unicast Packets	Total number of unicast packets received on the interface.
RX Non-Unicast Packets	Total number of nonunicast or multicast packets received on the interface.
Input CRC	Total number of CRC error in packets while receiving on the interface.
Input Errors	Sum of all errors in the packets while receiving on the interface.
Input Overrun	Number of times the receiver hardware was incapable of handling received data to a hardware buffer because the input rate exceeded the receiver's capability to handle that data.
Input Resource	Total number of resource errors in packets received on the interface.
Runts	Number of packets that are discarded because they are similar to the medium's minimum packet size.
Throttle	Total number of times the interface advised a sending NIC that it was overwhelmed by packets being sent and to slow the pace of delivery.
Output Collision	Total number of packet retransmitted due to an Ethernet collision.
Output Resource	Resource errors in packets transmitted on the interface.
Output Errors	Errors that prevented the final transmission of packets out of the interface.
Operational Status	Operational state of the physical ethernet interface on the AP.
Duplex	Interface's duplex mode.
TX Bytes	Number of bytes in the error-free packets transmitted on the interface.
TX Unicast Packets	Total number of unicast packets transmitted on the interface.
TX Non-Unicast Packets	Total number of nonunicast or multicast packets transmitted on the interface.
Input Aborts	Total number of packets aborted while receiving on the interface.
Input Frames	Total number of packets received incorrectly that has a CRC error and a noninteger number of octets on the interface.
Input Drops	Total number of packets dropped while receiving on the interface because the queue was full.
Unknown Protocol	Total number of packets discarded on the interface due to an unknown protocol.
Giants	Number of packets that are discarded because they exceeded the medium's maximum packet size.
Interface Resets	Number of times that an interface has been completely reset.
Output No Buffer	Total number of packets discarded because there was no buffer space.
Output Underrun	Number of times the transmitter has been running faster than the router can handle.
Outout Total Drops	Total number of packets dropped while transmitting from the interface because the queue was full.

Using the GUI to Search Access Point Radios

You can search for specific access point radios in the list of radios on the 802.11a/n Radios page or the 802.11b/g/n Radios page. You can access these pages from the Monitor tab on the menu bar when viewing access point radios or from the Wireless tab on the menu bar when configuring access point radios. To search for specific access point radios, you create a filter to display only radios that meet certain criteria (such as radio MAC address, access point name, or CleanAir status). This feature is especially useful if your list of access point radios spans multiple pages, which prevents you from viewing them all at once.

To search for access point radios using the controller GUI, follow these steps:

Step 1 Perform one of the following:

- Choose **Monitor > Access Points Summary> 802.11a/n** (or **802.11b/g/n**) **Radios > Details** to open the 802.11a/n (or 802.11b/g/n) Radios page (see Figure 8-6).
- Choose **Wireless > Access Points > Radios > 802.11a/n** (or **802.11b/g/n**) to open the 802.11a/n (or 802.11b/g/n) Radios page (see Figure 8-7).

Figure 8-6 802.11a/n Radios Page (from the Monitor Tab)

Figure 8-7 802.11a/n Radios Page (from the Wireless Tab)

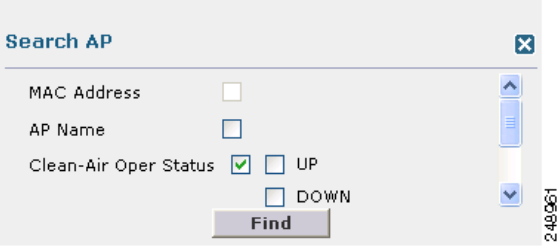
These pages show all of the 802.11a/n or 802.11b/g/n access point radios that are joined to the controller and their current settings.

The total number of access point radios appears in the upper right-hand corner of the page. If the list of radios spans multiple pages, you can access these pages by clicking the page number links. Each page shows up to 25 access point radios.

Note In a Cisco Unified Wireless Network environment, the 802.11a and 802.11b/g radios should not be differentiated based on their Base Radio MAC addresses, as they may have the same addresses. Instead, the radios should be differentiated based on their physical addresses.

Step 2 Click **Change Filter** to open the Search AP dialog box (see Figure 8-8).

Figure 8-8 Search AP Dialog Box



Step 3 Select one of the following check boxes to specify the criteria used when displaying access point radios:

- **MAC Address**—Enter the base radio MAC address of an access point radio.
- **AP Name**—Enter the name of an access point.

  Note When you enable the MAC address filter, the other filters are disabled automatically. When you enable any of the other filters, the MAC address filter is disabled automatically.

- **CleanAir Status**—Select one or more of the following check boxes to specify the operating status of the access points:
  - **UP**—The spectrum sensor for the access point radio is currently operational.
  - **DOWN**—The spectrum sensor for the access point radio is currently not operational because an error has occurred. The most likely reason for the error is that the access point radio is disabled.
  - **ERROR**—The spectrum sensor for the access point radio has crashed, making CleanAir monitoring nonoperational for this radio. We recommend rebooting the access point or disabling CleanAir functionality on the radio.
  - **N/A**—The access point radio is not capable of supporting CleanAir functionality. Currently, only Cisco Aironet 3500 series access point radios can be configured for Cisco CleanAir.

Step 4 Click **Find** to commit your changes. Only the access point radios that match your search criteria appear on the 802.11a/n Radios page or the 802.11b/g/n Radios page, and the Current Filter parameter at the top of the page specifies the filter used to generate the list (for example, MAC Address:00:1e:f7:75:0a:a0 or AP Name:pmsk-ap).

Note If you want to remove the filter and display the entire access point radio list, click **Clear Filter**.

Configuring Global Credentials for Access Points

Cisco IOS access points are shipped from the factory with *Cisco* as the default enable password. This password allows users to log into the nonprivileged mode and execute **show** and **debug** commands, posing a security threat. The default enable password must be changed to prevent unauthorized access and to enable users to execute configuration commands from the access point's console port.

In controller software releases prior to 5.0, you can set the access point enable password only for access points that are currently connected to the controller. In controller software release 5.0 or later releases, you can set a global username, password, and enable password that all access points that are currently joined to the controller and any that join in the future inherit as they join the controller. If desired, you can override the global credentials and assign a unique username, password, and enable password for a specific access point.

Also in controller software release 5.0 or later releases, after an access point joins the controller, the access point enables console port security, and you are prompted for your username and password whenever you log into the access point's console port. When you log in, you are in nonprivileged mode, and you must enter the enable password in order to use the privileged mode.

Note These controller software release 5.0 or later release features are supported on all access points that have been converted to lightweight mode, except the 1100 series. VxWorks access points are not supported.

The global credentials that you configure on the controller are retained across controller and access point reboots. They are overwritten only if the access point joins a new controller that is configured with a global username and password. If the new controller is not configured with global credentials, the access point retains the global username and password configured for the first controller.

Note You need to keep careful track of the credentials used by the access points. Otherwise, you might not be able to log into an access point's console port. if you need to return the access points to the default *Cisco*/*Cisco* username and password, you must clear the controller's configuration and the access point's configuration to return them to factory-default settings. To clear the controller's configuration, choose **Commands > Reset to Factory Default > Reset** on the controller GUI, or enter the **clear config** command on the controller CLI. To clear the access point's configuration, enter the **clear ap config** *Cisco_AP* command on the controller CLI. Once the access point rejoins a controller, it adopts the default *Cisco*/*Cisco* username and password.

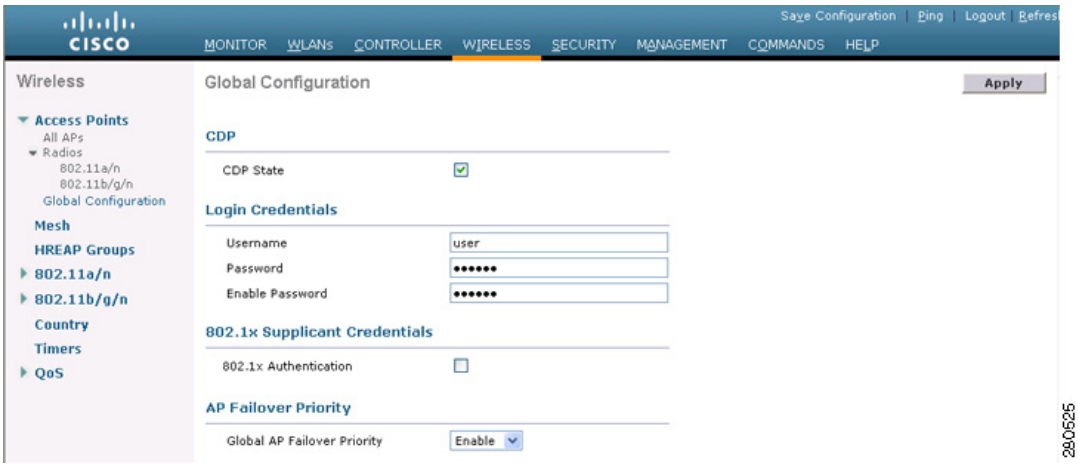
You can use the controller GUI or CLI to configure global credentials for access points that join the controller.

Using the GUI to Configure Global Credentials for Access Points

To configure global credentials for access points that join the controller using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page (see Figure 8-9).

Figure 8-9 Global Configuration Page



Step 2 In the Username text box, enter the username that is to be inherited by all access points that join the controller.

Step 3 In the Password text box, enter the password that is to be inherited by all access points that join the controller.

You can set a global username, password, and enable password that all access points inherit as they join the controller including access points that are currently joined to the controller and any that join in the future. You can override the global credentials and assign a unique username, password, and enable password for a specific access point. The following are requirements enforced on the password:

- The password should contain characters from at least three of the following classes: lower case letters, upper case letters, digits, and special characters.
- No character in the password can be repeated more than three times consecutively.
- The password should not contain the management username or the reverse of the username.
- The password should not contain words like Cisco, oscic, admin, nimda or any variant obtained by changing the capitalization of letters by substituting 1, |, or ! or substituting 0 for o or substituting $ for s.

Step 4 In the Enable Password text box, enter the enable password that is to be inherited by all access points that join the controller.

Step 5 Click **Apply** to send the global username, password, and enable password to all access points that are currently joined to the controller or that join the controller in the future.

Step 6 Click **Save Configuration** to save your changes.

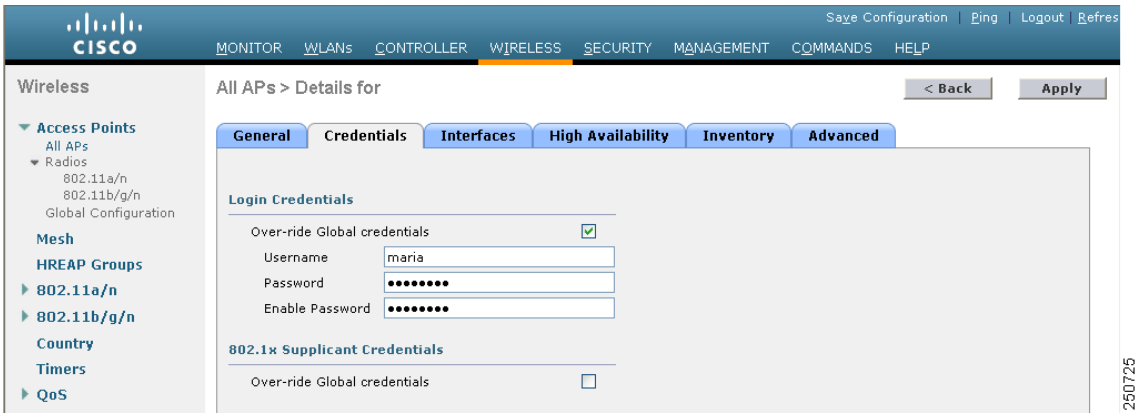
Step 7 (Optional) Override the global credentials for a specific access point and assign a unique username, password, and enable password to this access point as follows:

a. Choose **Access Points** > **All APs** to open the All APs page.

b. Click the name of the access point for which you want to override the global credentials.

c. Choose the **Credentials** tab. The All APs > Details for (Credentials) page appears (see Figure 8-10).

Figure 8-10 All APs > Details for (Credentials) Page



d. Select the **Over-ride Global Credentials** check box to prevent this access point from inheriting the global username, password, and enable password from the controller. The default value is unselected.

e. In the Username, Password, and Enable Password text boxes, enter the unique username, password, and enable password that you want to assign to this access point.

Note The information that you enter is retained across controller and access point reboots and if the access point joins a new controller.

f. Click **Apply** to commit your changes.

g. Click **Save Configuration** to save your changes.

Note If you want to force this access point to use the controller's global credentials, unselect the **Over-ride Global Credentials** check box.

Using the CLI to Configure Global Credentials for Access Points

To configure global credentials for access points that join the controller using the controller CLI, follow these steps:

Step 1 Configure the global username, password, and enable password for all access points currently joined to the controller as well as any access points that join the controller in the future by entering this command:

config ap mgmtuser add username *user* **password** *password* **enablesecret** *enable_password* **all**

Step 2 (Optional) Override the global credentials for a specific access point and assign a unique username, password, and enable password to this access point by entering this command:

config ap mgmtuser add username *user* **password** *password* **enablesecret** *enable_password Cisco_AP*

The credentials that you enter in this command are retained across controller and access point reboots and if the access point joins a new controller.

Note If you want to force this access point to use the controller's global credentials, enter the **config ap mgmtuser delete** *Cisco_AP* command. The following message appears after you execute this command: "AP reverted to global username configuration."

Step 3 Save your changes by entering this command:

save config

Step 4 Verify that global credentials are configured for all access points that join the controller by entering this command:

show ap summary

Information similar to the following appears:

```
Number of APs.................................. 1
Global AP User Name............................ globalap

AP Name  Slots  AP Model           Ethernet MAC       Location         Port  Country
-------- ------ ------------------ ------------------ ------------------ ----  -------
HReap       2    AIR-AP1131AG-N-K9 00:13:80:60:48:3e  default location  1     US
```

Note If global credentials are not configured, the Global AP User Name text box shows "Not Configured."

To view summary of specific access point you can specify the access point name. You can also use wildcard searches when filtering for access points.

Step 5 See the global credentials configuration for a specific access point by entering this command:

show ap config general *Cisco_AP*

Note The name of the access point is case sensitive.

Information similar to the following appears:

```
Cisco AP Identifier.............................. 0
Cisco AP Name.................................... HReap
...
AP User Mode..................................... AUTOMATIC
AP User Name..................................... globalap
```

Note If this access point is configured for global credentials, the AP User Mode text boxes shows "Automatic." If the global credentials have been overwritten for this access point, the AP User Mode text box shows "Customized."

Configuring Authentication for Access Points

You can configure 802.1X authentication between a lightweight access point and a Cisco switch. The access point acts as an 802.1X supplicant and is authenticated by the switch using EAP-FAST with anonymous PAC provisioning.

This feature is supported on the following hardware:

- Cisco Aironet 1130, 1140, 1240, 1250, 1260, and 3500 series access points
- All controller platforms running in local, hybrid-REAP, monitor, or sniffer mode. Bridge mode is not supported.

Note In hybrid-REAP mode, you can configure local switching with 802.1X authentication if you have configured a local external RADIUS server configured.

- All Cisco switches that support authentication.

Note See the *Release Notes for Cisco wireless LAN controllers and Lightweight Access Points for Release 7.0.155.0* for a list of supported switch hardware and minimum supported software.

Note The OEAP 600 Series access points do not support LEAP.

You can configure global authentication settings that all access points that are currently joined to the controller and any that join in the future. If desired, you can override the global authentication settings and assign unique authentication settings for a specific access point.

Observe the following process for configuring authentication for access points:

Step 1 If the access point is new, do the following:

a. Boot the access point with the installed recovery image.

b. If you choose not to follow this suggested flow and instead enable 802.1X authentication on the switch port connected to the access point prior to the access point joining the controller, enter this command:

lwapp ap dot1x username *username* **password** *password*

Note If you choose to follow this suggested flow and enable 802.1X authentication on the switch port after the access point has joined the controller and received the configured 802.1X credentials, you do not need to enter this command.

Note This command is available only for access points that are running the 5.1, 5.2, 6.0, or 7.0 recovery image.

c. Connect the access point to the switch port.

Step 2 Install the 5.1, 5.2, 6.0, or 7.0 image on the controller and reboot the controller.

Step 3 Allow all access points to join the controller.

Step 4 Configure authentication on the controller. See the "Using the GUI to Configure Authentication for Access Points" section on page 8-38 or the "Using the CLI to Configure Authentication for Access Points" section on page 8-39 for information on configuring authentication on the controller.

Step 5 Configure the switch to allow authentication. See the "Configuring the Switch for Authentication" section on page 8-41 for information on configuring the switch for authentication.

Using the GUI to Configure Authentication for Access Points

To configure authentication for access points that join the controller using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Access Points** > **Global Configuration** to open the Global Configuration page.

Step 2 Under 802.1x Supplicant Credentials, select the **802.1x Authentication** check box.

Step 3 In the Username text box, enter the username that is to be inherited by all access points that join the controller.

Step 4 In the Password and Confirm Password text boxes, enter the password that is to be inherited by all access points that join the controller.

Note You must enter a strong password in these text boxes. Strong passwords have the following characteristics:
- They are at least eight characters long.
- They contain a combination of uppercase and lowercase letters, numbers, and symbols.
- They are not a word in any language.

Step 5 Click **Apply** to send the global authentication username and password to all access points that are currently joined to the controller and to any that join the controller in the future.

Step 6 Click **Save Configuration** to save your changes.

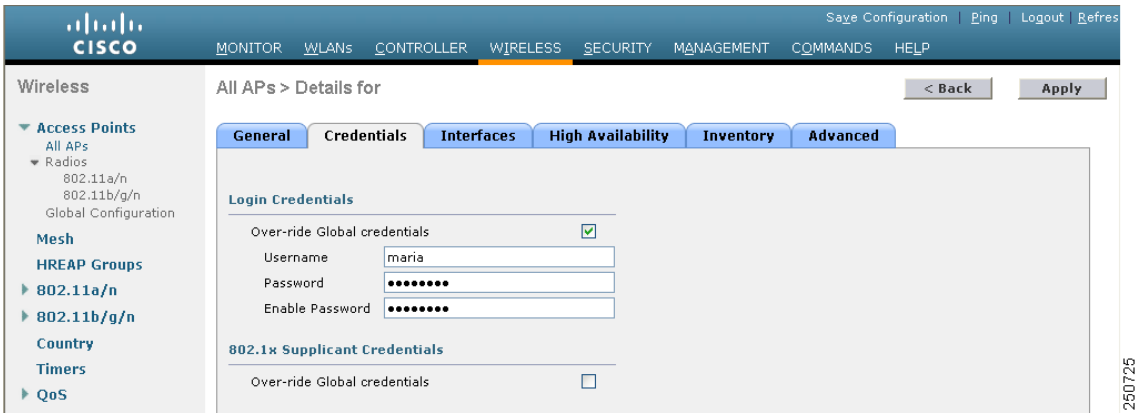
Step 7 If desired, you can choose to override the global authentication settings and assign a unique username and password to a specific access point as follows:

a. Choose **Access Points** > **All APs** to open the All APs page.

b. Click the name of the access point for which you want to override the authentication settings.

c. Choose the **Credentials** tab to open the All APs > Details for (Credentials) page (see Figure 8-11).

Figure 8-11 All APs > Details for (Credentials) Page



d. Under 802.1x Supplicant Credentials, select the **Over-ride Global Credentials** check box to prevent this access point from inheriting the global authentication username and password from the controller. The default value is unselected.

e. In the Username, Password, and Confirm Password text boxes, enter the unique username and password that you want to assign to this access point.

Note The information that you enter is retained across controller and access point reboots and whenever the access point joins a new controller.

f. Click **Apply** to commit your changes.

g. Click **Save Configuration** to save your changes.

Note If you want to force this access point to use the controller's global authentication settings, unselect the **Over-ride Global Credentials** check box.

Using the CLI to Configure Authentication for Access Points

To configure authentication for access points that join the controller using the controller CLI, follow these steps:

Step 1 Configure the global authentication username and password for all access points currently joined to the controller as well as any access points that join the controller in the future by entering this command:

config ap dot1xuser add username *user* **password** *password* **all**

Note You must enter a strong password for the *password* parameter. Strong passwords have the following characteristics:
- They are at least eight characters long.
- They contain a combination of uppercase and lowercase letters, numbers, and symbols.
- They are not a word in any language.

Step 2 (Optional) Override the global authentication settings and assign a unique username and password to a specific access point. To do so, enter this command:

config ap dot1xuser add username *user* **password** *password Cisco_AP*

Note You must enter a strong password for the *password* parameter. See the note in Step 1 for the characteristics of strong passwords.

The authentication settings that you enter in this command are retained across controller and access point reboots and whenever the access point joins a new controller.

Note If you want to force this access point to use the controller's global authentication settings, enter the **config ap dot1xuser delete** *Cisco_AP* command. The following message appears after you execute this command: "AP reverted to global username configuration."

Step 3 Save your changes by entering this command:

save config

Step 4 (Optional) Disable 802.1X authentication for all access points or for a specific access point by entering this command:

config ap dot1xuser disable {**all** | *Cisco_AP*}

Note You can disable 802.1X authentication for a specific access point only if global 802.1X authentication is not enabled. If global 802.1X authentication is enabled, you can disable 802.1X for all access points only.

Step 5 See the authentication settings for all access points that join the controller by entering this command:

show ap summary

Information similar to the following appears:

```
Number of APs.................................. 1
Global AP User Name............................ globalap
Global AP Dot1x User Name...................... globalDot1x
```

Note If global authentication settings are not configured, the Global AP Dot1x User Name text box shows "Not Configured."

To See summary of specific access point you can specify the access point name. You can also use wildcard searches when filtering for access points.

Step 6 See the authentication settings for a specific access point by entering this command:

show ap config general *Cisco_AP*

Note The name of the access point is case sensitive.

Information similar to the following appears:

```
Cisco AP Identifier.............................. 0
Cisco AP Name.................................... HReap
...
```

```
AP Dot1x User Mode.............................. AUTOMATIC
AP Dot1x User Name.............................. globalDot1x
...
```

Note If this access point is configured for global authentication, the AP Dot1x User Mode text boxes shows "Automatic." If the global authentication settings have been overwritten for this access point, the AP Dot1x User Mode text box shows "Customized."

Configuring the Switch for Authentication

To enable 802.1X authentication on a switch port, on the switch CLI, enter these commands:

- Switch# **configure terminal**
- Switch(config)# **dot1x system-auth-control**
- Switch(config)# **aaa new-model**
- Switch(config)# **aaa authentication dot1x default group radius**
- Switch(config)# **radius-server host** *ip_addr* **auth-port** *port* **acct-port** *port* **key** *key*
- Switch(config)# **interface fastethernet2/1**
- Switch(config-if)# **switchport mode access**
- Switch(config-if)# **dot1x pae authenticator**
- Switch(config-if)# **dot1x port-control auto**
- Switch(config-if)# **end**

Embedded Access Points

Controller software release 7.0.116.0 or later releases support the embedded access points: AP801 and AP802, which are the integrated access points on the Cisco 880 Series Integrated Services Routers (ISRs). This access points use a Cisco IOS software image that is separate from the router Cisco IOS software image. The access points can operate as autonomous access points configured and managed locally, or they can operate as centrally managed access points that utilize the CAPWAP or LWAPP protocol. The AP801 and AP802 access points are preloaded with both an autonomous Cisco IOS release and a recovery image for the unified mode.

Note Before you use an AP801 or AP802 Series Lightweight Access Point with controller software release 7.0.116.0 or later releases, you must upgrade the software in the Next Generation Cisco 880 Series Integrated Services Routers (ISRs) to Cisco IOS 151-4.M or later.

When you want to use the AP801 or AP802 with a controller, you must enable the recovery image for the unified mode on the access point by entering the **service-module wlan-ap 0 bootimage unified** command on the router in privileged EXEC mode.

Note If the **service-module wlan-ap 0 bootimage unified** command does not work successfully, make sure that the software license is still eligible.

After enabling the recovery image, enter the **service-module wlan-ap 0 reload** command on the router to shut down and reboot the access point. After the access point reboots, it discovers the controller, downloads the full CAPWAP or LWAPP software release from the controller, and acts as a lightweight access point.

Note To use the CLI commands mentioned above, the router must be running Cisco IOS Release 12.4(20)T or later releases. If you experience any problems, See the "Troubleshooting an Upgrade or Reverting the AP to Autonomous Mode" section in the ISR configuration guide at this URL: http://www.cisco.com/en/US/docs/routers/access/800/860-880-890/software/configuration/guide/admin_ap.html#wp1061143

In order to support CAPWAP or LWAPP, the router must be activated with at least the Cisco Advanced IP Services IOS license-grade image. A license is required to upgrade to this Cisco IOS image on the router. See this URL for licensing information:

http://www.cisco.com/en/US/docs/routers/access/sw_activation/SA_on_ISR.html

After the AP801 or AP802 boots up with the recovery image for the unified mode, it requires an IP address to communicate with the controller and to download its unified image and configuration from the controller. The router can provide DHCP server functionality, the DHCP pool to reach the controller, and setup option 43 for the controller IP address in the DHCP pool configuration. Use the following configuration to perform this task:

ip dhcp pool *pool_name*

network *ip_address subnet_mask*

dns-server *ip_address*

default-router *ip_address*

option 43 hex *controller_ip_address_in_hex*

Example:

```
ip dhcp pool embedded-ap-pool
    network 60.0.0.0 255.255.255.0
   dns-server 171.70.168.183
   default-router 60.0.0.1
   option 43 hex  f104.0a0a.0a0f   /* single WLC IP address(10.10.10.15) in hex format  */
```

The AP801 and AP802 802.11n radio supports lower power levels than the 802.11n radio in the Cisco Aironet 1250 series access points. The AP801 and AP802 access points store the radio power levels and passes them to the controller when the access point joins the controller. The controller uses the supplied values to limit the user's configuration.

The AP801 and AP802 access points can be used in hybrid-REAP mode. See Chapter 15, "Configuring Hybrid REAP," for more information on hybrid REAP.

Note For more information on the AP801, see the documentation for the Cisco 800 Series ISRs at this URL: http://www.cisco.com/en/US/products/hw/routers/ps380/tsd_products_support_series_home.html.

Note For more information on the AP802, see the documentation for the Next generation Cisco 880 Series ISRs at http://www.cisco.com/en/US/docs/routers/access/800/860-880-890/software/configuration/guide/860-880-890SCG.html.

Autonomous Access Points Converted to Lightweight Mode

You can use an upgrade conversion tool to convert autonomous Cisco Aironet 1100, 1130AG, 1200, 1240AG, and 1300 Series Access Points to lightweight mode. When you upgrade one of these access points to lightweight mode, the access point communicates with a controller and receives a configuration and software image from the controller.

See the *Upgrading Autonomous Cisco Aironet Access Points to Lightweight Mode* document for instructions on upgrading an autonomous access point to lightweight mode. You can find this document at this URL:

http://www.cisco.com/en/US/docs/wireless/access_point/conversion/lwapp/upgrade/guide/lwapnote.html

Guidelines for Using Access Points Converted to Lightweight Mode

Follow these guidelines when you use autonomous access points that have been converted to lightweight mode:

- Access points converted to lightweight mode do not support Wireless Domain Services (WDS). Converted access points communicate only with Cisco wireless LAN controllers and cannot communicate with WDS devices. However, the controller provides functionality that is equivalent to WDS when the access point associates to it.
- In controller software release 4.2 or later releases, all Cisco lightweight access points support 16 BSSIDs per radio and a total of 16 wireless LANs per access point. In previous releases, they supported only 8 BSSIDs per radio and a total of 8 wireless LANs per access point. When a converted access point associates to a controller, only wireless LANs with IDs 1 through 16 are pushed to the access point.
- Access points converted to lightweight mode must get an IP address and discover the controller using DHCP, DNS, or IP subnet broadcast.
- After you convert an access point to lightweight mode, the console port provides read-only access to the unit.
- The 1130AG and 1240AG access points support hybrid-REAP mode. See Chapter 15, "Configuring Hybrid REAP," for details.
- The upgrade conversion tool adds the self-signed certificate (SSC) key-hash to only one of the controllers on the Cisco WiSM. After the conversion has been completed, add the SSC key-hash to the second controller on the Cisco WiSM by copying the SSC key-hash from the first controller to the second controller. To copy the SSC key-hash, open the AP Policies page of the controller GUI (**Security > AAA > AP Policies**) and copy the SSC key-hash from the SHA1 Key Hash column under AP Authorization List (see Figure 8-14). Then, using the second controller's GUI, open the same page and paste the key-hash into the SHA1 Key Hash text box under Add AP to Authorization List. If you have more than one Cisco WiSM, use WCS to push the SSC key-hash to all the other controllers.

Reverting from Lightweight Mode to Autonomous Mode

After you use the upgrade tool to convert an autonomous access point to lightweight mode, you can convert the access point from a lightweight unit back to an autonomous unit by loading a Cisco IOS release that supports autonomous mode (Cisco IOS Release 12.3(7)JA or earlier releases). If the access point is associated to a controller, you can use the controller to load the Cisco IOS release. If the access point is not associated to a controller, you can load the Cisco IOS release using TFTP. In either method, the access point must be able to access a TFTP server that contains the Cisco IOS release to be loaded.

Using a Controller to Return to a Previous Release

To revert from lightweight mode to autonomous mode using a wireless LAN controller, follow these steps:

Step 1 Log into the CLI on the controller to which the access point is associated.

Step 2 Revert from lightweight mode, by entering this command:

config ap tftp-downgrade *tftp-server-ip-address filename access-point-name*

Step 3 Wait until the access point reboots and reconfigure the access point using the CLI or GUI.

Using the MODE Button and a TFTP Server to Return to a Previous Release

To revert from lightweight mode to autonomous mode by using the access point MODE (reset) button to load a Cisco IOS release from a TFTP server, follow these steps:

Step 1 Configure the PC on which your TFTP server software runs with a static IP address in the range of 10.0.0.2 to 10.0.0.30.

Step 2 Make sure that the PC contains the access point image file (such as *c1200-k9w7-tar.123-7.JA.tar* for a 1200 series access point) in the TFTP server folder and that the TFTP server is activated.

Step 3 Rename the access point image file in the TFTP server folder to **c1200-k9w7-tar.default** for a 1200 series access point.

Step 4 Connect the PC to the access point using a Category 5 (CAT5) Ethernet cable.

Step 5 Disconnect power from the access point.

Step 6 Press and hold the **MODE** button while you reconnect power to the access point.

Note The MODE button on the access point must be enabled. Follow the steps in the "Disabling the Reset Button on Access Points Converted to Lightweight Mode" section on page 8-66 to select the status of the access point MODE button.

Step 7 Hold the **MODE** button until the status LED turns red (approximately 20 to 30 seconds), and release the MODE button.

Step 8 Wait until the access point reboots as indicated by all LEDs turning green followed by the Status LED blinking green.

Step 9 After the access point reboots, reconfigure the access point using the GUI or the CLI.

Authorizing Access Points

In controller software releases prior to 5.2, the controller may either use self-signed certificates (SSCs) to authenticate access points or send the authorization information to a RADIUS server (if access points have manufactured-installed certificates [MICs]). In controller software release 5.2 or later releases, you can configure the controller to use a local significant certificate (LSC).

Authorizing Access Points Using SSCs

The Control and Provisioning of Wireless Access Points protocol (CAPWAP) secures the control communication between the access point and controller by a secure key distribution requiring X.509 certificates on both the access point and controller. CAPWAP relies on provisioning of the X.509 certificates. Cisco Aironet access points shipped before July 18, 2005 do not have a MIC, so these access points create an SSC when upgraded to operate in lightweight mode. Controllers are programmed to accept local SSCs for authentication of specific access points and do not forward those authentication requests to a RADIUS server. This behavior is acceptable and secure.

Authorizing Access Points Using MICs

You can configure controllers to use RADIUS servers to authorize access points using MICs. The controller uses an access point's MAC address as both the username and password when sending the information to a RADIUS server. For example, if the MAC address of the access point is 000b85229a70, both the username and password used by the controller to authorize the access point are 000b85229a70.

Note The lack of a strong password by the use of the access point's MAC address should not be an issue because the controller uses MIC to authenticate the access point prior to authorizing the access point through the RADIUS server. Using MIC provides strong authentication.

Note If you use the MAC address as the username and password for access point authentication on a RADIUS AAA server, do not use the same AAA server for client authentication.

Authorizing Access Points Using LSCs

You can use an LSC if you want your own public key infrastructure (PKI) to provide better security, to have control of your certificate authority (CA), and to define policies, restrictions, and usages on the generated certificates.

The LSC CA certificate is installed on access points and controllers. You need to provision the device certificate on the access point. The access point gets a signed X.509 certificate by sending a certRequest to the controller. The controller acts as a CA proxy and receives the certRequest signed by the CA for the access point.

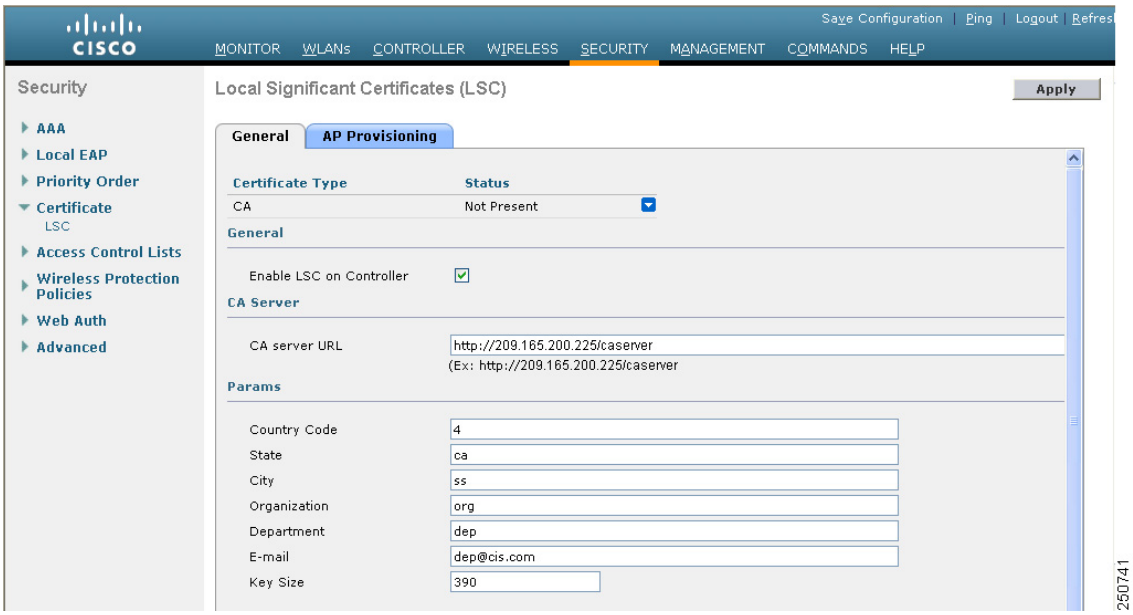
Note Access points that are configured for bridge mode are not supported.

Using the GUI to Configure LSC

To enable the use of LSC on the controller using the controller GUI, follow these steps:

Step 1 Choose **Security** > **Certificate** > **LSC** to open the Local Significant Certificates (LSC) - General page (see Figure 8-12).

Figure 8-12 Local Significant Certificates (LSC) - General Page



Step 2 Select the **Enable LSC on Controller** check box to enable the LSC on the system.

Step 3 In the CA Server URL text box, enter the URL to the CA server. You can enter either a domain name or an IP address.

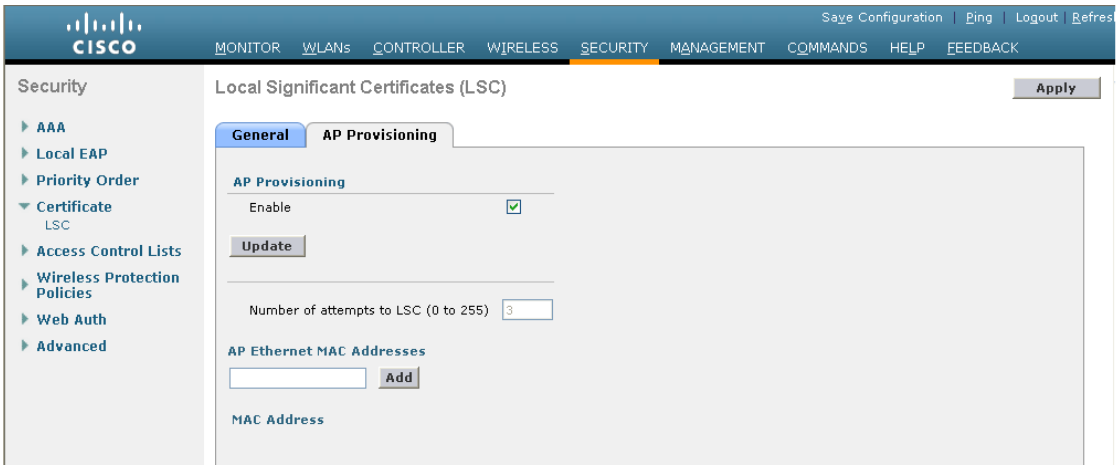
Step 4 In the Params text boxes, enter the parameters for the device certificate. The key size is a value from 384 to 2048 (in bits), and the default value is 2048.

Step 5 Click **Apply** to commit your changes.

Step 6 To add the CA certificate into the controller's CA certificate database, hover your cursor over the blue drop-down arrow for the certificate type and choose **Add**.

Step 7 Choose the **AP Provisioning** tab to open the Local Significant Certificates (LSC) - AP Provisioning page (see Figure 8-13).

Figure 8-13 Local Significant Certificates (LSC) - AP Provisioning Page



Step 8 Select the **Enable** check box and click **Update** to provision the LSC on the access point.

Step 9 When a message appears indicating that the access points will be rebooted, click **OK**.

Step 10 In the Number of Attempts to LSC text box, enter the number of times that the access point attempts to join the controller using an LSC before the access point reverts to the default certificate (MIC or SSC). The range is 0 to 255 (inclusive), and the default value is 3.

Note If you set the number of retries to a nonzero value and the access point fails to join the controller using an LSC after the configured number of retries, the access point reverts to the default certificate. If you set the number of retries to 0 and the access point fails to join the controller using an LSC, the access point does not attempt to join the controller using the default certificate.

Note If you are configuring LSC for the first time, we recommend that you configure a nonzero value.

Step 11 Enter the access point MAC address in the AP Ethernet MAC Addresses text box and click **Add** to add access points to the provision list.

Note To remove an access point from the provision list, hover your cursor over the blue drop-down arrow for the access point and choose **Remove**.

Note If you configure an access point provision list, only the access points in the provision list are provisioned when you enable AP provisioning. If you do not configure an access point provision list, all access points with a MIC or SSC certificate that join the controller are LSC provisioned.

Step 12 Click **Apply** to commit your changes.

Step 13 Click **Save Configuration** to save your changes.

Using the CLI to Configure LSC

To enable the use of LSC on the controller using the controller CLI, follow these steps:

Step 1 Enable LSC on the system by entering this command:

config certificate lsc {**enable** | **disable**}

Step 2 Configure the URL to the CA server by entering this command:

config certificate lsc ca-server http://*url:port/path*

where *url* can be either a domain name or IP address.

Note You can configure only one CA server. To configure a different CA server, delete the configured CA server using the **config certificate lsc ca-server delete** command, and then configure a different CA server.

Step 3 Add the LSC CA certificate into the controller's CA certificate database by entering this command:

config certificate lsc ca-cert {**add** | **delete**}

Step 4 Configure the parameters for the device certificate by entering this command:

config certificate lsc subject-params *country state city orgn dept e-mail*

Note The common name (CN) is generated automatically on the access point using the current MIC/SSC format C*xxxx-MacAddr*, where *xxxx* is the product number.

Step 5 Configure a key size by entering this command:

config certificate lsc other-params *keysize*

The *keysize* is a value from 384 to 2048 (in bits), and the default value is 2048.

Step 6 Add access points to the provision list by entering this command:

config certificate lsc ap-provision auth-list add *AP_mac_addr*

Note To remove access points from the provision list, enter the **config certificate lsc ap-provision auth-list delete** *AP_mac_addr* command.

Note If you configure an access point provision list, only the access points in the provision list are provisioned when you enable AP provisioning (in Step 8). If you do not configure an access point provision list, all access points with a MIC or SSC certificate that join the controller are LSC provisioned.

Step 7 Configure the number of times that the access point attempts to join the controller using an LSC before the access point reverts to the default certificate (MIC or SSC) by entering this command:

config certificate lsc ap-provision revert-cert *retries*

where *retries* is a value from 0 to 255, and the default value is 3.

Note If you set the number of retries to a nonzero value and the access point fails to join the controller using an LSC after the configured number of retries, the access point reverts to the default certificate. If you set the number of retries to 0 and the access point fails to join the controller using an LSC, the access point does not attempt to join the controller using the default certificate.

Note If you are configuring LSC for the first time, we recommend that you configure a nonzero value.

Step 8 Provision the LSC on the access point by entering this command:

config certificate lsc ap-provision {**enable** | **disable**}

Step 9 See the LSC summary by entering this command:

show certificate lsc summary

Information similar to the following appears:

```
LSC Enabled..................................... Yes
LSC CA-Server................................... http://10.0.0.1:8080/caserver

LSC AP-Provisioning............................. Yes
    Provision-List.............................. Not Configured
    LSC Revert Count in AP reboots.............. 3

LSC Params:
    Country..................................... 4
    State....................................... ca
    City........................................ ss
    Orgn........................................ org
    Dept........................................ dep
    Email....................................... dep@co.com
    KeySize..................................... 390

LSC Certs:
    CA Cert..................................... Not Configured
    RA Cert..................................... Not Configured
```

Step 10 See details about the access points that are provisioned using LSC by entering this command:

show certificate lsc ap-provision

Information similar to the following appears:

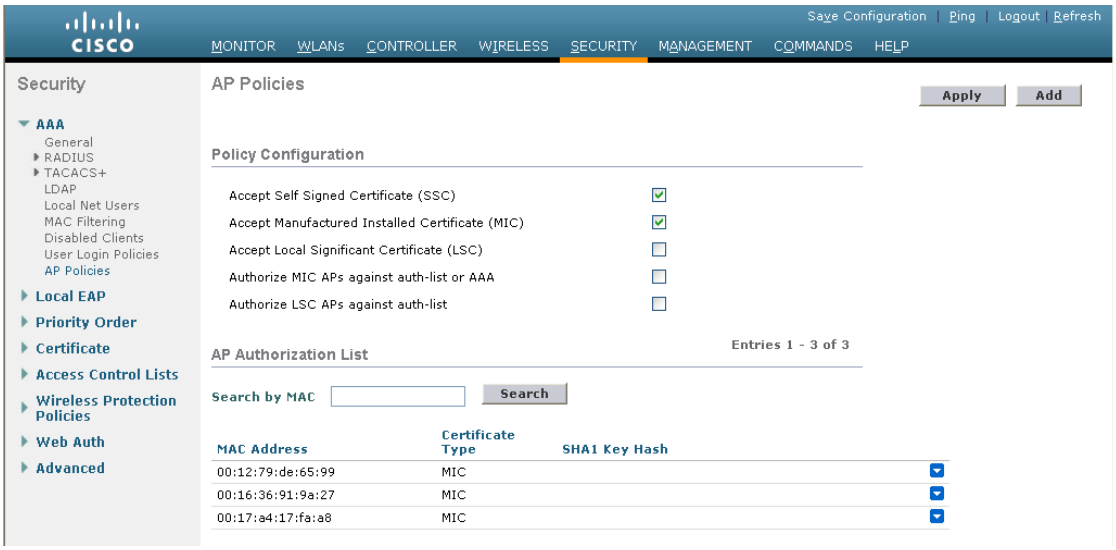
```
LSC AP-Provisioning..................... Yes
Provision-List.......................... Present

Idx     Mac Address
---     ------------
1       00:18:74:c7:c0:90
```

Using the GUI to Authorize Access Points

To authorize access points using the controller GUI, follow these steps:

Step 1 Choose **Security** > **AAA** > **AP Policies** to open the AP Policies page (see Figure 8-14).

Figure 8-14 AP Policies Page



Step 2 If you want the access point to accept self-signed certificates (SSCs), manufactured-installed certificates (MICs), or local significant certificates (LSCs), select the appropriate check box.

Step 3 If you want the access points to be authorized using a AAA RADIUS server, select the **Authorize MIC APs against auth-list or AAA** check box.

Step 4 If you want the access points to be authorized using an LSC, select the **Authorize LSC APs against auth-list** check box.

Step 5 Click **Apply** to commit your changes.

Step 6 Follow these steps to add an access point to the controller's authorization list:

a. Click **Add** to access the Add AP to Authorization List area.

b. In the MAC Address text box, enter the MAC address of the access point.

c. From the Certificate Type drop-down list, choose **MIC**, **SSC**, or **LSC**.

d. Click **Add**. The access point appears in the access point authorization list.

Note To remove an access point from the authorization list, hover your cursor over the blue drop-down arrow for the access point and choose **Remove**.

Note To search for a specific access point in the authorization list, enter the MAC address of the access point in the Search by MAC text box and click **Search**.

Using the CLI to Authorize Access Points

To authorize access points using the controller CLI, follow these steps:

Step 1 Configure an access point authorization policy by entering this command:

config auth-list ap-policy {**authorize-ap** {**enable** | **disable**} | **authorize-lsc-ap** {**enable** | **disable**}}

Step 2 Configure an access point to accept manufactured-installed certificates (MICs), self-signed certificates (SSCs), or local significant certificates (LSCs) by entering this command:

config auth-list ap-policy {**mic** | **ssc** | **lsc** {**enable** | **disable**}}

Step 3 Add an access point to the authorization list by entering this command:

config auth-list add {**mic** | **ssc** | **lsc**} *ap_mac* [*ap_key*]

where *ap_key* is an optional key hash value equal to 20 bytes or 40 digits.

Note To delete an access point from the authorization list, enter this command: **config auth-list delete** *ap_mac*.

Step 4 See the access point authorization list by entering this command:

show auth-list

Information similar to the following appears:

```
Authorize MIC APs against AAA ..................... disabled
Authorize LSC APs against Auth-List ................ disabled

Allow APs with MIC - Manufactured Installed C ..... enabled
Allow APs with SSC - Self-Signed Certificate ...... enabled
Allow APs with LSC - Locally Significant Cert ..... enabled

Mac Addr                  Cert Type    Key Hash
-----------------------   ----------   ----------------------------------------------
00:12:79:de:65:99          SSC         ca528236137130d37049a5ef3d1983b30ad7e543
00:16:36:91:9a:27          MIC         593f34e7cb151997a28cc7da2a6cac040b329636
```

Using DHCP Option 43 and DHCP Option 60

Cisco Aironet access points use the type-length-value (TLV) format for DHCP option 43. DHCP servers must be programmed to return the option based on the access point's DHCP Vendor Class Identifier (VCI) string (DHCP option 60). Table 8-19 lists the VCI strings for Cisco access points capable of operating in lightweight mode.

Table 8-19 VCI Strings For Lightweight Access Points

Access Point	VCI String
Cisco Aironet 1130 Series	Cisco AP c1130
Cisco Aironet 1140 Series	Cisco AP c1140
Cisco Aironet 1200 Series	Cisco AP c1200
Cisco Aironet 1240 Series	Cisco AP c1240
Cisco Aironet 1250 Series	Cisco AP c1250
Cisco Aironet 1260 Series	Cisco AP c1260

Table 8-19 VCI Strings For Lightweight Access Points (continued)

Access Point	VCI String
Cisco Aironet 3500 Series	Cisco AP c3500
Cisco AP801 Embedded Access Point	Cisco AP801
Cisco AP802 Embedded Access Point	Cisco AP802

The format of the TLV block is as follows:

- Type: 0xf1 (decimal 241)
- Length: Number of controller IP addresses * 4
- Value: List of the IP addresses of controller management interfaces

See the product documentation for your DHCP server for instructions on configuring DHCP option 43. The *Upgrading Autonomous Cisco Aironet Access Points to Lightweight Mode* document contains example steps for configuring option 43 on a DHCP server.

If the access point is ordered with the Service Provider Option - AIR-OPT60-DHCP selected, the VCI string for that access point will be different than those listed above. The VCI string will have the “ServiceProvider”. For example, a 1260 with this option will return this VCI string: "Cisco AP c1260-ServiceProvider".

Note The controller IP address that you obtain from the DHCP server should be a unicast IP address. Do not configure the controller IP address as a multicast address when configuring DHCP Option 43.

Troubleshooting the Access Point Join Process

Access points can fail to join a controller for many reasons such as a RADIUS authorization is pending, self-signed certificates are not enabled on the controller, the access point and controller’s regulatory domains do not match, and so on.

Note For join information specific to an OfficeExtend access point, see the “OfficeExtend Access Points” section on page 8-69.

Controller software release 5.2 or later releases enable you to configure the access points to send all CAPWAP-related errors to a syslog server. You do not need to enable any debug commands on the controller because all of the CAPWAP error messages can be viewed from the syslog server itself.

The state of the access point is not maintained on the controller until it receives a CAPWAP join request from the access point, so it can be difficult to determine why the CAPWAP discovery request from a certain access point was rejected. In order to troubleshoot such joining issues without enabling CAPWAP debug commands on the controller, the controller collects information for all access points that send a discovery message to this controller and maintains information for any access points that have successfully joined this controller.

The controller collects all join-related information for each access point that sends a CAPWAP discovery request to the controller. Collection begins with the first discovery message received from the access point and ends with the last configuration payload sent from the controller to the access point.

You can view join-related information for the following numbers of access points:

- Up to 250 access points for Cisco 5500 Series Controllers
- Up to 300 access points for 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Integrated Wireless LAN Controller Switch
- Up to three times the maximum number of access points supported by the platform for the Cisco 2100 Series Controller and the Controller Network Module within the Cisco 28/37/38xx Series Integrated Services Routers

When the controller is maintaining join-related information for the maximum number of access points, it does not collect information for any more access points.

An access point sends all syslog messages to IP address 255.255.255.255 by default when any of the following conditions are met:

- An access point that runs software release 4.2 or later releases has been newly deployed.
- An existing access point that runs a software release prior to 4.2 releases has been upgraded to 4.2 or a later release.
- An existing access point that runs software release 4.2 or later releases has been reset after clearing the configuration.

If any of these conditions are met and the access point has not yet joined a controller, you can also configure a DHCP server to return a syslog server IP address to the access point using option 7 on the server. The access point then starts sending all syslog messages to this IP address.

You can also configure the syslog server IP address through the access point CLI, provided the access point is currently not connected to the controller by entering the **lwapp ap log-server** *syslog_server_IP_address* command.

When the access point joins a controller for the first time, the controller pushes the global syslog server IP address (the default is 255.255.255.255) to the access point. After that, the access point sends all syslog messages to this IP address, until it is overridden by one of the following scenarios:

- The access point is still connected to the same controller, and the global syslog server IP address configuration on the controller has been changed using the **config ap syslog host global** *syslog_server_IP_address* command. In this case, the controller pushes the new global syslog server IP address to the access point.
- The access point is still connected to the same controller, and a specific syslog server IP address has been configured for the access point on the controller using the **config ap syslog host specific** *Cisco_AP syslog_server_IP_address* command. In this case, the controller pushes the new specific syslog server IP address to the access point.
- The access point gets disconnected from the controller, and the syslog server IP address has been configured from the access point CLI using the **lwapp ap log-server** *syslog_server_IP_address* command. This command works only if the access point is not connected to any controller.
- The access point gets disconnected from the controller and joins another controller. In this case, the new controller pushes its global syslog server IP address to the access point.

Whenever a new syslog server IP address overrides the existing syslog server IP address, the old address is erased from persistent storage, and the new address is stored in its place. The access point also starts sending all syslog messages to the new IP address, provided the access point can reach the syslog server IP address.

You can configure the syslog server for access points using the controller GUI and view the access point join information using the controller GUI or CLI.

Using the CLI to Configure the Syslog Server for Access Points

To configure the syslog server for access points using the controller CLI, follow these steps:

Step 1 Perform one of the following:

- To configure a global syslog server for all access points that join this controller, enter this command:

  config ap syslog host global *syslog_server_IP_address*

  Note By default, the global syslog server IP address for all access points is 255.255.255.255. Make sure that the access points can reach the subnet on which the syslog server resides before configuring the syslog server on the controller. If the access points cannot reach this subnet, the access points are unable to send out syslog messages.

- To configure a syslog server for a specific access point, enter this command:

  config ap syslog host specific *Cisco_AP syslog_server_IP_address*

  Note By default, the syslog server IP address for each access point is 0.0.0.0, which indicates that the access point is not yet set. When the default value is used, the global access point syslog server IP address is pushed to the access point.

Step 2 Save your changes by entering this command:

save config

Step 3 See the global syslog server settings for all access points that join the controller by entering this command:

show ap config global

Information similar to the following appears:

```
AP global system logging host..................... 255.255.255.255
```

Step 4 See the syslog server settings for a specific access point by entering this command:

show ap config general *Cisco_AP*

Viewing Access Point Join Information

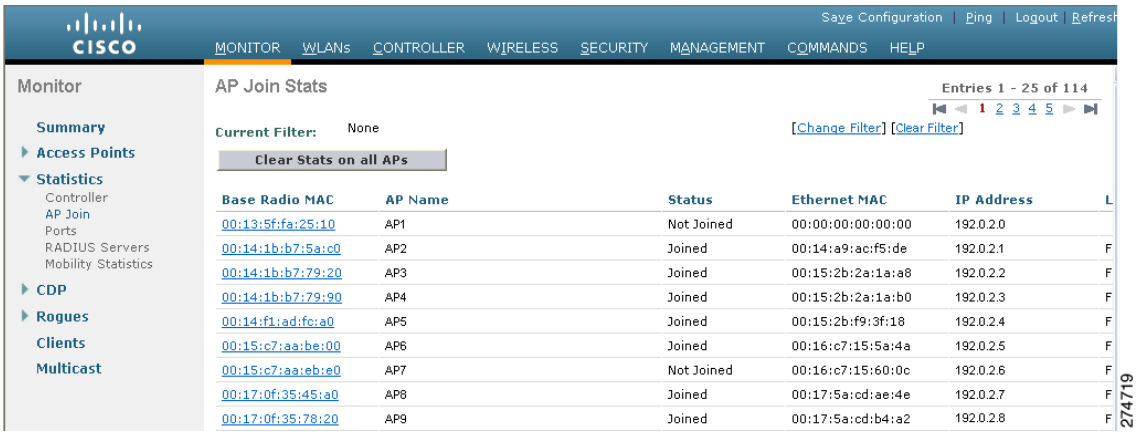
Join statistics for an access point that sends a CAPWAP discovery request to the controller at least once are maintained on the controller even if the access point is rebooted or disconnected. These statistics are removed only when the controller is rebooted or when you choose to clear the statistics.

Using the GUI to View Access Point Join Information

To view access point join information using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Statistics** > **AP Join** to open the AP Join Stats page (see Figure 8-15).

Figure 8-15 AP Join Stats Page



This page lists all of the access points that are joined to the controller or that have tried to join. It shows the radio MAC address, access point name, current join status, Ethernet MAC address, IP address, and last join time for each access point.

The total number of access points appears in the upper right-hand corner of the page. If the list of access points spans multiple pages, you can view these pages by clicking the page number links. Each page shows the join statistics for up to 25 access points.

Note If you want to remove an access point from the list, hover your cursor over the blue drop-down arrow for that access point and click **Remove**.

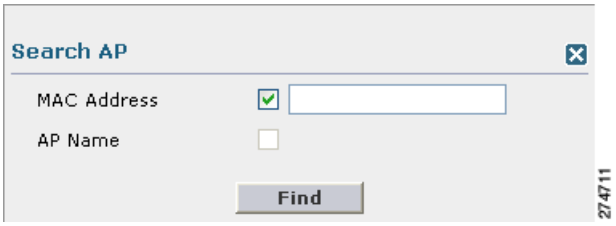
Note If you want to clear the statistics for all access points and start over, click **Clear Stats on All APs**.

Step 2 If you want to search for specific access points in the list of access points on the AP Join Stats page, follow these steps to create a filter to display only access points that meet certain criteria (such as MAC address or access point name).

Note This feature is especially useful if your list of access points spans multiple pages, preventing you from viewing them all at once.

a. Click **Change Filter** to open the Search AP dialog box (see Figure 8-16).

Figure 8-16 Search AP Dialog Box



b. Select one of the following check boxes to specify the criteria used when displaying access points:

- **MAC Address**—Enter the base radio MAC address of an access point.
- **AP Name**—Enter the name of an access point.

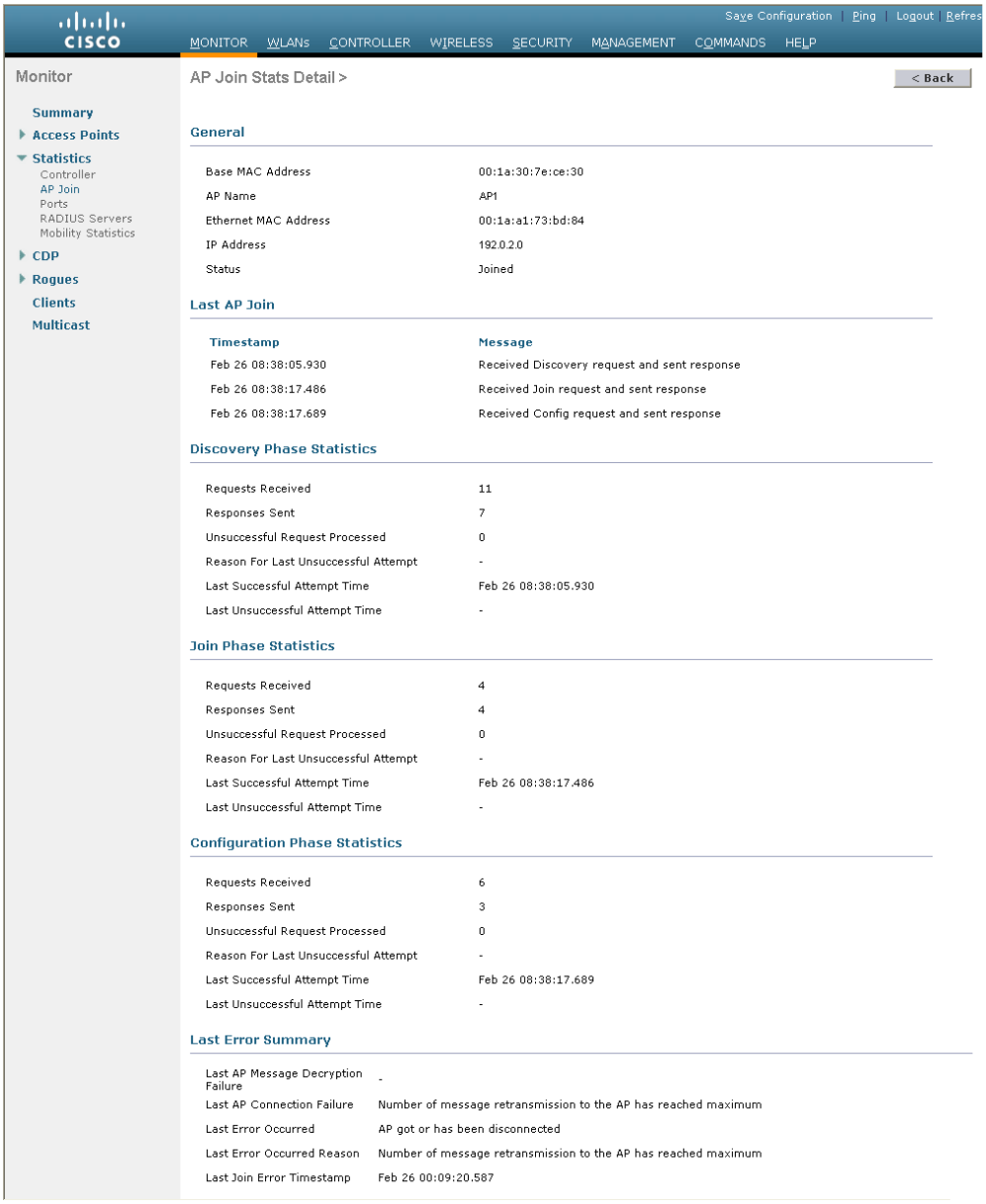
Note When you enable one of these filters, the other filter is disabled automatically.

c. Click **Find** to commit your changes. Only the access points that match your search criteria appear on the AP Join Stats page, and the Current Filter parameter at the top of the page specifies the filter used to generate the list (for example, MAC Address:00:1e:f7:75:0a:a0 or AP Name:pmsk-ap).

Note If you want to remove the filter and display the entire access point list, click **Clear Filter**.

Step 3 To see detailed join statistics for a specific access point, click the radio MAC address of the access point. The AP Join Stats Detail page appears (see Figure 8-17).

Figure 8-17 AP Join Stats Detail Page



This page provides information from the controller's perspective on each phase of the join process and shows any errors that have occurred.

Using the CLI to View Access Point Join Information

Use these CLI commands to see access point join information:

- See the MAC addresses of all the access points that are joined to the controller or that have tried to join by entering this command:

  show ap join stats summary all

Information similar to the following appears:

```
Number of APs.......................................... 4

Base Mac             AP EthernetMac     AP Name       IP Address       Status
00:0b:85:57:bc:c0    00:0b:85:57:bc:c0   AP1130       10.10.163.217   Joined
00:1c:0f:81:db:80    00:1c:63:23:ac:a0   AP1140       10.10.163.216   Not joined
00:1c:0f:81:fc:20    00:1b:d5:9f:7d:b2   AP1          10.10.163.215   Joined
00:21:1b:ea:36:60   00:0c:d4:8a:6b:c1    AP2          10.10.163.214   Not joined
```

- See the last join error detail for a specific access point by entering this command:

  show ap join stats summary *ap_mac*

  where *ap_mac* is the MAC address of the 802.11 radio interface.

Note To obtain the MAC address of the 802.11 radio interface, enter the **show interfaces Dot11Radio 0** command on the access point.

Information similar to the following appears:

```
Is the AP currently connected to controller..... Yes
Time at which the AP joined this controller last time...... Aug 21 12:50:36.061
Type of error that occurred last..... AP got or has been
disconnected
Reason for error that occurred last..... The AP has been reset by
the controller
Time at which the last join error occurred..... Aug 21 12:50:34.374
```

- See all join-related statistics collected for a specific access point by entering this command:

  show ap join stats detailed *ap_mac*

  Information similar to the following appears:

```
Discovery phase statistics
- Discovery requests received..... 2
- Successful discovery responses sent..... 2
- Unsuccessful discovery request processing..... 0
- Reason for last unsuccessful discovery attempt..... Not applicable
- Time at last successful discovery attempt..... Aug 21 12:50:23.335
- Time at last unsuccessful discovery attempt..... Not applicable

Join phase statistics
- Join requests received..... 1
- Successful join responses sent..... 1
- Unsuccessful join request processing..... 1
- Reason for last unsuccessful join attempt..... RADIUS authorization
 is pending for the AP
- Time at last successful join attempt..... Aug 21 12:50:34.481
- Time at last unsuccessful join attempt..... Aug 21 12:50:34.374

Configuration phase statistics
- Configuration requests received..... 1
- Successful configuration responses sent..... 1
- Unsuccessful configuration request processing..... 0
- Reason for last unsuccessful configuration attempt..... Not applicable
- Time at last successful configuration attempt..... Aug 21 12:50:34.374
- Time at last unsuccessful configuration attempt..... Not applicable

Last AP message decryption failure details
- Reason for last message decryption failure..... Not applicable
```

```
Last AP disconnect details
- Reason for last AP connection failure..... The AP has been reset by
the controller

Last join error summary
- Type of error that occurred last..... AP got or has been
disconnected
- Reason for error that occurred last..... The AP has been reset by
the controller
- Time at which the last join error occurred..... Aug 21 12:50:34.374
```

- Clear the join statistics for all access points or for a specific access point by entering this command:

  clear ap join stats {**all** | *ap_mac*}

Using a Controller to Send Debug Commands to Access Points Converted to Lightweight Mode

You can enable the controller to send debug commands to an access point converted to lightweight mode by entering this command:

debug ap {**enable** | **disable** | **command** *cmd*} *Cisco_AP*

When this feature is enabled, the controller sends debug commands to the converted access point as character strings. You can send any debug command supported by Cisco Aironet access points that run Cisco IOS software in lightweight mode.

Understanding How Converted Access Points Send Crash Information to the Controller

When a converted access point unexpectedly reboots, the access point stores a crash file on its local flash memory at the time of the crash. After the unit reboots, it sends the reason for the reboot to the controller. If the unit rebooted because of a crash, the controller pulls up the crash file using existing CAPWAP messages and stores it in the controller flash memory. The crash info copy is removed from the access point flash memory when the controller pulls it from the access point.

Understanding How Converted Access Points Send Radio Core Dumps to the Controller

When a radio module in a converted access point generates a core dump, the access point stores the core dump file of the radio on its local flash memory at the time of the radio crash. It sends a notification message to the controller indicating which radio generated a core dump file. The controller sends a trap that alerts you so that you can retrieve the radio core file from the access point.

The retrieved core file is stored in the controller flash and can be uploaded through TFTP or FTP to an external server for analysis. The core file is removed from the access point flash memory when the controller pulls it from the access point.

Using the CLI to Retrieve Radio Core Dumps

To retrieve the radio core dump file using the controller CLI, follow these steps:

Step 1 Transfer the radio core dump file from the access point to the controller by entering this command:

config ap crash-file get-radio-core-dump *slot Cisco_AP*

For the *slot* parameter, enter the slot ID of the radio that crashed.

Step 2 Verify that the file was downloaded to the controller by entering this command:

show ap crash-file

Information similar to the following appears:

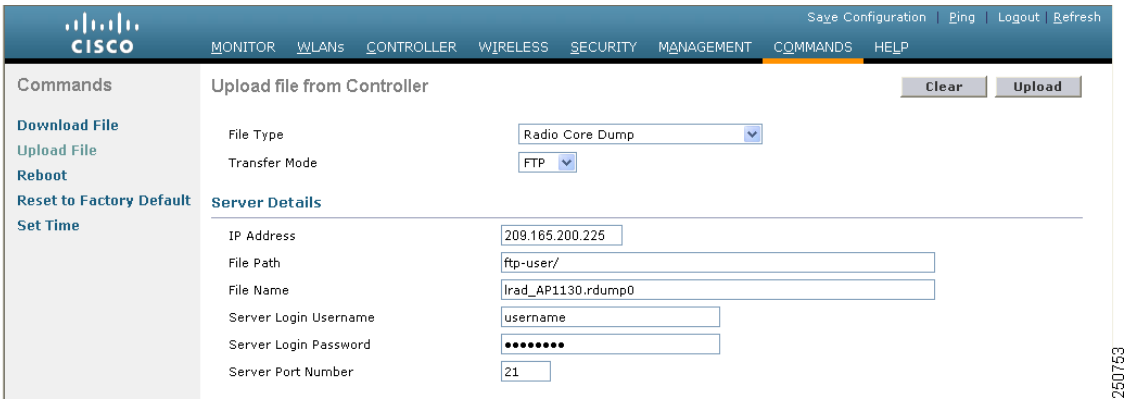
```
Local Core Files:
lrad_AP1130.rdump0    (156)

The number in parentheses indicates the size of the file. The size should be greater than
zero if a core dump file is available.
```

Using the GUI to Upload Radio Core Dumps

To upload the radio core dump file to a TFTP or FTP server using the controller GUI, follow these steps:

Step 1 Choose **Commands** > **Upload File** to open the Upload File from Controller page (see Figure 8-18).

Figure 8-18 Upload File from Controller Page



Step 2 From the File Type drop-down list, choose **Radio Core Dump**.

Step 3 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 4 In the IP Address text box, enter the IP address of the TFTP or FTP server.

Step 5 In the File Path text box, enter the directory path of the file.

Step 6 In the File Name text box, enter the name of the radio core dump file.

Note The *filename* that you enter should match the filename generated on the controller. You can determine the *filename* on the controller by entering the **show ap crash-file** command.

Step 7 If you chose FTP as the Transfer Mode, follow these steps:

a. In the Server Login Username text box, enter the FTP server login name.

b. In the Server Login Password text box, enter the FTP server login password.

c. In the Server Port Number text box, enter the port number of the FTP server. The default value for the server port is 21.

Step 8 Click **Upload** to upload the radio core dump file from the controller. A message appears indicating the status of the upload.

Using the CLI to Upload Radio Core Dumps

To upload the radio core dump file to a TFTP or FTP server using the controller CLI, follow these steps:

Step 1 Transfer the file from the controller to a TFTP or FTP server by entering these commands:

- **transfer upload mode** {**tftp** | **ftp**}
- **transfer upload datatype radio-core-dump**
- **transfer upload serverip** *server_ip_address*
- **transfer upload path** *server_path_to_file*
- **transfer upload filename** *filename*

Note The *filename* that you enter should match the filename generated on the controller. You can determine the *filename* on the controller by entering the **show ap crash-file** command.

Step 2 If you are using an FTP server, also enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 3 View the updated settings by entering this command:

transfer upload start

Step 4 When prompted to confirm the current settings and start the software upload, answer **y**.

Uploading Memory Core Dumps from Converted Access Points

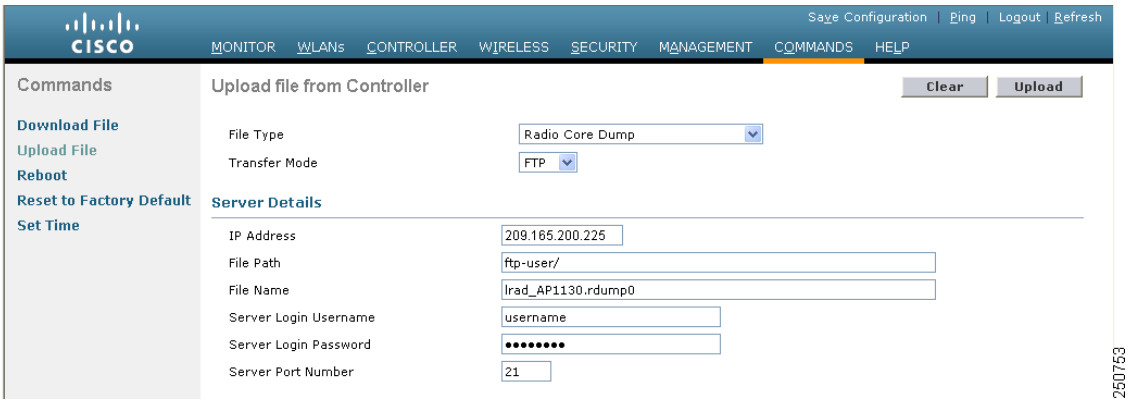
By default, access points converted to lightweight mode do not send memory core dumps to the controller. This section provides instructions to upload access point core dumps using the controller GUI or CLI.

Using the GUI to Upload Access Point Core Dumps

To upload a core dump file of the access point using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Access Points** > **All APs** > *access point name* > and choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 8-19).

Figure 8-19 All APs > Details for (Advanced) Page



Step 2 Select the **AP Core Dump** check box to upload a core dump of the access point.

Step 3 In the TFTP Server IP text box, enter the IP address of the TFTP server.

Step 4 In the File Name text box, enter a name of the access point core dump file (such as *dump.log*).

Step 5 Select the **File Compression** check box to compress the access point core dump file. When you enable this option, the file is saved with a .gz extension (such as *dump.log.gz*). This file can be opened with WinZip.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Upload Access Point Core Dumps

To upload a core dump file of the access point using the controller CLI, follow these steps:

Step 1 Upload a core dump of the access point by entering this command on the controller:

config ap core-dump enable *tftp_server_ip_address filename* {**compress** | **uncompress**} {*ap_name* | **all**}

where

- *tftp_server_ip_address* is the IP address of the TFTP server to which the access point sends core dump files.

  Note The access point must be able to reach the TFTP server.

- *filename* is the name that the access points uses to label the core file.
- **compress** configures the access point to send compressed core files whereas **uncompress** configures the access point to send uncompressed core files.

  Note When you choose **compress**, the file is saved with a .gz extension (for example, dump.log.gz). This file can be opened with WinZip.

- *ap_name* is the name of a specific access point for which core dumps are uploaded and **all** is all access points converted to lightweight mode.

Step 2 Save your changes by entering this command:

save config

Viewing the AP Crash Log Information

Note Whenever the controller reboots or upgrades, the AP crash log information gets deleted from the controller. We recommend that you make a backup of AP crash log information before rebooting or upgrading the controller.

Using the GUI to View the AP Crash Log information

To view the AP crash log information using the controller GUI, follow these steps:

Step 1 Choose **Management** > **Tech Support** > **AP Crash Log** to open the AP Crash Logs page (see Figure 8-20).

Figure 8-20 AP Crash Logs Page

Using the CLI to View the AP Crash Log information

To retrieve the AP crash log information using the controller CLI, follow these steps:

Step 1 Verify that the crash file was downloaded to the controller by entering this command:

show ap crash-file

Information similar to the following appears:

```
Local Core Files:
lrad_AP1130.rdump0 (156)
The number in parentheses indicates the size of the file. The size should be greater than
zero if a core dump file is available.
```

Step 2 See the contents of the AP crash log file by entering this command:

show ap crash-file *Cisoc_AP*

Displaying MAC Addresses for Converted Access Points

There are some differences in the way that controllers display the MAC addresses of converted access points on information pages in the controller GUI:

- On the AP Summary page, the controller lists the Ethernet MAC addresses of converted access points.
- On the AP Detail page, the controller lists the BSS MAC addresses and Ethernet MAC addresses of converted access points.
- On the Radio Summary page, the controller lists converted access points by radio MAC address.

Disabling the Reset Button on Access Points Converted to Lightweight Mode

You can disable the reset button on access points converted to lightweight mode. The reset button is labeled MODE on the outside of the access point.

Use this command to disable or enable the reset button on one or all converted access points associated to a controller:

config ap reset-button {**enable** | **disable**} {*ap-name* | **all**}

The reset button on converted access points is enabled by default.

Configuring a Static IP Address on a Lightweight Access Point

If you want to specify an IP address for an access point rather than having one assigned automatically by a DHCP server, you can use the controller GUI or CLI to configure a static IP address for the access point. Static IP addresses are generally used only for deployments with a limited number of users.

Note See the "Configuring DHCP" section on page 7-10 for information on assigning IP addresses using DHCP.

An access point cannot discover the controller using domain name system (DNS) resolution if a static IP address is configured for the access point, unless you specify a DNS server and the domain to which the access point belongs. Previously, these parameters could be configured only using the CLI, but controller software release 6.0 or later releases expand this functionality to the GUI.

Note If you configure an access point to use a static IP address that is not on the same subnet on which the access point's previous DHCP address was, the access point falls back to a DHCP address after the access point reboots. If the access point falls back to a DHCP address, enter the **show ap config general** *Cisco_AP* CLI command to show that the access point is using a fallback IP address. However, the GUI shows both the static IP address and the DHCP address, but it does not identify the DHCP address as a fallback address.

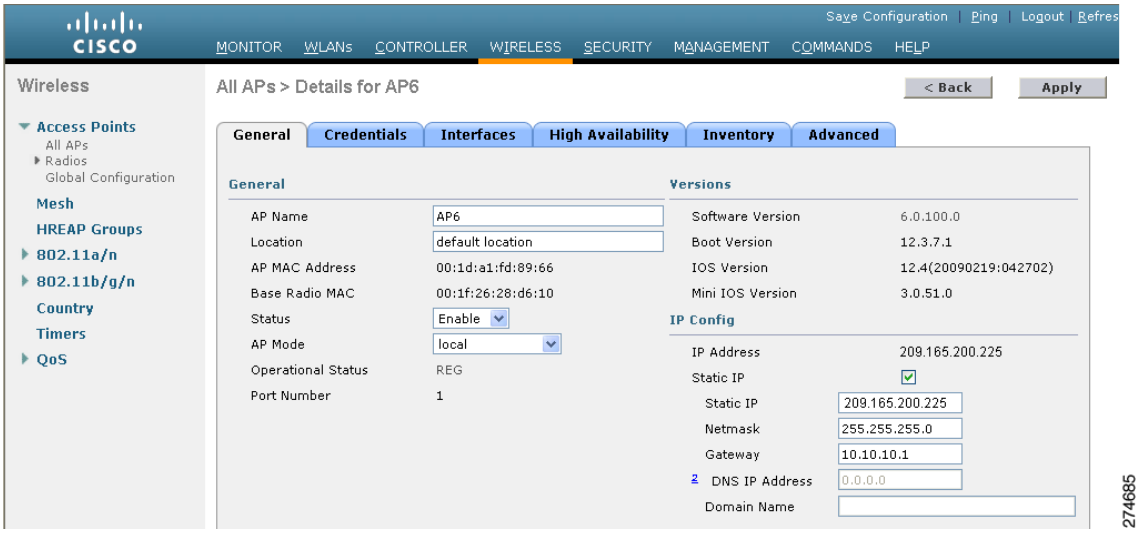
Using the GUI to Configure a Static IP Address

To configure a static IP address for a lightweight access point using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to configure a static IP address. The All APs > Details for (General) page appears (see Figure 8-21).

Figure 8-21 All APs > Details for (General) Page



Step 3 Under IP Config, select the **Static IP** check box if you want to assign a static IP address to this access point. The default value is unselected.

Step 4 Enter the static IP address, netmask, and default gateway in the corresponding text boxes.

Step 5 Click **Apply** to commit your changes. The access point reboots and rejoins the controller, and the static IP address that you specified in Step 4 is sent to the access point.

Step 6 After the static IP address has been sent to the access point, you can configure the DNS server IP address and domain name as follows:

a. In the DNS IP Address text box, enter the IP address of the DNS server.

b. In the Domain Name text box, enter the name of the domain to which the access point belongs.

c. Click **Apply** to commit your changes.

d. Click **Save Configuration** to save your changes.

Using the CLI to Configure a Static IP Address

To configure a static IP address for a lightweight access point using the controller CLI, follow these steps:

Step 1 Configure a static IP address on the access point by entering this command:

config ap static-ip enable *Cisco_AP ip_address mask gateway*

Note To disable static IP for the access point, enter the **config ap static-ip disable** *Cisco_AP* command.

Step 2 Save your changes by entering this command:

save config

The access point reboots and rejoins the controller, and the static IP address that you specified in Step 1 is pushed to the access point.

Step 3 After the static IP address has been sent to the access point, you can configure the DNS server IP address and domain name as follows:

a. To specify a DNS server so that a specific access point or all access points can discover the controller using DNS resolution, enter this command:

config ap static-ip add nameserver {*Cisco_AP* | **all**} *ip_address*

Note To delete a DNS server for a specific access point or all access points, enter the **config ap static-ip delete nameserver** {*Cisco_AP* | **all**} command.

b. To specify the domain to which a specific access point or all access points belong, enter this command:

config ap static-ip add domain {*Cisco_AP* | **all**} *domain_name*

Note To delete a domain for a specific access point or all access points, enter this command: **config ap static-ip delete domain** {*Cisco_AP* | **all**}.

c. To save your changes, enter this command:

save config

Step 4 See the IP address configuration for the access point by entering this command:

show ap config general *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 4
Cisco AP Name.................................... AP6
...
IP Address Configuration......................... Static IP assigned
IP Address....................................... 10.10.10.118
IP NetMask....................................... 255.255.255.0
Gateway IP Addr.................................. 10.10.10.1
Domain........................................... Domain1
Name Server...................................... 10.10.10.205
...
```

Supporting Oversized Access Point Images

Controller software release 5.0 or later releases allow you to upgrade to an oversized access point image by automatically deleting the recovery image to create sufficient space. This feature affects only access points with 8 MB of flash (the 1100, 1200, and 1310 series access points). All newer access points have a larger flash size than 8 MB.

Note As of August 2007, there are no oversized access point images, but as new features are added, the access point image size will continue to grow.

The recovery image provides a backup image that can be used if an access point power-cycles during an image upgrade. The best way to avoid the need for access point recovery is to prevent an access point from power-cycling during a system upgrade. If a power-cycle occurs during an upgrade to an oversized access point image, you can recover the access point using the TFTP recovery procedure.

To perform the TFTP recovery procedure, follow these steps:

Step 1 Download the required recovery image from Cisco.com (c1100-rcvk9w8-mx, c1200-rcvk9w8-mx, or c1310-rcvk9w8-mx) and install it in the root directory of your TFTP server.

Step 2 Connect the TFTP server to the same subnet as the target access point and power-cycle the access point. The access point boots from the TFTP image and then joins the controller to download the oversized access point image and complete the upgrade procedure.

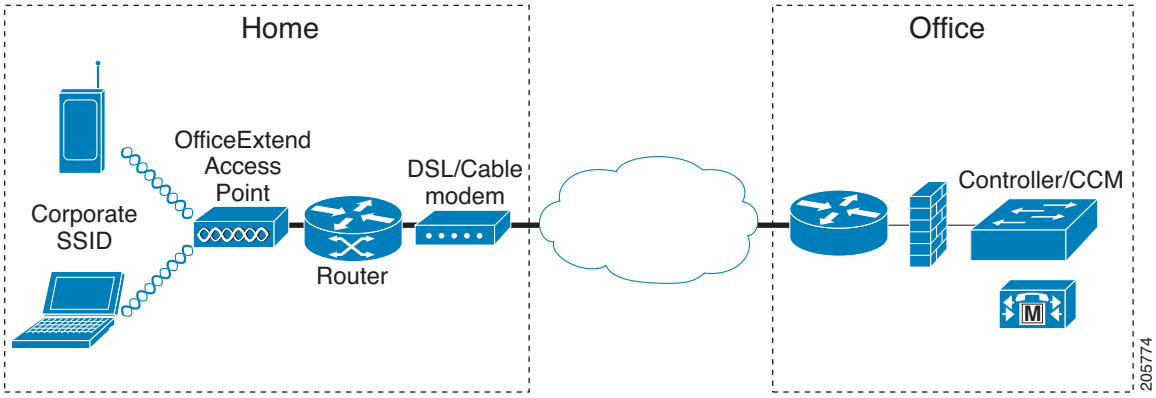
Step 3 After the access point has been recovered, you may remove the TFTP server.

OfficeExtend Access Points

An OfficeExtend access point provides secure communications from a controller to an access point at a remote location, seamlessly extending the corporate WLAN over the Internet to an employee's residence. The user's experience at the home office is exactly the same as it would be at the corporate office. Datagram Transport Layer Security (DTLS) encryption between the access point and the controller ensures that all communications have the highest level of security.

Figure 8-22 shows a typical OfficeExtend access point setup.

Figure 8-22 Typical OfficeExtend Access Point Setup



Note OfficeExtend access points are designed to work behind a router or other gateway device that is using network address translation (NAT). NAT allows a device, such as a router, to act as an agent between the Internet (public) and a personal network (private), enabling an entire group of computers to be represented by a single IP address. In controller software release 6.0 or later releases, only one OfficeExtend access point can be deployed behind a single NAT device.

Currently, Cisco 1040, 1130, 1140, and 3502I series access points that are joined to a Cisco 5500 Series Controller can be configured to operate as OfficeExtend access points.

OEAP 600 Series Access Points

This section details the requirements for configuring a Cisco wireless LAN controller for use with the Cisco 600 Series OfficeExtend Access Point. The 600 Series OfficeExtend Access Point supports split mode operation, and it requires configuration through the WLAN controller in local mode. This section describes the configurations necessary for proper connection and supported feature sets.

Note The Cisco 600 Series OfficeExtend access points are designed to work behind a router or other gateway device that is using Network Address Translation (NAT). NAT allows a device, such as a router, to act as an agent between the Internet (public) and a personal network (private), enabling an entire group of computers to be represented by a single IP address. In controller software release 6.0 or later releases, only one OfficeExtend access point can be deployed behind a single NAT device.

Note The following ports must be open on the firewall between the WLAN controller and the 600 Series OfficeExtend Access Point: CAPWAP UDP 5246 and 5247

Supported Controller Platforms

The 600 Series OfficeExtend Access Point is supported on the Cisco 5508 Series Controller, WISM-2, and Cisco 2500 Series Controllers and requires the controller software 7.0.116.0 release.

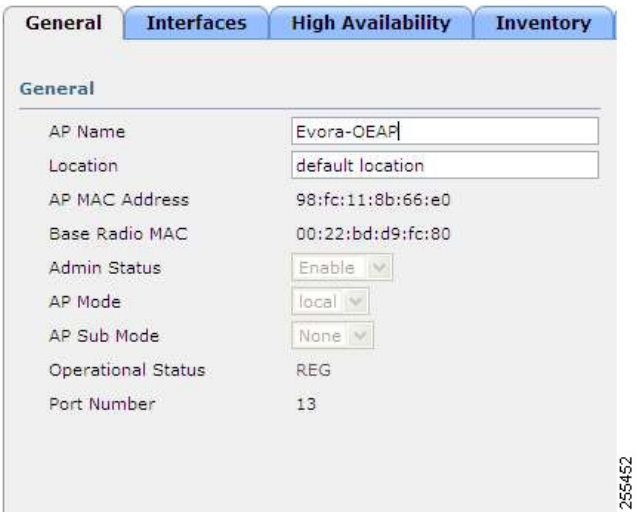
The 600 Series OfficeExtend Access Point has DTLS permanently enabled. You cannot disable DTLS on this access point.

OEAP in Local Mode

The 600 Series OfficeExtend Access Point connects to the controller in local mode. You cannot alter these settings.

Note Monitor mode, H-REAP mode, sniffer mode, rogue detector, bridge, and SE-Connect are not supported on the 600 Series OfficeExtend Access Point and are not configurable.

Figure 8-23 OEAP Mode

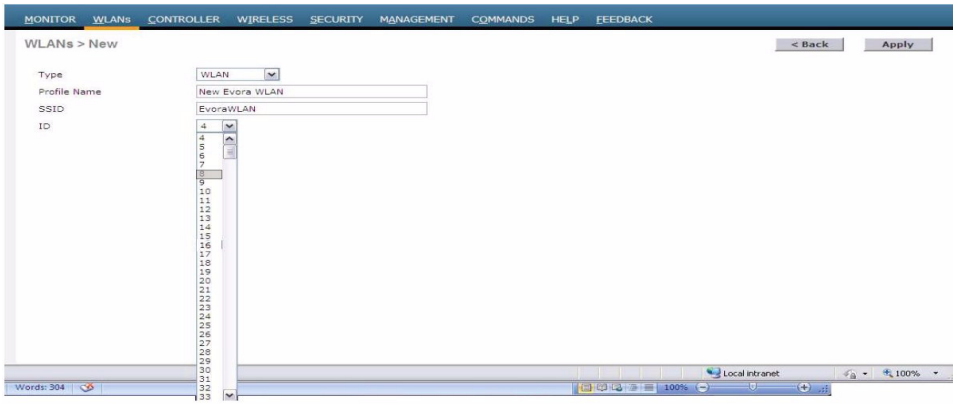


Supported WLAN Settings for 600 Series OfficeExtend Access Point

The 600 Series OfficeExtend Access Point supports a maximum of two WLANs and one remote LAN. If your network deployment has more than two WLANs, you must place the 600 Series OfficeExtend Access Point in an AP group. If the 600 Series OfficeExtend Access Points are added to an AP group, the same limit of two WLANs and one remote LAN still applies for the configuration of the AP group.

If the 600 Series OfficeExtend Access Point is in the default group, which means that it is not in a defined AP group, the WLAN/remote LAN IDs must be set lower than ID 8.

Figure 8-24 WLAN ID for OEAP



If additional WLANs or remote LANs are created with the intent of changing the WLANs or remote LAN being used by the 600 Series OfficeExtend Access Point, you must disable the current WLANs or remote LAN that you are removing before enabling the new WLANs or remote LAN on the 600 Series OfficeExtend Access Point. If there are more than one remote LANs enabled for an AP group, disable all remote LANs and then enable only one of them.

If more than two WLANs are enabled for an AP group, disable all WLANs and then enable only two of them.

For more information on WLANs, see Chapter 7, "Configuring WLANs."

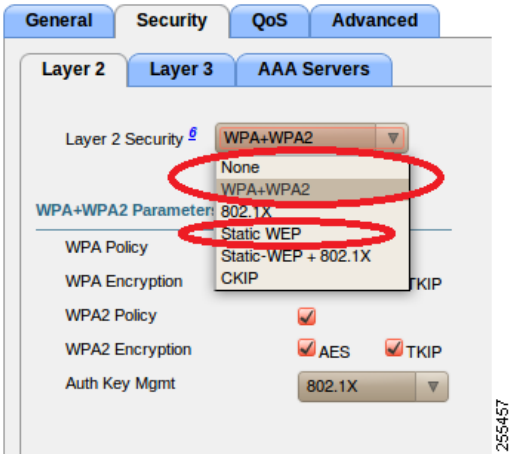
WLAN Security Settings for the 600 Series OfficeExtend Access Point

When configuring the security settings in the WLAN, note that there are specific elements that are not supported on the 600 Series OfficeExtend Access Point. CCX is not supported on the 600 Series OfficeExtend Access Point, and elements related to CCX are not supported.

For Layer 2 Security, the following options are supported for the 600 Series OfficeExtend Access Point:

- None
- WPA+WPA2
- Static WEP

Figure 8-25 WLAN Security Settings



In the Security tab, do not select CCKM in WPA + WPA2 settings. Select only 802.1x or PSK.

Figure 8-26 WLAN Security Settings

Security encryption settings must be identical for WPA and WPA2 for TKIP and AES. The following are examples of incompatible settings for TKIP and AES.

Figure 8-27 and Figure 8-28 display the incompatible configuration

Figure 8-27 Incompitable WPA and WPA2 Security Encryption Settings for OEAP 600 Series

Figure 8-28 Incompitable WPA and WPA2 Security Enctyption Settings for OEAP 600 Series.

The following are examples of compatible settings:

Figure 8-29 Compitable Security Settings for OEAP Series.

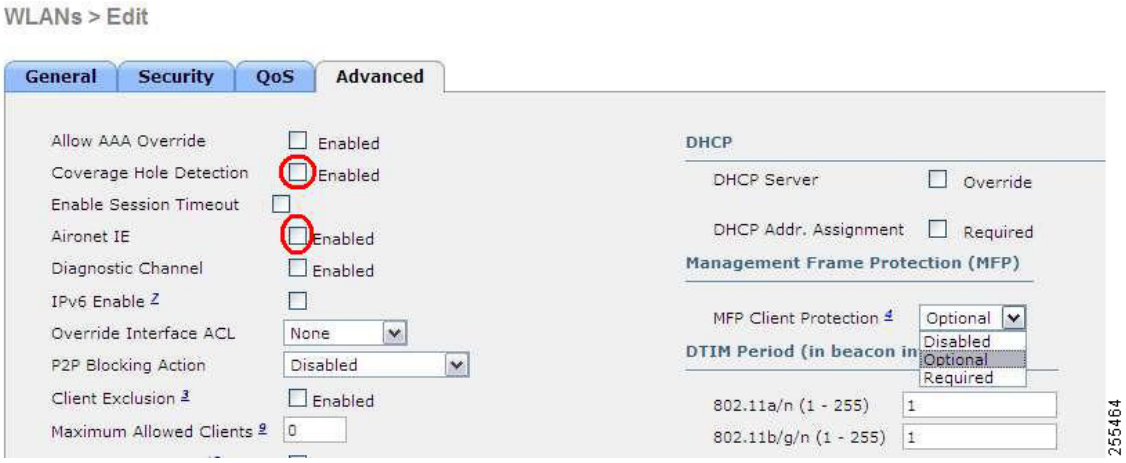
Figure 8-30

QOS settings are supported, but CAC is not supported and should not be enabled.

Note Coverage Hole Detection should not be enabled.

Note Aironet IE should not be enabled. This option is not supported.

Figure 8-31 QoS Settings for OEAP 600



MFP is also not supported and should be disabled or set to optional.

Figure 8-32 MPF Settings for OEAP Series Access Points

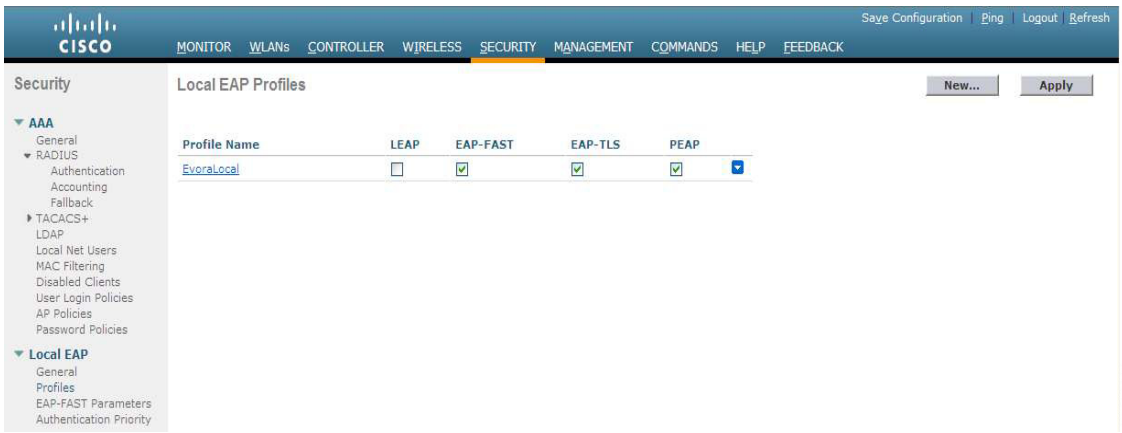
Client Load Balancing and Client Band Select are not supported:

Authentication Settings

For authentication on the 600 Series OfficeExtend Access Point, LEAP is not supported. This configuration needs to be addressed on the clients and radius servers to migrate them to EAP-Fast, EAP-TTLS, EAP-TLS, or PEAP.

If Local EAP is being utilized on the controller, then the settings would also have to be modified not to utilize LEAP:

Figure 8-33 Local EAP Profiles



Supported User Count on 600 Series OfficeExtend Access Point

Only fifteen users are allowed to connect on the WLAN Controller WLANs provided on the 600 Series OfficeExtend Access Point at any one time, a sixteenth user cannot authenticate until one of the first clients is deauthenticated or timeout on the controller occurs. This number is cumulative across the controller WLANs on the 600 Series OfficeExtend Access Point.

For example, if two controller WLANs are configured and there are fifteen users on one of the WLANs, no users can join the other WLAN on the 600 Series OfficeExtend Access Point at that time.

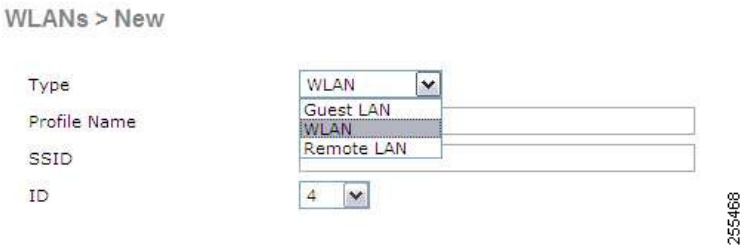
This limit does not apply to the local private WLANs that the end user configures on the 600 Series OfficeExtend Access Point for personal use. Clients connected on these private WLANs or on the wired ports do not affect these limits.

Remote LAN Settings

Only four clients can connect through a remote LAN port on the 600 Series OfficeExtend Access Point. This number does not affect the fifteen user limit imposed for the Controller WLANs. The remote LAN client limit supports connecting a switch or hub to the remote LAN port for multiple devices or connecting directly to a Cisco IP phone that is connected to that port. Only the first four devices can connect connect until one of the devices is idle for more than one minute.

Remote LAN is configured in the same way that a WLAN or Guest LAN is configured on the controller:

Figure 8-34 Remote LAN Settings for OEAP 600 Series AP



Security settings can be left open, set for MAC filtering, or set for Web Authentication. The default is to utilize MAC filtering.

Figure 8-35 shows the security settings for MAC filtering.

Figure 8-35 MAC filtering for OEAP 600 Series AP

Figure 8-36 displays the Layer 4 security configuration.

Figure 8-36 Security Configuation for OEAP 600 AP

Channel Management and Settings

The radios for the 600 Series OfficeExtend Access Point are controlled through the Local GUI on the access point and not through the Wireless LAN Controller. Attempting to control the spectrum channel or power, or to disable the radios through the controller does not have effect on the 600 Series OfficeExtend Access Point. RRM is not supported on the 600 Series OfficeExtend Access Point.

The 600 series scans and chooses channels for 2.4GHz and 5.0GHz during startup as long as the default settings on the local GUI are left as default in both spectrums.

Figure 8-37 Channel Selection for OEAP 600 Series APs

The channel bandwidth for 5.0 GHz is also configured on the 600 Series OfficeExtend Access Point Local GUI, for 20 MHz or 40 MHz wide channels. Setting the channel width to 40 MHz for 2.4 GHz is not supported and fixed at 20 MHz.

Figure 8-38 Channel Width for OEAP 600 APs

Additional Caveats

The 600 Series OfficeExtend Access Points are designed for single AP deployments, therefore client roaming between 600 Series OfficeExtend Access Points is not supported.

Disabling the 802.11a/n or 802.11b/g/n on the controller may not disable these spectrums on the 600 Series OfficeExtend Access Point since local SSID may be still working.

Note Your firewall must be configured to allow traffic from access points using CAPWAP. Make sure that UDP ports 5246 and 5247 are enabled and are not blocked by an intermediate device that could prevent an access point from joining the controller.

Implementing Security

Note Configuring LSC is not a requirement but an option.

To ensure that only valid OfficeExtend access points join the company network, follow these steps:

Step 1 Use local significant certificates (LSCs) to authorize your OfficeExtend access points, by following the instructions in the "Authorizing Access Points Using LSCs" section on page 8-46.

Step 2 Implement AAA server validation using the access point's MAC address, name, or both as the username in authorization requests, by entering this command:

config auth-list ap-policy authorize-ap username {*ap_mac* | *Cisco_AP* | **both**}

Using the access point name for validation can ensure that only the OfficeExtend access points of valid employees can join the controller. To implement this security policy, make sure to name each OfficeExtend access point with an employee ID or employee number. When an employee is terminated, run a script to remove this user from the AAA server database, which prevents that employee's OfficeExtend access point from joining the network.

Step 3 Save your changes by entering this command:

save config

Note CCX is not supported on the 600 OEAP. Elements related to CCX are not supported. Also, only 802.1x or PSK is supported. TKIP and AES security encryption settings must be identical for WPA and WPA2.

Licensing for an OfficeExtend Access Point

To use OfficeExtend access points, a base license must be installed and in use on the Cisco 5500 Series Controller. After the license is installed, you can enable the OfficeExtend mode on an 1130 series or 1140 series access point.

Note See Chapter 4, "Configuring Controller Settings," for information on obtaining and installing licenses.

Configuring OfficeExtend Access Points

After the 1130 series or 1140 series access point has joined the controller, you can configure it as an OfficeExtend access point using the controller GUI or CLI.

Note Configuring LSC is not a requirement but an option.

Using the GUI to Configure OfficeExtend Access Points

To configure an OfficeExtend access point using the controller GUI, follow these steps:

Step 1 Enable hybrid REAP on the access point as follows:

a. Choose **Wireless** to open the All APs page.

b. Click the name of the desired access point. The All APs > Details for (General) page appears.

c. Choose **H-REAP** from the AP Mode drop-down list to enable hybrid REAP for this access point.

Note For more information on hybrid-REAP, see Chapter 15, "Configuring Hybrid REAP."

Step 2 Configure one or more controllers for the access point as follows:

a. Choose the **High Availability** tab to open the All APs > Details for (High Availability) page.

b. Enter the name and IP address of the primary controller for this access point in the Primary Controller Name and Management IP Address text boxes.

Note You must enter both the name and IP address of the controller. Otherwise, the access point cannot join this controller.

c. If desired, enter the name and IP address of a secondary or tertiary controller (or both) in the corresponding Controller Name and Management IP Address text boxes.

d. Click **Apply** to commit your changes. The access point reboots and then rejoins the controller.

Note OfficeExtend access points do not use the generic broadcast or over-the air (OTAP) discovery process to locate a controller. You must configure one or more controllers because OfficeExtend access points try to connect only to their configured controllers.

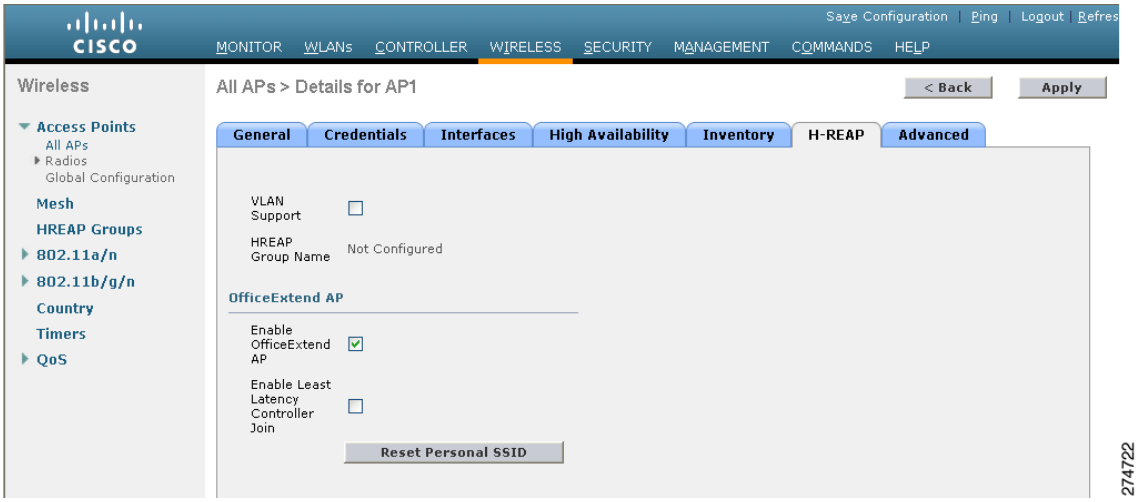
Note The names and IP addresses must be unique for the primary, secondary, and tertiary controllers.

Step 3 Enable OfficeExtend access point settings as follows:

a. Click the access point name on the All APs page.

b. Choose the **H-REAP** tab to open the All APs > Details for (H-REAP) page (see Figure 8-39).

Figure 8-39 All APs > Details for (H-REAP) Page



c. Select the **Enable OfficeExtend AP** check box to enable the OfficeExtend mode for this access point. The default value is selected.

Unselecting this check box disables OfficeExtend mode for this access point. It does not undo all of the configuration settings on the access point. If you want to clear the access point's configuration and return it to the factory-default settings, enter **clear ap config** *Cisco_AP* on the controller CLI. If you want to clear only the access point's personal SSID, click **Reset Personal SSID**.

Note Rogue detection is disabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable rogue detection for a specific access point by selecting the **Rogue Detection** check box on the All APs > Details for (Advanced) page. Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect a large number of rogue devices. See the "Managing Rogue Devices" section on page 6-89 for more information on rogue detection.

Note DTLS data encryption is enabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable DTLS data encryption for a specific access point by selecting the **Data Encryption** check box on the All APs > Details for (Advanced) page. See the "Configuring Data Encryption" section on page 8-2 for more information on DTLS data encryption.

Note Telnet and SSH access are disabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable Telnet or SSH access for a specific access point by selecting the **Telnet** or **SSH** check box on the All APs > Details for (Advanced) page. See the "Troubleshooting Access Points Using Telnet or SSH" section on page D-48 for more information on Telnet and SSH.

Note Link latency is enabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable link latency for a specific access point by selecting the **Enable Link Latency** check box on the All APs > Details for (Advanced) page. See the "Configuring Link Latency" section on page 8-124 for more information on this feature.

d. Select the **Enable Least Latency Controller Join** check box if you want the access point to choose the controller with the least latency when joining. Otherwise, leave this check box unselected, which is the default value. When you enable this feature, the access point calculates the time between the discovery request and discovery response and joins the Cisco 5500 Series Controller that responds first.

e. Click **Apply** to commit your changes.

The OfficeExtend AP text box on the All APs page shows which access points are configured as OfficeExtend access points.

Step 4 Configure a specific username and password for the OfficeExtend access point so that the user at home can log into the GUI of the OfficeExtend access point:

a. Click the access point name on the All APs page again.

b. Choose the **Credentials** tab to open the All APs > Details for (Credentials) page.

c. Select the **Over-ride Global Credentials** check box to prevent this access point from inheriting the global username, password, and enable password from the controller. The default value is unselected.

d. In the Username, Password, and Enable Password text boxes, enter the unique username, password, and enable password that you want to assign to this access point.

Note The information that you enter is retained across controller and access point reboots and if the access point joins a new controller.

e. Click **Apply** to commit your changes.

f. Click **Save Configuration** to save your changes.

Note If you want to force this access point to use the controller's global credentials, unselect the **Over-ride Global Credentials** check box.

Step 5 If your controller supports only OfficeExtend access points, see the "Configuring RRM" section on page 13-10 for instructions on setting the recommended values for the DCA interval, channel scan duration, and neighbor packet frequency.

Using the CLI to Configure OfficeExtend Access Points

To configure an OfficeExtend access point using the controller CLI, follow these steps:

Step 1 Enable hybrid-REAP on the access point by entering this command:

config ap mode h-reap *Cisco_AP*

Note For more information on hybrid-REAP, see Chapter 15, "Configuring Hybrid REAP."

Step 2 Configure one or more controllers for the access point by entering one or all of these commands:

config ap primary-base *controller_name Cisco_AP controller_ip_address*

config ap secondary-base *controller_name Cisco_AP controller_ip_address*

config ap tertiary-base *controller_name Cisco_AP controller_ip_address*

Note You must enter both the name and IP address of the controller. Otherwise, the access point cannot join this controller.

Note OfficeExtend access points do not use the generic broadcast or over-the air (OTAP) discovery process to find a controller. You must configure one or more controllers because OfficeExtend access points try to connect only to their configured controllers.

Note The names and IP addresses must be unique for the primary, secondary, and tertiary controllers.

Step 3 Enable the OfficeExtend mode for this access point by entering this command:

config hreap office-extend {**enable** | **disable**} *Cisco_AP*

The default value is enabled. The **disable** parameter disables OfficeExtend mode for this access point. It does not undo all of the configuration settings on the access point. If you want to clear the access point's configuration and return it to the factory-default settings, enter this command:

clear ap config *Cisco_AP*

If you want to clear only the access point's personal SSID, enter this command:

config hreap office-extend clear-personalssid-config *Cisco_AP.*

Note Rogue detection is disabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable rogue detection for a specific access point or for all access points using the **config rogue detection** {**enable** | **disable**} {*Cisco_AP* | **all**} command. Rogue detection is disabled by default for OfficeExtend access points because these access points, which are deployed in a home environment, are likely to detect a large number of rogue devices. See the "Managing Rogue Devices" section on page 6-89 for more information on rogue detection.

Note DTLS data encryption is enabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable DTLS data encryption for a specific access point or for all access points using the **config ap link-encryption** {**enable** | **disable**} {*Cisco_AP* | **all**} command. See the "Configuring Data Encryption" section on page 8-2 for more information on DTLS data encryption.

Note Telnet and SSH access are disabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable Telnet or SSH access for a specific access point using the **config ap** {**telnet** | **ssh**} {**enable** | **disable**} *Cisco_AP* command. See the "Troubleshooting Access Points Using Telnet or SSH" section on page D-48 for more information on Telnet and SSH.

Note Link latency is enabled automatically when you enable the OfficeExtend mode for an access point. However, you can enable or disable link latency for a specific access point or for all access points currently associated to the controller using the **config ap link-latency** {**enable** | **disable**} {*Cisco_AP* | **all**} command. See the "Configuring Link Latency" section on page 8-124 for more information on this feature.

Step 4 Enable the access point to choose the controller with the least latency when joining by entering this command:

config hreap join min-latency {**enable** | **disable**} *Cisco_AP*

The default value is disabled. When you enable this feature, the access point calculates the time between the discovery request and discovery response and joins the Cisco 5500 Series Controller that responds first.

Step 5 Configure a specific username and password that users at home can enter to log into the GUI of the OfficeExtend access point by entering this command:

config ap mgmtuser add username *user* **password** *password* **enablesecret** *enable_password Cisco_AP*

The credentials that you enter in this command are retained across controller and access point reboots and if the access point joins a new controller.

Note If you want to force this access point to use the controller's global credentials, enter the **config ap mgmtuser delete** *Cisco_AP* command. The following message appears after you execute this command: "AP reverted to global username configuration."

Step 6 Save your changes by entering this command:

save config

Step 7 If your controller supports only OfficeExtend access points, see the "Configuring Radio Resource Management" section on page 13-1 for instructions on setting the recommended value for the DCA interval.

Configuring a Personal SSID on an OfficeExtend Access Point

To instruct users at home to log into the GUI of their OfficeExtend access point and configure a personal SSID, follow these steps:

Step 1 Find the IP address of your OfficeExtend access point by doing one of the following:

- Log into your home router and look for the IP address of your OfficeExtend access point.
- Ask your company's IT professional for the IP address of your OfficeExtend access point.
- Use an application such as Network Magic to detect devices on your network and their IP addresses.

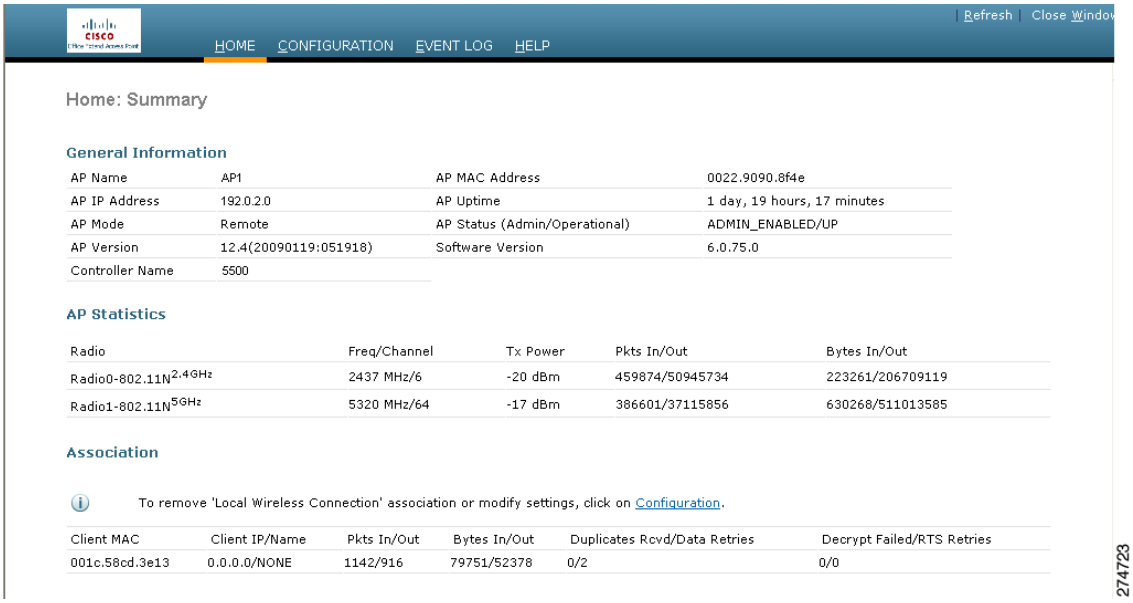
Step 2 With the OfficeExtend access point connected to your home router, enter the IP address of the OfficeExtend access point in the Address text box of your Internet browser and click **Go**.

Note Make sure that you are not connected to your company's network using a virtual private network (VPN) connection.

Step 3 When prompted, enter the username and password to log into the access point.

Step 4 On the OfficeExtend Access Point Welcome page, click **Enter**. The OfficeExtend Access Point Home page appears (see Figure 8-40).

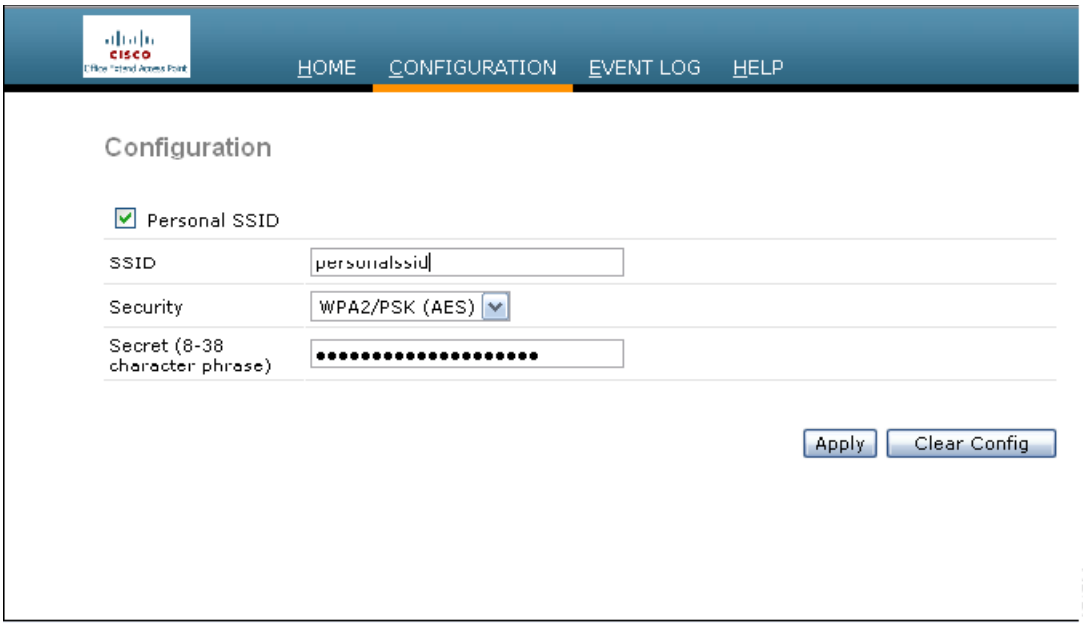
Figure 8-40 OfficeExtend Access Point Home Page



This page shows the access point name, IP address, MAC address, software version, status, channel, transmit power, and client traffic.

Step 5 Choose **Configuration** to open the Configuration page (see Figure 8-41).

Figure 8-41 OfficeExtend Access Point Configuration Page



Step 6 Select the **Personal SSID** check box to enable this wireless connection. The default value is disabled.

Step 7 In the SSID text box, enter the personal SSID that you want to assign to this access point. This SSID is locally switched.

Note A controller with an OfficeExtend access point publishes only up to 15 WLANs to each connected access point because it reserves one WLAN for the personal SSID.

Step 8 From the Security drop-down list, choose **Open**, **WPA2/PSK (AES)**, or **104 bit WEP** to set the security type to be used by this access point.

Note If you choose WPA2/PSK (AES), make sure that the client is configured for WPA2/PSK and AES encryption.

Step 9 If you chose WPA2/PSK (AES) in Step 8, enter an 8- to 38-character WPA2 passphrase in the Secret text box. If you chose 104 bit WEP, enter a 13-character ASCII key in the Key text box.

Step 10 Click **Apply** to commit your changes.

Note If you want to use the OfficeExtend access point for another application, you can clear this configuration and return the access point to the factory-default settings by clicking **Clear Config**. You can also clear the access point's configuration from the controller CLI by entering the **clear ap config** *Cisco_AP* command.

Viewing OfficeExtend Access Point Statistics

Use these commands to view information about the OfficeExtend access points on your network:

- See a list of all OfficeExtend access points by entering this command:

  show hreap office-extend summary

  Information similar to the following appears:

```
Summary of OfficeExtend AP
AP Name      Ethernet MAC       Encryption  Join-Mode   Join-Time
---------- ----------------- ----------- ----------- ---------------------------
AP1130     00:22:90:e3:37:70   Enabled    Latency    Sun Jan  4 21:46:07 2009
AP1140     01:40:91:b5:31:70   Enabled    Latency     Sat Jan  3 19:30:25 2009
```

- See the link delay for OfficeExtend access points by entering this command:

  show hreap office-extend latency

  Information similar to the following appears:

```
Summary of OfficeExtend AP link latency
AP Name   Status       Current   Maximum   Minimum
--------- ----------- ---------- --------- ---------
AP1130     Enabled    15 ms     45 ms     12 ms
AP1140     Enabled    14 ms    179 ms     12 ms
```

- See the encryption state of all access points or a specific access point by entering this command:

  show ap link-encryption {**all** | *Cisco_AP*}

  Information similar to the following appears:

```
                Encryption Dnstream  Upstream Last
AP Name         State      Count     Count    Update
--------------  ---------- --------  --------  --------
AP1130          En         112       1303      23:49
AP1140          En         232       2146      23:49
             auth err: 198 replay err: 0
AP1250          En         0         0         Never
AP1240          En         6191    15011       22:13
```

  This command also shows authentication errors, which track the number of integrity check failures, and replay errors, which track the number of times that the access point receives the same packet.
  See the data plane status for all access points or a specific access point by entering this command:

  show ap data-plane {**all** | *Cisco_AP*}

  Information similar to the following appears:

```
                  Min Data          Data          Max Data   Last
AP Name           Round Trip      Round Trip      Round Trip    Update
---------------  -------------  --------------  -------------- ---------
AP1130             0.012s        0.014s          0.020s      13:46:23
```

```
AP1140              0.012s          0.017s          0.111s       13:46:46
```

- See the join statistics for the OfficeExtend access points by entering the "Using the CLI to View Access Point Join Information" section on page 8-58.

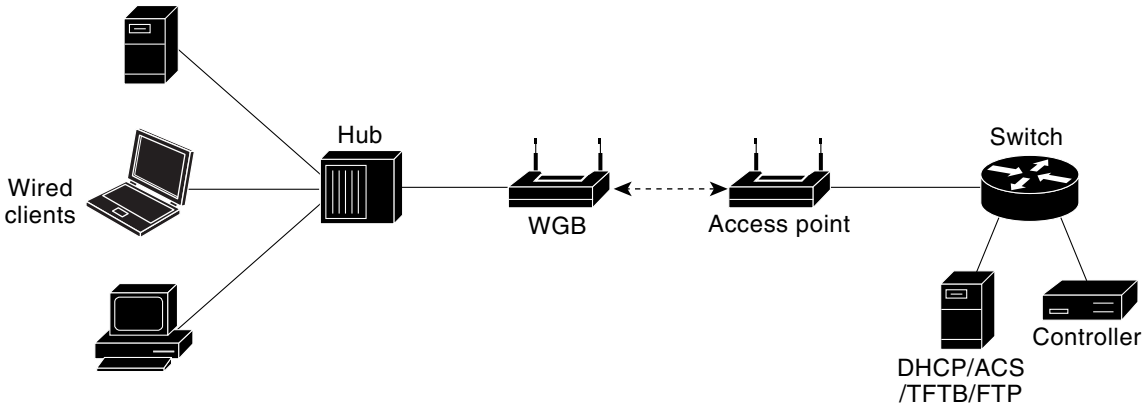
Troubleshooting OfficeExtend Access Points

If you experience any problems with OfficeExtend access points, see the Appendix D.

Cisco Workgroup Bridges

A workgroup bridge (WGB) is a mode that can be configured on an autonomous IOS access point to provide wireless connectivity to a lightweight access point on behalf of clients that are connected by Ethernet to the WGB access point. A WGB connects a wired network over a single wireless segment by learning the MAC addresses of its wired clients on the Ethernet interface and reporting them to the lightweight access point using Internet Access Point Protocol (IAPP) messaging. The WGB provides wireless access connectivity to wired clients by establishing a single wireless connection to the lightweight access point. The lightweight access point treats the WGB as a wireless client. See the example in Figure 8-42.

Figure 8-42 WGB Example



Note If the lightweight access point fails, the WGB attempts to associate to another access point.

Guidelines for Using WGBs

Follow these guidelines for using WGBs on your network:

- The WGB can be any autonomous access point that supports the workgroup bridge mode and is running Cisco IOS Release 12.4(3g)JA or later releases (on 32-MB access points) or Cisco IOS Release 12.3(8)JEB or later releases (on 16-MB access points). These access points include the AP1120, AP1121, AP1130, AP1231, AP1240, and AP1310. Cisco IOS releases prior to 12.4(3g)JA and 12.3(8)JEB are not supported.

Note If your access point has two radios, you can configure only one for workgroup bridge mode. This radio is used to connect to the lightweight access point. We recommend that you disable the second radio.

Enable the workgroup bridge mode on the WGB as follows:

- On the WGB access point GUI, choose **Workgroup Bridge** for the role in radio network on the Settings > Network Interfaces page.
- On the WGB access point CLI, enter the **station-role workgroup-bridge** command.

Note See the sample WGB access point configuration in the "Sample WGB Configuration" section on page 8-90.

- The WGB can associate only to lightweight access points.
- Only WGBs in client mode (which is the default value) are supported. Those WGBs in infrastructure mode are not supported. Perform one of the following to enable client mode on the WGB:
  - On the WGB access point GUI, choose **Disabled** for the Reliable Multicast to WGB parameter.
  - On the WGB access point CLI, enter the **no infrastructure client** command.

Note VLANs are not supported for use with WGBs.

Note See the sample WGB access point configuration in the "Sample WGB Configuration" section on page 8-90.

- These features are supported for use with a WGB:
  - Guest N+1 redundancy
  - Local EAP
  - Open, WEP 40, WEP 128, CKIP, WPA+TKIP, WPA2+AES, LEAP, EAP-FAST, and EAP-TLS authentication modes
- These features are not supported for use with a WGB:
  - Cisco Centralized Key Management (CCKM)
  - Hybrid REAP
  - Idle timeout
  - Web authentication

Note If a WGB associates to a web-authentication WLAN, the WGB is added to the exclusion list, and all of the WGB wired clients are deleted.

- The WGB supports a maximum of 20 wired clients. If you have more than 20 wired clients, use a bridge or another device.

- Wired clients connected to the WGB are not authenticated for security. Instead, the WGB is authenticated against the access point to which it associates. Therefore, we recommend that you physically secure the wired side of the WGB.
- With Layer 3 roaming, if you plug a wired client into the WGB network after the WGB has roamed to another controller (for example, to a foreign controller), the wired client's IP address displays only on the anchor controller, not on the foreign controller.
- If a wired client does not send traffic for an extended period of time, the WGB removes the client from its bridge table, even if traffic is continuously being sent to the wired client. As a result, the traffic flow to the wired client fails. To avoid the traffic loss, prevent the wired client from being removed from the bridge table by configuring the aging-out timer on the WGB to a large value using the following Cisco IOS commands on the WGB:

  ```
  configure terminal
  bridge bridge-group-number aging-time seconds
  exit
  end
  ```

  where *bridge-group-number* is a value between 1 and 255, and *seconds* is a value between 10 and 1,000,000 seconds. We recommend configuring the *seconds* parameter to a value greater than the wired client's idle period.
- When you delete a WGB record from the controller, all of the WGB wired clients' records are also deleted.
- Wired clients connected to a WGB inherit the WGB's QoS and AAA override attributes.
- These features are not supported for wired clients connected to a WGB:
  - MAC filtering
  - Link tests
  - Idle timeout
- To enable the WGB to communicate with the lightweight access point, create a WLAN and make sure that Aironet IE is enabled.
- Wired clients behind a WGB cannot connect to a DMZ/Anchor controller. This scenario is not supported.

Sample WGB Configuration

A sample configuration of a WGB access point using static WEP with a 40-bit WEP key is as follows:

```
ap# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
ap(config)# dot11 ssid WGB_with_static_WEP
ap(config-ssid)# authentication open
ap(config-ssid)# guest-mode
ap(config-ssid)# exit
ap(config)# interface  dot11Radio 0
ap(config)# station-role workgroup-bridge
ap(config-if)# encry mode wep 40
ap(config-if)# encry key 1 size 40 0 1234567890
ap(config-if)# ssid WGB_with_static_WEP
ap(config-if)# end
```

Verify that the WGB is associated to an access point by entering this command on the WGB:

show dot11 association

Information similar to the following appears:

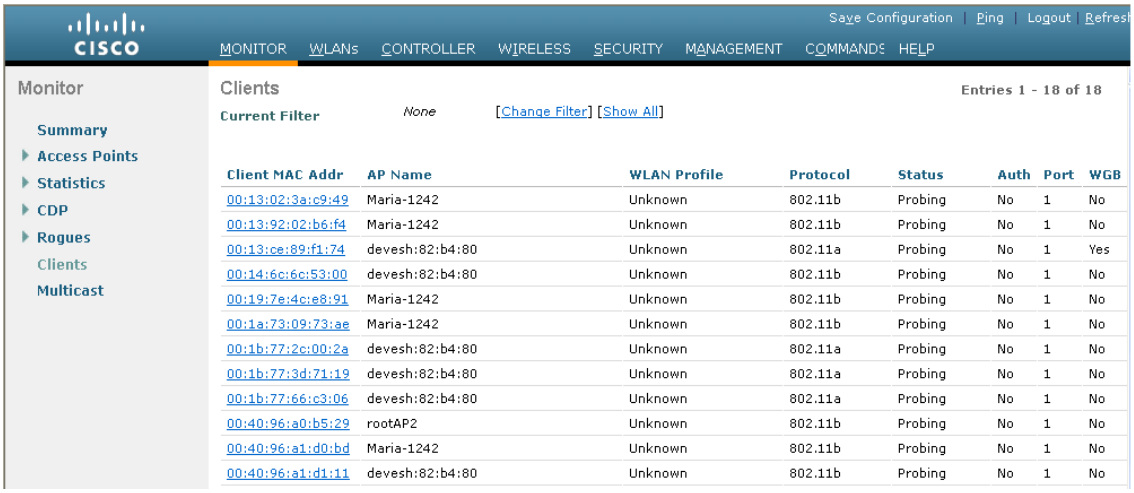
```
ap# show dot11 associations
802.11 Client Stations on Dot11Radio0:
SSID [FCVTESTING] :
MAC Address    IP address      Device         Name            Parent          State
000b.8581.6aee 10.11.12.1      WGB-client     map1            -               Assoc
ap#
```

Using the GUI to View the Status of Workgroup Bridges

To view the status of WGBs on your network using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Clients** to open the Clients page (see Figure 8-43).

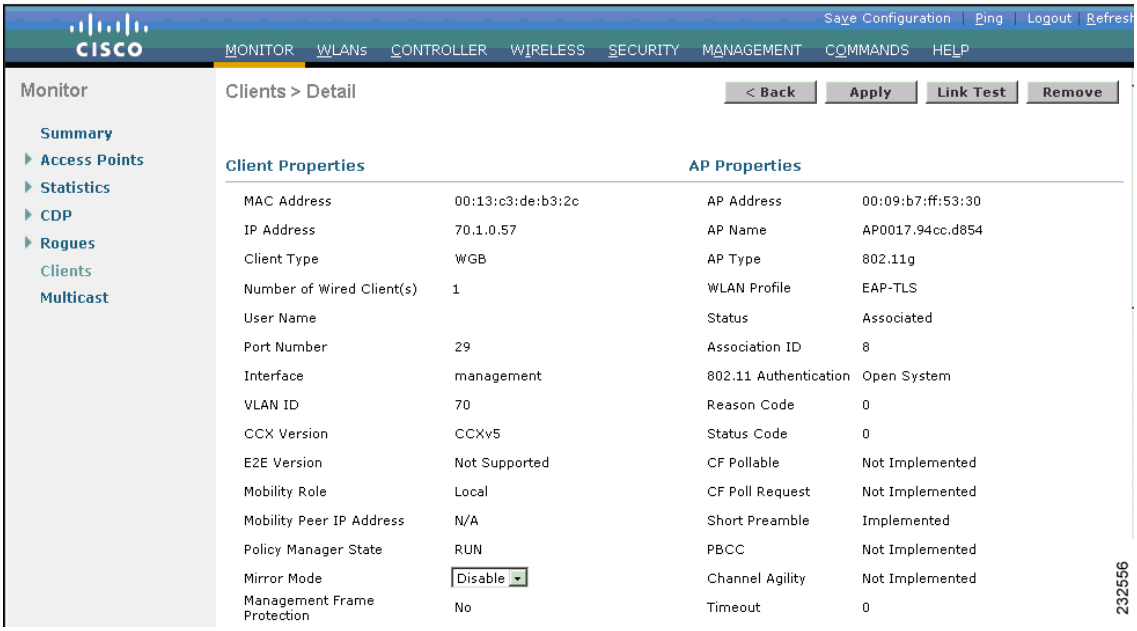
Figure 8-43 Clients Page



The WGB text box on the right side of the page indicates whether any of the clients on your network are workgroup bridges.

Step 2 Click the MAC address of the desired client. The Clients > Detail page appears (see Figure 8-44).

Figure 8-44 Clients > Detail Page



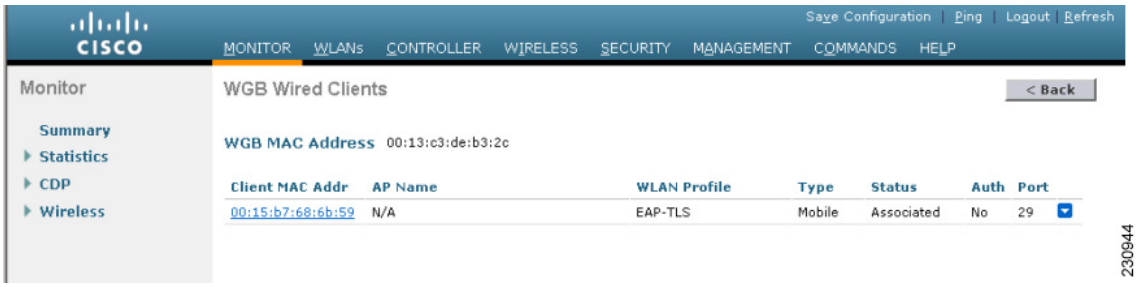
The Client Type text box under Client Properties shows "WGB" if this client is a workgroup bridge, and the Number of Wired Client(s) text box shows the number of wired clients that are connected to this WGB.

Step 3 See the details of any wired clients that are connected to a particular WGB as follows:

a. Click **Back** on the Clients > Detail page to return to the Clients page.

b. Hover your cursor over the blue drop-down arrow for the desired WGB and choose **Show Wired Clients**. The WGB Wired Clients page appears (see Figure 8-45).

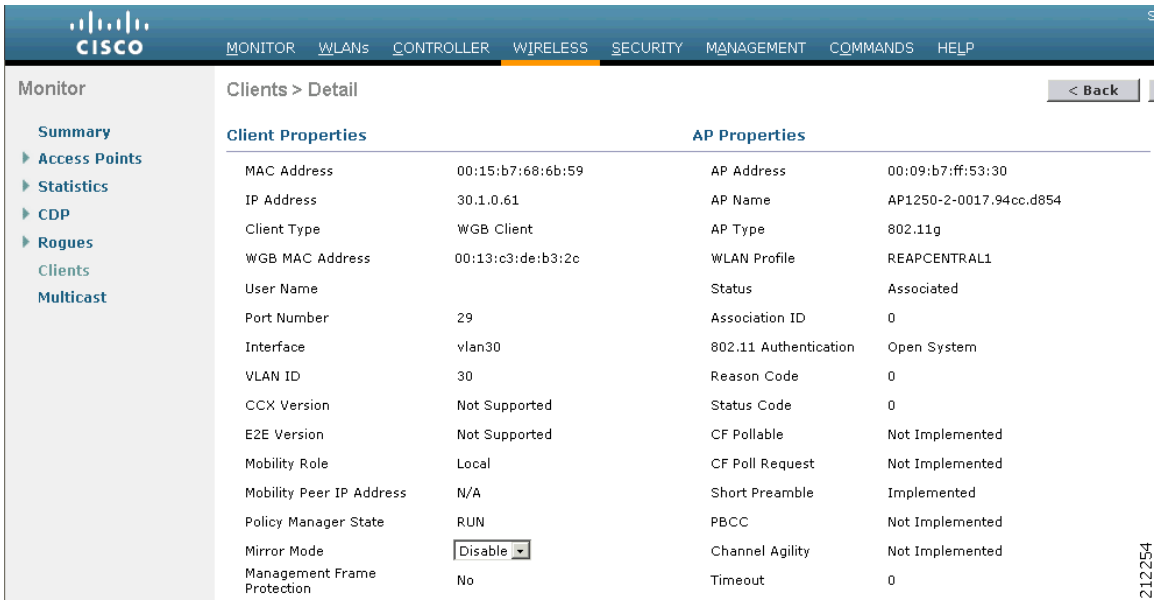
Figure 8-45 WGB Wired Clients Page



Note If you want to disable or remove a particular client, hover your cursor over the blue drop-down arrow for the desired client and choose **Remove** or **Disable**, respectively.

c. Click the MAC address of the desired client to see more details for this particular client. The Clients > Detail page appears (see Figure 8-46).

Figure 8-46 Clients > Detail Page



The Client Type text box under Client Properties shows "WGB Client," and the rest of the text boxes on this page provide additional information for this client.

Using the CLI to View the Status of Workgroup Bridges

To see the status of WGBs on your network using the controller CLI, follow these steps:

Step 1 See any WGBs on your network by entering this command:

show wgb summary

Information similar to the following appears:

```
Number of WGBs..................................... 1

MAC Address         IP Address AP Name  Status  WLAN  Auth  Protocol  Clients
------------------ ---------- -------- ------  ----  ----- --------- --------
00:0d:ed:dd:25:82  10.24.8.73      a1   Assoc   3     Yes   802.11b   1
```

Step 2 See the details of any wired clients that are connected to a particular WGB by entering this command:

show wgb detail *wgb_mac_address*

Information similar to the following appears:

```
Number of wired client(s): 1

MAC Address         IP Address AP Name  Mobility   WLAN   Auth
------------------- ---------- -------- ---------  -----  -----
00:0d:60:fc:d5:0b   10.24.8.75   a1      Local      3     Yes
```

Using the CLI to Debug WGB Issues

Use these commands if you experience any problems with the WGB:

- Enable debugging for IAPP messages, errors, and packets by entering these commands:
  - **debug iapp all enable**—Enables debugging for IAPP messages.
  - **debug iapp error enable**—Enables debugging for IAPP error events.
  - **debug iapp packet enable**—Enables debugging for IAPP packets.
- Debug an roaming issue by entering this command:

  debug mobility handoff enable
- Debug an IP assignment issue when DHCP is used by entering these commands:
  - **debug dhcp message enable**
  - **debug dhcp packet enable**
- Debug an IP assignment issue when static IP is used by entering these commands:
  - **debug dot11 mobile enable**
  - **debug dot11 state enable**

Non-Cisco Workgroup Bridges

When a Cisco workgroup bridge (WGB) is used, the WGB informs the access points of all the clients that it is associated with. The controller is aware of the clients associated with the access point. When non-Cisco WGBs are used, the controller has no information about the IP address of the clients on the wired segment behind the WGB. Without this information, the controller drops the following types of messages:

- ARP REQ from the distribution system for the WGB client
- ARP RPLY from the WGB client
- DHCP REQ from the WGB client
- DHCP RPLY for the WGB client

Starting in release 7.0.116.0, the controller can accommodate non-Cisco WGBs so that the controller can forward ARP, DHCP, and data traffic to and from the wired clients behind workgroup bridges by enabling the passive client feature. To configure your controller to work with non-Cisco WGBs, you must enable the passive client feature so that all traffic from the wired clients is routed through the WGB to the access point. All traffic from the wired clients is routed through the work group bridge to the access point. To know more about how to configure the controller to use passive clients, see the "Configuring Passive Client" section on page 74.

Note The Non-Cisco WGB feature is supported only on the 5508, 2500 and 2100 Controllers. NPU based platforms (4400/wism/3750w) do not support this feature.

The following restrictions apply to non-Cisco WGB:

- Only Layer 2 roaming is supported for WGB devices.
- Layer 3 security (web authentication) is not support for WGB clients.

- Visibility of wired hosts behind a WGB on a controller is not supported because the non-Cisco WGB device performs MAC hiding. Cisco WGB supports IAPP.
- ARP poisoning detection does not work on a WLAN when the flag is enabled.
- VLAN select is not supported for WGB clients.
- Some third-party WGBs need to operate in non-DHCP relay mode. If problems occur with the DHCP assignment on devices behind the non-Cisco WGB, use the following commands:
  - **config dhcp proxy disable**
  - **config dhcp proxy disable bootp-broadcast disable**

  The default state is DHCP proxy enabled. The best combination depends on the third-party characteristics and configuration.
- When a WGB wired client leaves a multicast group, the downstream multicast traffic to other WGB wired clients is interrupted briefly.
- If you have clients that use PC virtualization software like VMware, you must enable this feature.

Note We have tested multiple third-party devices for compatibility, but cannot ensure that all non-Cisco devices will work. Support for any interaction or configuration details on the third-party device should be discussed with the device manufacturer.

Notes About Some non-Cisco WGBs

Note You must enable the passive client functionality for all non Cisco workgroup bridges. For more information, see "Configuring Passive Client" section on page 74.

You might need to use the following commands to configure DHCP on clients:

- Disable DHCP proxy by using the **config dhcp proxy disable** command.
- Enable DHCP boot broadcast by using the **tconfig dhcp proxy disable bootp-broadcast enable** command.

Configuring Backup Controllers

A single controller at a centralized location can act as a backup for access points when they lose connectivity with the primary controller in the local region. Centralized and regional controllers do not need to be in the same mobility group. In controller software release 4.2 or later releases, you can specify a primary, secondary, and tertiary controller for specific access points in your network. Using the controller GUI or CLI, you can specify the IP addresses of the backup controllers, which allows the access points to fail over to controllers outside of the mobility group.

In controller software release 5.0 or later releases, you can also configure primary and secondary backup controllers (which are used if primary, secondary, or tertiary controllers are not specified or are not responsive) for all access points connected to the controller as well as various timers, including heartbeat timers and discovery request timers. To reduce the controller failure detection time, you can configure the fast heartbeat interval (between the controller and the access point) with a smaller timeout value.

When the fast heartbeat timer expires (at every heartbeat interval), the access point determines if any data packets have been received from the controller within the last interval. If no packets have been received, the access point sends a fast echo request to the controller.

Note You can configure the fast heartbeat timer only for access points in local and hybrid-REAP modes.

The access point maintains a list of backup controllers and periodically sends primary discovery requests to each entry on the list. When the access point receives a new discovery response from a controller, the backup controller list is updated. Any controller that fails to respond to two consecutive primary discovery requests is removed from the list. If the access point's local controller fails, it chooses an available controller from the backup controller list in this order: primary, secondary, tertiary, primary backup, and secondary backup. The access point waits for a discovery response from the first available controller in the backup list and joins the controller if it receives a response within the time configured for the primary discovery request timer. If the time limit is reached, the access point assumes that the controller cannot be joined and waits for a discovery response from the next available controller in the list.

Note When an access point's primary controller comes back online, the access point disassociates from the backup controller and reconnects to its primary controller. The access point falls back to its primary controller and not to any secondary controller for which it is configured. For example, if an access point is configured with primary, secondary, and tertiary controllers, it fails over to the tertiary controller when the primary and secondary controllers become unresponsive and waits for the primary controller to come back online so that it can fall back to the primary controller. The access point does not fall back from the tertiary controller to the secondary controller if the secondary controller comes back online; it stays connected to the tertiary controller until the primary controller comes back up.

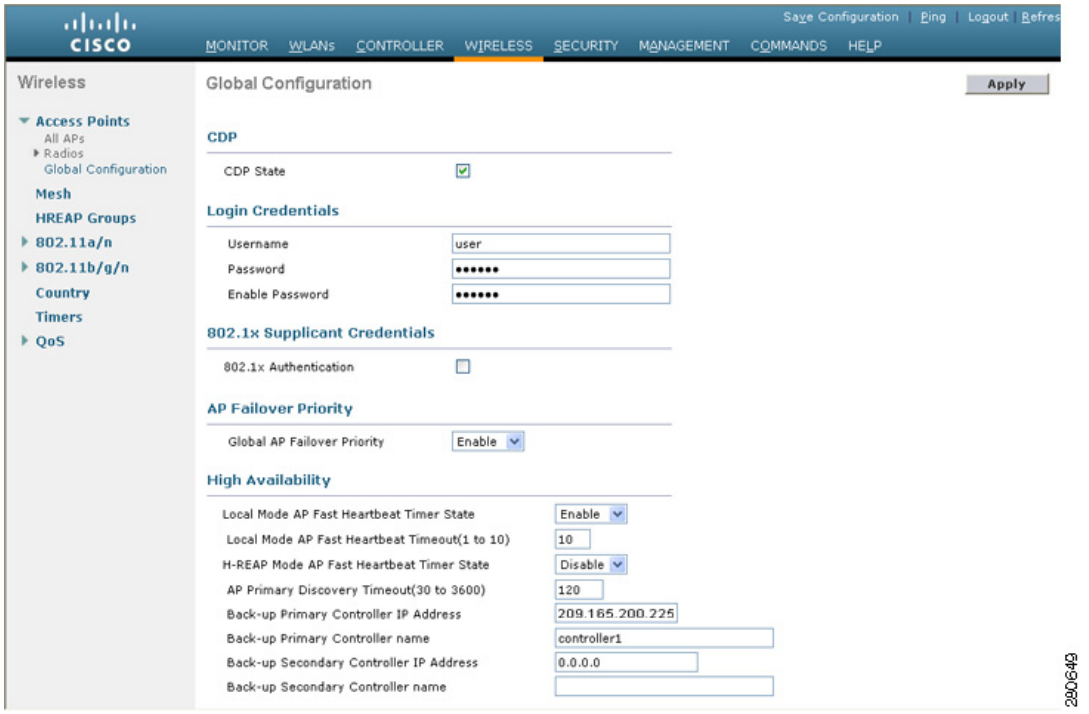
Note If you inadvertently configure a controller that is running software release 5.2 or later releases with a failover controller that is running a different software release (such as 4.2, 5.0, or 5.1), the access point might take a long time to join the failover controller because the access point starts the discovery process in CAPWAP and then changes to LWAPP discovery.

Using the GUI to Configure Backup Controllers

To configure primary, secondary, and tertiary controllers for a specific access point and to configure primary and secondary backup controllers for all access points using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page (see Figure 8-47).

Figure 8-47 Global Configuration Page



Step 2 From the Local Mode AP Fast Heartbeat Timer State drop-down list, choose **Enable** to enable the fast heartbeat timer for access points in local mode or choose **Disable** to disable this timer. The default value is Disable.

Step 3 If you chose Enable in Step 2, enter a number between 1 and 10 seconds (inclusive) in the Local Mode AP Fast Heartbeat Timeout text box to configure the fast heartbeat timer for access points in local mode. Specifying a small heartbeat interval reduces the amount of time it takes to detect a controller failure. The default value is 0 seconds, which disables the timer.

Step 4 From the H-REAP Mode AP Fast Heartbeat Timer State drop-down list, choose **Enable** to enable the fast heartbeat timer for hybrid-REAP access points or choose **Disable** to disable this timer. The default value is Disable.

Step 5 If you chose Enable in Step 4, enter a value between 1 and 10 seconds (inclusive) in the H-REAP Mode AP Fast Heartbeat Timeout text box to configure the fast heartbeat timer for hybrid-REAP access points. Specifying a small heartbeat interval reduces the amount of time it takes to detect a controller failure. The default value is 0 seconds, which disables the timer.

Step 6 In the AP Primary Discovery Timeout text box, a value between 30 and 3600 seconds (inclusive) to configure the access point primary discovery request timer. The default value is 120 seconds.

Step 7 If you want to specify a primary backup controller for all access points, enter the IP address of the primary backup controller in the Back-up Primary Controller IP Address text box and the name of the controller in the Back-up Primary Controller Name text box.

Note The default value for the IP address is 0.0.0.0, which disables the primary backup controller.

Step 8 If you want to specify a secondary backup controller for all access points, enter the IP address of the secondary backup controller in the Back-up Secondary Controller IP Address text box and the name of the controller in the Back-up Secondary Controller Name text box.

Note The default value for the IP address is 0.0.0.0, which disables the secondary backup controller.

Step 9 Click **Apply** to commit your changes.

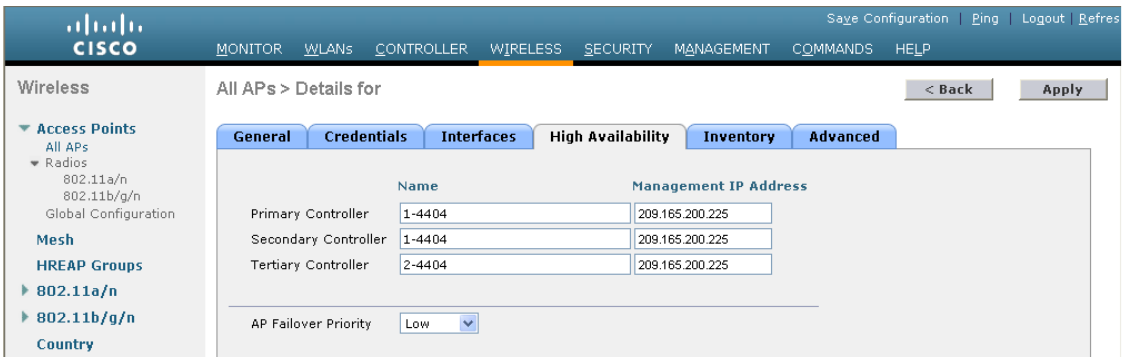
Step 10 Configure primary, secondary, and tertiary backup controllers for a specific access point as follows:

a. Choose **Access Points** > **All APs** to open the All APs page.

b. Click the name of the access point for which you want to configure primary, secondary, and tertiary backup controllers.

c. Choose the **High Availability** tab to open the All APs > Details for (High Availability) page (see Figure 8-48).

Figure 8-48 All APs > Details for (High Availability) Page



d. If desired, enter the name and IP address of the primary controller for this access point in the Primary Controller text boxes.

Note Entering an IP address for the backup controller is optional in this step and the next two steps. If the backup controller is outside the mobility group to which the access point is connected (the primary controller), then you need to provide the IP address of the primary, secondary, or tertiary controller, respectively. The controller name and IP address must belong to the same primary, secondary, or tertiary controller. Otherwise, the access point cannot join the backup controller.

e. If desired, enter the name and IP address of the secondary controller for this access point in the Secondary Controller text boxes.

f. If desired, enter the name and IP address of the tertiary controller for this access point in the Tertiary Controller text boxes.

g. Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Configure Backup Controllers

To configure primary, secondary, and tertiary controllers for a specific access point and to configure primary and secondary backup controllers for all access points using the controller CLI, follow these steps:

Step 1 Configure a primary controller for a specific access point by entering this command:

config ap primary-base *controller_name Cisco_AP* [*controller_ip_address*]

Note The *controller_ip_address* parameter in this command and the next two commands is optional. If the backup controller is outside the mobility group to which the access point is connected (the primary controller), then you need to provide the IP address of the primary, secondary, or tertiary controller, respectively. In each command, the *controller_name* and *controller_ip_address* must belong to the same primary, secondary, or tertiary controller. Otherwise, the access point cannot join the backup controller.

Step 2 Configure a secondary controller for a specific access point by entering this command:

config ap secondary-base *controller_name Cisco_AP* [*controller_ip_address*]

Step 3 Configure a tertiary controller for a specific access point by entering this command:

config ap tertiary-base *controller_name Cisco_AP* [*controller_ip_address*]

Step 4 Configure a primary backup controller for all access points by entering this command:

config advanced backup-controller primary *backup_controller_name backup_controller_ip_address*

Step 5 Configure a secondary backup controller for all access points by entering this command:

config advanced backup-controller secondary *backup_controller_name backup_controller_ip_address*

Note To delete a primary or secondary backup controller entry, enter **0.0.0.0** for the controller IP address.

Step 6 Enable or disable the fast heartbeat timer for local or hybrid-REAP access points by entering this command:

config advanced timers ap-fast-heartbeat {**local** | **hreap** | **all**} {**enable** | **disable**} *interval*

where **all** is both local and hybrid-REAP access points, and *interval* is a value between 1 and 10 seconds (inclusive). Specifying a small heartbeat interval reduces the amount of time that it takes to detect a controller failure. The default value is disabled.Configure the access point heartbeat timer by entering this command:

config advanced timers ap-heartbeat-timeout *interval*

where *interval* is a value between 1 and 30 seconds (inclusive). This value should be at least three times larger than the fast heartbeat timer. The default value is 30 seconds.

Caution Do not enable the fast heartbeat timer with the high latency link. If you have to enable the fast heartbeat timer, the timer value must be greater than the latency.

Step 7 Configure the access point primary discovery request timer by entering this command:

config advanced timers ap-primary-discovery-timeout *interval*

where *interval* is a value between 30 and 3600 seconds. The default value is 120 seconds.

Step 8 Configure the access point discovery timer by entering this command:

config advanced timers ap-discovery-timeout *interval*

where *interval* is a value between 1 and 10 seconds (inclusive). The default value is 10 seconds.

Step 9 Configure the 802.11 authentication response timer by entering this command:

config advanced timers auth-timeout *interval*

where *interval* is a value between 10 and 600 seconds (inclusive). The default value is 10 seconds.

Step 10 Save your changes by entering this command:

save config

Step 11 See an access point's configuration by entering these commands:

- **show ap config general** *Cisco_AP*
- **show advanced backup-controller**
- **show advanced timers**

Information similar to the following appears for the **show ap config general** *Cisco_AP* command:

```
Cisco AP Identifier.............................. 1
Cisco AP Name.................................... AP5
Country code..................................... US  - United States
Regulatory Domain allowed by Country............. 802.11bg:-AB    802.11a:-AB
AP Country code.................................. US  - United States
AP Regulatory Domain............................. 802.11bg:-A    802.11a:-N
Switch Port Number .............................. 1
MAC Address...................................... 00:13:80:60:48:3e
IP Address Configuration......................... DHCP
IP Address....................................... 1.100.163.133
...
Primary Cisco Switch Name....................... 1-4404
Primary Cisco Switch IP Address.................. 2.2.2.2
Secondary Cisco Switch Name..................... 1-4404
Secondary Cisco Switch IP Address................ 2.2.2.2
Tertiary Cisco Switch Name...................... 2-4404
Tertiary Cisco Switch IP Address................. 1.1.1.4
...
```

Information similar to the following appears for the **show advanced backup-controller** command:

```
AP primary Backup Controller .................... controller1 10.10.10.10
AP secondary Backup Controller ................ 0.0.0.0
```

Information similar to the following appears for the **show advanced timers** command:

```
Authentication Response Timeout (seconds)........ 10
Rogue Entry Timeout (seconds).................... 1300
AP Heart Beat Timeout (seconds).................. 30
AP Discovery Timeout (seconds)................... 10
AP Local mode Fast Heartbeat (seconds)........... 10 (enable)
AP Hreap mode Fast Heartbeat (seconds)........... disable
AP Primary Discovery Timeout (seconds)........... 120
```

Configuring Failover Priority for Access Points

Each controller has a defined number of communication ports for access points. When multiple controllers with unused access point ports are deployed on the same network and one controller fails, the dropped access points automatically poll for unused controller ports and associate with them.

In controller software releases prior to 5.1, the backup controllers accept association requests in the order that the requests are received until all the ports are in use. As a result, the probability of an access point finding an open port on a backup controller is determined by where in the association request queue it is after the controller failure.

In controller software release 5.1 or later releases, you can configure your wireless network so that the backup controller recognizes a join request from a higher-priority access point and if necessary disassociates a lower-priority access point as a means to provide an available port.

Note Failover priority is not in effect during the regular operation of your wireless network. It takes effect only if there are more association requests after a controller failure than there are available backup controller ports.

To configure this feature, you must enable failover priority on your network and assign priorities to the individual access points. You can do so using the controller GUI or CLI.

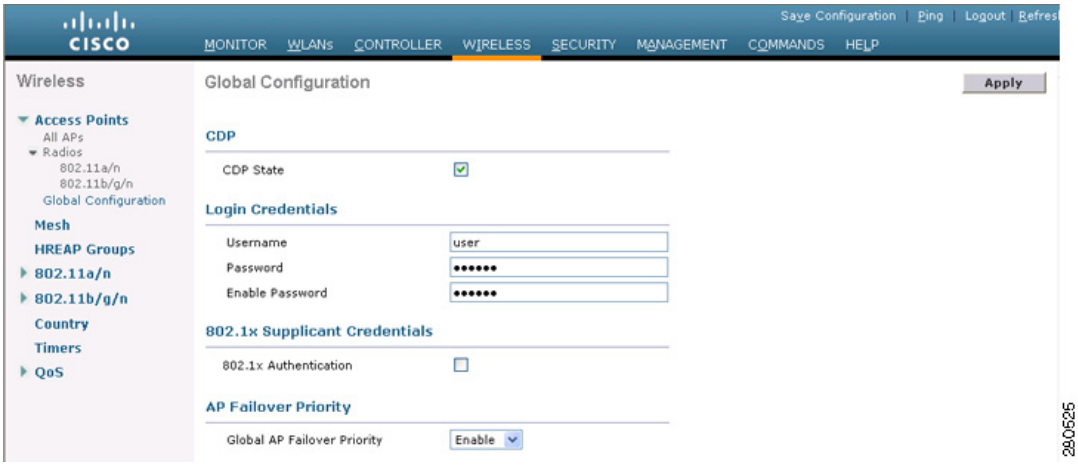
By default, all access points are set to priority level 1, which is the lowest priority level. Therefore, you need to assign a priority level only to those access points that warrant a higher priority.

Using the GUI to Configure Failover Priority for Access Points

To configure failover priority for access points that join the controller using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page (see Figure 8-49).

Figure 8-49 Global Configuration Page



Step 2 From the Global AP Failover Priority drop-down list, choose **Enable** to enable access point failover priority or choose **Disable** to disable this feature and turn off any access point priority assignments. The default value is Disable.

Step 3 Click **Apply** to commit your changes.

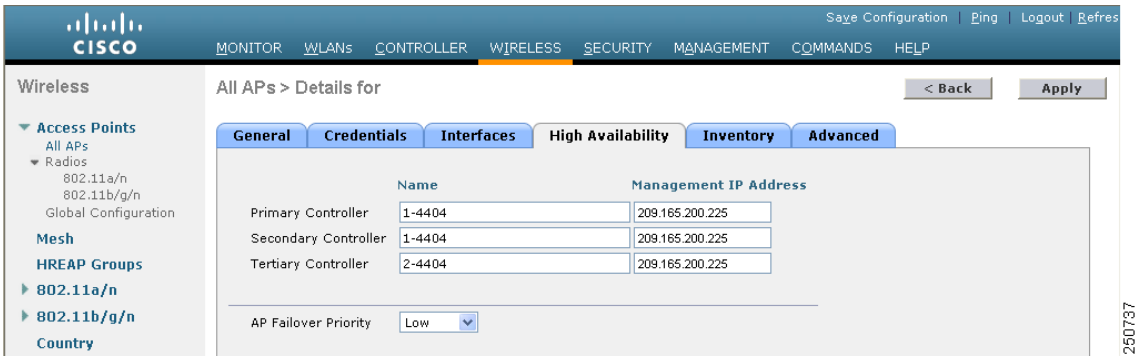
Step 4 Click **Save Configuration** to save your changes.

Step 5 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 6 Click the name of the access point for which you want to configure failover priority.

Step 7 Choose the **High Availability** tab. The All APs > Details for (High Availability) page appears (see Figure 8-50).

Figure 8-50 All APs > Details for (High Availability) Page



Step 8 From the AP Failover Priority drop-down list, choose one of the following options to specify the priority of the access point:

- **Low**—Assigns the access point to the level 1 priority, which is the lowest priority level. This is the default value.
- **Medium**—Assigns the access point to the level 2 priority.
- **High**—Assigns the access point to the level 3 priority.
- **Critical**—Assigns the access point to the level 4 priority, which is the highest priority level.

Step 9 Click **Apply** to commit your changes.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Configure Failover Priority for Access Points

To configure failover priority for access points that join the controller using the controller CLI, follow these steps:

Step 1 Enable or disable access point failover priority by entering this command:

config network ap-priority {**enable** | **disable**}

Step 2 Specify the priority of an access point by entering this command:

config ap priority {**1** | **2** | **3** | **4**} *Cisco_AP*

where 1 is the lowest priority level and 4 is the highest priority level. The default value is 1.

Step 3 Save your changes by entering this command:

save config

Using the CLI to View Failover Priority Settings

Use these commands to see the failover priority configuration settings on your network:

- Confirm whether access point failover priority is enabled on your network by entering this command:

  show network summary

  Information similar to the following appears:

```
RF-Network Name............................. mrf
Web Mode.................................... Enable
Secure Web Mode............................. Enable
Secure Web Mode Cipher-Option High.......... Disable
Secure Shell (ssh).......................... Enable
Telnet...................................... Enable
Ethernet Multicast Mode..................... Disable
Ethernet Broadcast Mode..................... Disable
IGMP snooping............................... Disabled
IGMP timeout................................ 60 seconds
User Idle Timeout........................... 300 seconds
ARP Idle Timeout............................ 300 seconds
Cisco AP Default Master..................... Disable
AP Join Priority.......................... Enabled
...
```

- See the failover priority for each access point by entering this command:

  show ap summary

  Information similar to the following appears:

```
Number of APs.................................. 2
Global AP User Name............................ user
Global AP Dot1x User Name...................... Not Configured

AP Name  Slots  AP Model           Ethernet MAC       Location   Port Country Priority
-------  -----  ------------------ -----------------  ---------  ---- ------- -------
ap:1252  2      AIR-LAP1252AG-A-K9 00:1b:d5:13:39:74  hallway 6  1    US      1
ap:1121  1      AIR-LAP1121G-A-K9  00:1b:d5:a9:ad:08  reception  1    US      3
```

To see summary of specific access point you can specify the access point name. You can also use wildcard searches when filtering for access points.

Configuring Access Point Retransmission Interval and Retry Count

This section describes how to configure the retransmission interval and retry count for an access point when associating with a controller.

The controller and the access points exchange packets using the CAPWAP reliable transport protocol. For each request, a response is defined. This response is used to acknowledge the receipt of the request message. Response messages are not explicitly acknowledged; therefore, if a response message is not received, the original request message is retransmitted after the retransmit interval. If the request is not acknowledged after a maximum number of retransmissions, the session is closed and the access points reassociate with another controller.

You can configure the retransmission intervals and retry count both at a global as well as a specific access point level. A global configuration applies these configuration parameters to all the access points. That is, the retransmission interval and the retry count are uniform for all access points. Alternatively, when you configure the retransmission level and retry count at a specific access point level, the values are applied to that particular access point. The access point specific configuration has a higher precedence than the global configuration.

Note Retransmission intervals and the retry count do not apply for mesh access point.

Using the GUI to Configure the Access Point Retransmission Interval and Retry Count

You can configure the retransmission interval and retry count for all access points globally or a specific access point.

To configure the controller to set the retransmission interval and retry count globally using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > Global Configuration**.

Step 2 Choose one of the following options under the AP Transmit Config Parameters section:

- AP Retransmit Count—Enter the number of times you want the access point to retransmit the request to the controller. This parameter can take values between 3 and 8.
- AP Retransmit Interval—Enter the time duration between the retransmission of requests. This parameter can take values between 2 and 5.

Step 3 Click **Apply**.

To configure the controller to set retransmission interval and retry count for a specific access point, follow these steps:

Step 1 Choose **Wireless > Access Points > All APs**.

Step 2 Click on the AP Name link for the access point on which you want to set the values.

The **All APs > Details** page appears.

Step 3 Click the **Advanced Tab** to open the advanced parameters page.

Step 4 Choose one of the following parameters under the AP Transmit Config Parameters section:

- **AP Retransmit Count**—Enter the number of times that you want the access point to retransmit the request to the controller. This parameter can take values between 3 and 8.

- **AP Retransmit Interval**—Enter the time duration between the retransmission of requests. This parameter can take values between 2 and 5.

Step 5 Click **Apply**.

Using the CLI to Configure the Access Point Retransmission Interval and Retry Count

You can configure the retransmission interval and retry count for all access points globally or a specific access point.

- Configure the retransmission interval and retry count for all access points globally by entering the this command:

  config ap retransmit {interval | count} *seconds* **all**

  The valid range for the **interval** parameter is between 3 and 8. The valid range for the **count** parameter is between 2 and 5.

- Configure the retransmission interval and retry count for a specific access point, by entering this command:

  config ap retransmit {interval | count} *seconds Cisco_AP*

  The valid range for the **interval** parameter is between 3 and 8. The valid range for the **count** parameter is between 2 and 5.

- See the status of the configured retransmit parameters on all or specific APs by entering this command:

  show ap retransmit all

```
(Cisco Controller) >show ap retransmit all
Global control packet retransmit interval: 5
Global control packet retransmit count: 6
AP Name             Retransmit Interval  Retransmit count
------------------  -------------------  -------------------
AP_1131                N/A(Mesh mode)      N/A(Mesh mode)
AP_cisco_              5                4
abhes_1240             5                6
```

Note Because retransmit and retry values cannot be set for access points in mesh mode, these values are displayed as N/A (not applicable).

- See the status of the configured retransmit parameters on a specific access point by entering this command:

  show ap retransmit *Cisco_AP*

```
(Cisco Controller) >show ap retransmit cisco_AP1
Global control packet retransmit interval: 5
Global control packet retransmit count: 6
AP Name             Retransmit Interval  Retransmit count
------------------  -------------------  -------------------
cisco_AP1              5                6
(Cisco Controller) >
```

Configuring Country Codes

Controllers and access points are designed for use in many countries with varying regulatory requirements. The radios within the access points are assigned to a specific regulatory domain at the factory (such as -E for Europe), but the country code enables you to specify a particular country of operation (such as FR for France or ES for Spain). Configuring a country code ensures that each radio's broadcast frequency bands, interfaces, channels, and transmit power levels are compliant with country-specific regulations.

Generally, you configure one country code per controller, the one matching the physical location of the controller and its access points. However, controller software release 4.1 or later releases allows you to configure up to 20 country codes per controller. This multiple-country support enables you to manage access points in various countries from a single controller.

Note Although the controller supports different access points in different regulatory domains (countries), it requires all radios in a single access point to be configured for the same regulatory domain. For example, you should not configure a Cisco 1231 access point's 802.11b/g radio for the US (-A) regulatory domain and its 802.11a radio for the Great Britain (-E) regulatory domain. Otherwise, the controller allows only one of the access point's radios to turn on, depending on which regulatory domain you selected for the access point on the controller. Therefore, make sure that the same country code is configured for both of the access point's radios.

For a complete list of country codes supported per product, see http://tools.cisco.com/cse/prdapp/jsp/externalsearch.do?action=externalsearch&page=EXTERNAL_SEARCH or

http://www.cisco.com/en/US/prod/collateral/wireless/ps5679/ps5861/product_data_sheet0900aecd80537b6a_ps6087_Products_Data_Sheet.html

Guidelines for Configuring Multiple Country Codes

Follow these guidelines when configuring multiple country codes:

- When the multiple-country feature is being used, all controllers that are going to join the same RF group must be configured with the same set of countries, configured in the same order.
- When multiple countries are configured and the radio resource management (RRM) auto-RF feature is enabled, the common channels allowed is derived by performing a union (or superset) of the allowed channels in the countries. The access points are always able to use all legal frequencies, but noncommon channels can only be assigned manually.
- The access point can only operate on the channels for the countries that they are designed for.

  Note If an access point was already set to a higher legal power level or is configured manually, the power level is limited only by the particular country to which that access point is assigned.

- The country list configured on the RF group leader determines what channels the members would operate on. This list is independent of what countries have been configured on the RF group members.

You can configure country codes through the controller GUI or CLI.

Using the GUI to Configure Country Codes

To configure country codes using the controller GUI, follow these steps:

Step 1 Follow these steps to disable the 802.11a and 802.11b/g networks as follows:

a. Choose **Wireless> 802.11a/n > Network**.

b. Unselect the **802.11a Network Status** check box.

c. Click **Apply** to commit your changes.

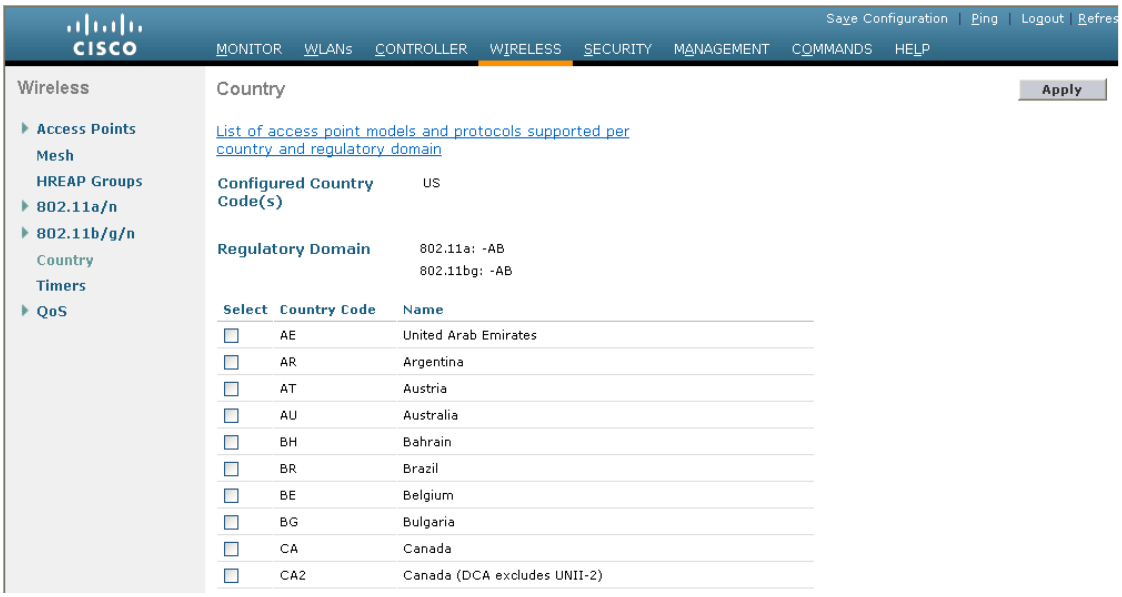
d. Choose **Wireless > 802.11b/g/n > Network**.

e. Unselect the **802.11b/g Network Status** check box.

f. Click **Apply** to commit your changes.

Step 2 Choose **Wireless > Country** to open the Country page (see Figure 8-51).

Figure 8-51 Country Page



Step 3 Select the check box for each country where your access points are installed. If you selected more than one check box, a message appears indicating that RRM channels and power levels are limited to common channels and power levels.

Step 4 Click **OK** to continue or **Cancel** to cancel the operation.

Step 5 Click **Apply** to commit your changes.

If you selected multiple country codes in Step 3, each access point is assigned to a country.

Step 6 See the default country chosen for each access point and choose a different country if necessary as follows:

Note If you remove a country code from the configuration, any access points currently assigned to the deleted country reboot and when they rejoin the controller, they get re-assigned to one of the remaining countries if possible.

a. Perform one of the following:
   - Leave the 802.11a and 802.11b/g networks disabled.
   - Reenable the 802.11a and 802.11b/g networks and then disable only the access points for which you are configuring a country code. To disable an access point, choose **Wireless > Access Points > All APs**, click the link of the desired access point, choose **Disable** from the Status drop-down list, and click **Apply**.

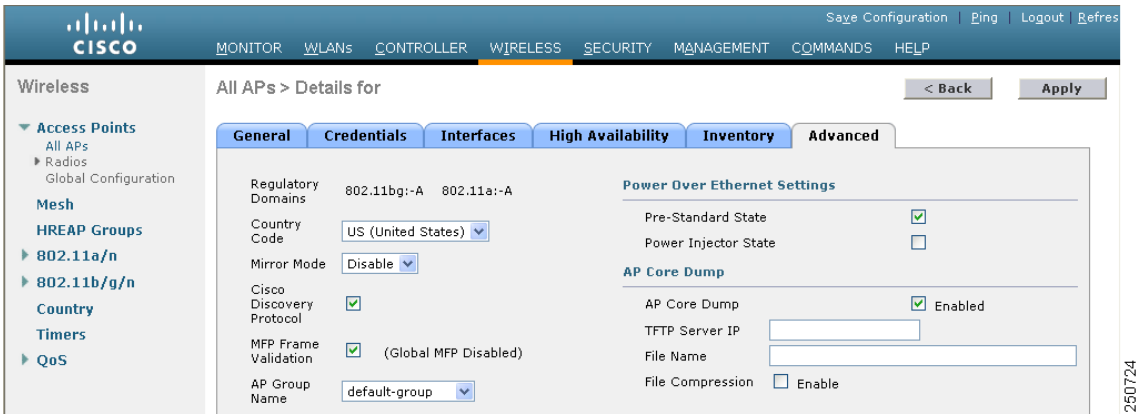
b. Choose **Wireless > Access Points > All APs** to open the All APs page.

c. Click the link for the desired access point.

d. Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 8-52).

   The default country for this access point appears in the Country Code drop-down list.

Figure 8-52 All APs > Details for (Advanced) Page



e. If the access point is installed in a country other than the one shown, choose the correct country from the drop-down list. The box contains only those country codes that are compatible with the regulatory domain of at least one of the access point's radios.

f. Click **Apply** to commit your changes.

g. Repeat these steps to assign all access points joined to the controller to a specific country.

h. Reenable any access points that you disabled in Step a.

Step 7 Reenable the 802.11a and 802.11b/g networks if you did not enable them in Step 6.

Step 8 Click **Save Configuration** to save your settings.

Using the CLI to Configure Country Codes

To configure country codes using the controller CLI, follow these steps:

Step 1 See a list of all available country codes by entering this command:

show country supported

Step 2 Disable the 802.11a and 802.11b/g networks by entering these commands:

config 802.11a disable network

config 802.11b disable network

Step 3 Configure the country codes for the countries where your access points are installed by entering this command:

config country *code1*[,*code2*,*code3*,...]

If you are entering more than one country code, separate each by a comma (for example, **config country US,CA,MX**). Information similar to the following appears:

```
Changing country code could reset channel configuration.
If running in RFM One-Time mode, reassign channels after this command.
Check customized APs for valid channel values after this command.
Are you sure you want to continue? (y/n) y
```

Step 4 Enter **Y** when prompted to confirm your decision. Information similar to the following appears:

```
Configured Country..................... Multiple Countries:US,CA,MX
Auto-RF for this country combination is limited to common channels and power.
      KEY: * = Channel is legal in this country and may be configured manually.
           A = Channel is the Auto-RF default in this country.
           . = Channel is not legal in this country.
           C = Channel has been configured for use by Auto-RF.
           x = Channel is available to be configured for use by Auto-RF.
         (-) = Regulatory Domains allowed by this country.
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-
802.11BG    :
Channels    :                   1 1 1 1 1
            : 1 2 3 4 5 6 7 8 9 0 1 2 3 4
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-
 US (-AB)   : A * * * * A * * * * A . . .
 CA (-AB)   : A * * * * A * * * * A . . .
 MX (-NA)   : A * * * * A * * * * A . . .
 Auto-RF    : C x x x x C x x x x C . . .
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 802.11A    :                         1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Channels    : 3 3 3 4 4 4 4 4 5 5 6 6 0 0 0 1 1 2 2 2 3 3 4 4 5 5 6 6
--More-- or (q)uit
            : 4 6 8 0 2 4 6 8 2 6 0 4 0 4 8 2 6 0 4 8 2 6 0 9 3 7 1 5
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 US (-AB)   : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
 CA (-ABN)  : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
 MX (-N)    : . A . A . A . A A A A A . . . . . . . . . . . . A A A A *
    Auto-RF : . C . C . C . C C C C C . . . . . . . . . . . . C C C C x
```

Step 5 Verify your country code configuration by entering this command:

show country

Step 6 See the list of available channels for the country codes configured on your controller by entering this command:

show country channels

Information similar to the following appears:

```
Configured Country..................................... Multiple Countries:US,CA,MX
Auto-RF for this country combination is limited to common channels and power.
      KEY: * = Channel is legal in this country and may be configured manually.
           A = Channel is the Auto-RF default in this country.
           . = Channel is not legal in this country.
           C = Channel has been configured for use by Auto-RF.
           x = Channel is available to be configured for use by Auto-RF.
         (-) = Regulatory Domains allowed by this country.
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-
802.11BG    :
Channels    :                   1 1 1 1 1
            : 1 2 3 4 5 6 7 8 9 0 1 2 3 4
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 US (-AB)   : A * * * * A * * * * A . . .
 CA (-AB)   : A * * * * A * * * * A . . .
 MX (-NA)   : A * * * * A * * * * A . . .
 Auto-RF    : C x x x x C x x x x C . . .
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 802.11A    :                         1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Channels    : 3 3 3 4 4 4 4 4 5 5 6 6 0 0 0 1 1 2 2 2 3 3 4 4 5 5 6 6

            : 4 6 8 0 2 4 6 8 2 6 0 4 0 4 8 2 6 0 4 8 2 6 0 9 3 7 1 5
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
 US (-AB)   : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
 CA (-ABN)  : . A . A . A . A A A A A * * * * * . . . * * * A A A A *
 MX (-N)    : . A . A . A . A A A A A . . . . . . . . . . . . A A A A *
    Auto-RF : . C . C . C . C C C C C . . . . . . . . . . . . C C C C x
------------:+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-
```

Step 7 Save your settings by entering this command:

save config

Step 8 See the countries to which your access points have been assigned by entering this command:

To see a summary of specific access point you can specify the access point name. You can also use wildcard searches when filtering for access points.

show ap summary

Information similar to the following appears:

```
Number of APs.................................... 2

AP Name  Slots  AP Model          Ethernet MAC        Location          Port    Country
-------- ------ ----------------- -----------------  ----------------  ------- --------
ap1        2   AP1030            00:0b:85:5b:8e:c0  default location     1     US
ap2        2   AIR-AP1242AG-A-K9 00:14:1c:ed:27:fe  default location     1     US
```

Step 9 If you entered multiple country codes in Step 3, follow these steps to assign each access point to a specific country:

a. Perform one of the following:

- Leave the 802.11a and 802.11b/g networks disabled.
- Reenable the 802.11a and 802.11b/g networks and then disable only the access points for which you are configuring a country code. To Reenable the networks, enter these commands:

  config 802.11a enable network

  config 802.11b enable network

  To disable an access point, enter this command:

config ap disable *ap_name*

b. To assign an access point to a specific country, enter this command:

config ap country *code* {*ap_name* | **all**}

Make sure that the country code you choose is compatible with the regulatory domain of at least one of the access point's radios.

Note If you enabled the networks and disabled some access points and then run the **config ap country** *code* **all** command, the specified country code is configured on only the disabled access points. All other access points are ignored.

For example, if you enter **config ap country mx all**, information similar to the following appears:

```
To change country code: first disable target AP(s) (or disable all networks).
  Changing the country may reset any customized channel assignments.
  Changing the country will reboot disabled target AP(s).

 Are you sure you want to continue? (y/n) y

AP Name    Country  Status
---------  -------- --------
ap2         US      enabled (Disable AP before configuring country)
ap1         MX      changed (New country configured, AP rebooting)
```

c. To reenable any access points that you disabled in Step a, enter this command:

config ap enable *ap_name*

Step 10 If you did not reenable the 802.11a and 802.11b/g networks in Step 9, enter these commands to reenable them now:

config 802.11a enable network

config 802.11b enable network

Step 11 Save your settings by entering this command:

save config

Migrating Access Points from the -J Regulatory Domain to the -U Regulatory Domain

The Japanese government has changed its 5-GHz radio spectrum regulations. These regulations allow a text box upgrade of 802.11a 5-GHz radios. Japan allows three frequency sets:

- J52 = 34 (5170 MHz), 38 (5190 MHz), 42 (5210 MHz), 46 (5230 MHz)
- W52 = 36 (5180 MHz), 40 (5200 MHz), 44 (5220 MHz), 48 (5240 MHz)
- W53 = 52 (5260 MHz), 56 (5280 MHz), 60 (5300 MHz), 64 (5320 MHz)

Cisco has organized these frequency sets into the following regulatory domains:

- -J regulatory domain = J52
- -P regulatory domain = W52 + W53

- -U regulatory domain = W52

Regulatory domains are used by Cisco to organize the legal frequencies of the world into logical groups. For example, most of the European countries are included in the -E regulatory domain. Cisco access points are configured for a specific regulatory domain at the factory and, with the exception of this migration process, never change. The regulatory domain is assigned per radio, so an access point's 802.11a and 802.11b/g radios may be assigned to different domains.

Note Controllers and access points may not operate properly if they are not designed for use in your country of operation. For example, an access point with part number AIR-AP1030-A-K9 (which is included in the Americas regulatory domain) cannot be used in Australia. Always be sure to purchase controllers and access points that match your country's regulatory domain.

The Japanese regulations allow the regulatory domain that is programmed into an access point's radio to be migrated from the -J domain to the -U domain. New access points for the Japanese market contain radios that are configured for the -P regulatory domain. -J radios are no longer being sold. In order to make sure that your existing -J radios work together with the new -P radios in one network, you need to migrate your -J radios to the -U domain.

Country codes define the channels that can be used legally in each country. These country codes are available for Japan:

- JP—Allows only -J radios to join the controller
- J2—Allows only -P radios to join the controller

Note J2 -Q works with 7.0.116.0 for all access points except 1550. The 1550 access point needs the -J4 domain to join the controller.

- J3—Uses the -U frequencies but allows both -U and -P radios to join the controller
- J4—Allows 2.4G PQU and 5G JPQU to join the controller.

Note After migration, you need to use the J3 country code. If your controller is running software release 4.1 or later releases, you can use the multiple-country feature to choose both J2 and J3. You can manually configure your -P radios to use the channels not supported by J3.

See the *Channels and Maximum Power Settings for Cisco Aironet Lightweight Access Points* document for the list of channels and power levels supported by access points in the Japanese regulatory domains.

Guidelines for Migration

Follow these guidelines before migrating your access points to the -U regulatory domain:

- You can migrate only Cisco Aironet 1130, 1200, and 1240 lightweight access points that support the -J regulatory domain and Airespace AS1200 access points. Other access points cannot be migrated.
- Your controller and all access points must be running software release 4.1 or later releases or software release 3.2.193.0.

Note Software release 4.0 is not supported. If you migrate your access points using software release 3.2.193.0, you cannot upgrade to software release 4.0. You can upgrade only to software release 4.1 or later releases or to a later release of the 3.2 software.

- You must have had one or more Japan country codes (JP, J2, or J3) configured on your controller at the time you last booted your controller.
- You must have at least one access point with a -J regulatory domain joined to your controller.
- You cannot migrate your access points from the -U regulatory domain back to the -J domain. The Japanese government has made reverse migration illegal.

Note You cannot undo an access point migration. Once an access point has been migrated, you cannot return to software release 4.0. Migrated access points will have nonfunctioning 802.11a radios under software release 4.0.

Using the GUI to Migrate Access Points to the -U Regulatory Domain

To migrate your access points from the -J regulatory domain to the -U regulatory domain using the controller CLI, follow these steps:

Note This process cannot be performed using the controller GUI.

Step 1 Determine which access points in your network are eligible for migration by entering this command:

show ap migrate

Information similar to the following appears:

```
These 1 APs are eligible for migration:
00:14:1c:ed:27:fe AIR-AP1242AG-J-K9ap1240      "J"Reg. Domain

No APs have already been migrated.
```

Step 2 Disable the 802.11a and 802.11b/g networks by entering these commands:

config 802.11a disable network

config 802.11b disable network

Step 3 Change the country code of the access points to be migrated to J3 by entering this command:

config country J3

Step 4 Wait for any access points that may have rebooted to rejoin the controller.

Step 5 Migrate the access points from the -J regulatory domain to the -U regulatory domain by entering this command:

config ap migrate j52w52 {**all** | *ap_name*}

Information similar to the following appears:

```
Migrate APs with 802.11A Radios in the "J" Regulatory Domain to the "U" Regulatory Domain.
The "J" domain allows J52 frequencies, the "U" domain allows W52 frequencies.
WARNING: This migration is permanent and is not reversible, as required by law.
WARNING: Once migrated the 802.11A radios will not operate with previous OS versions.
```

```
WARNING: All attached "J" radios will be migrated.
WARNING: All migrated APs will reboot.
WARNING: All migrated APs must be promptly reported to the manufacturer.
Send the AP list and your company name to: abc@cisco.com

This AP is eligible for migration:
00:14:1c:ed:27:fe AIR-AP1242AG-J-K9ap1240

Begin to migrate Access Points from "J"(J52) to "U"(W52). Are you sure? (y/n)
```

Step 6 Enter **Y** when prompted to confirm your decision to migrate.

Step 7 Wait for all access points to reboot and rejoin the controller. This process may take up to 15 minutes, depending on access point. The AP1130, AP1200, and AP1240 reboot twice; all other access points reboot once.

Step 8 Verify migration for all access points by entering this command:

show ap migrate

Information similar to the following appears:

```
No APs are eligible for migration.

These 1 APs have already been migrated:
00:14:1c:ed:27:fe AIR-AP1242AG-J-K9ap1240      "U"Reg. Domain
```

Step 9 Reenable the 802.11a and 802.11b/g networks by entering these commands:

config 802.11a enable network

config 802.11b enable network

Step 10 Send an e-mail with your company name and the list of access points that have been migrated to this e-mail address: migrateapj52w52@cisco.com. We recommend that you cut and paste the output from the **show ap migrate** command in Step 8 into the e-mail.

Using the W56 Band in Japan

The Japanese government is formally permitting wireless LAN use of the frequencies in the W56 band for 802.11a radios. The W56 band includes the following channels, frequencies, and power levels (in dBm):

Channel	Frequency (MHz)	Maximum Power for AIR-LAP1132AG-Q-K9	Maximum Power for AIR-LAP1242AG-Q-K9
100	5500	17	15
104	5520	17	15
108	5540	17	15
112	5560	17	15
116	5580	17	15
120	5600	17	15
124	5620	17	15
128	5640	17	15

Channel	Frequency (MHz)	Maximum Power for AIR-LAP1132AG-Q-K9	Maximum Power for AIR-LAP1242AG-Q-K9
132	5660	17	15
136	5680	17	15
140	5700	17	15

All of the channels in the W56 band require dynamic frequency selection (DFS). In Japan, the W56 band is subject to Japan's DFS regulations. Currently, only the new 1130 and 1240 series access point SKUs (with the -Q product code) support this requirement: AIR-LAP1132AG-Q-K9 and AIR-LAP1242AG-Q-K9.

To set up a network consisting of only -P and -Q access points, configure the country code to J2. To set up a network consisting of -P, -Q, and -U access points, configure the country code to J3.

Dynamic Frequency Selection

The Cisco UWN solution complies with regulations that require radio devices to use dynamic frequency selection (DFS) to detect radar signals and avoid interfering with them.

When a lightweight access point with a 5-GHz radio operates on one of the 15 channels listed in Table 8-20, the controller to which the access point is associated automatically uses DFS to set the operating frequency.

When you manually select a channel for DFS-enabled 5-GHz radios, the controller checks for radar activity on the channel for 60 seconds. If there is no radar activity, the access point operates on the channel that you selected. If there is radar activity on the channel that you selected, the controller automatically selects a different channel, and after 30 minutes, the access point retries the channel.

Note After radar has been detected on a DFS-enabled channel, it cannot be used for 30 minutes.

Note The Rogue Location Detection Protocol (RLDP) and rogue containment are not supported on the channels listed in Table 8-20.

Note The maximum legal transmit power is greater for some 5-GHz channels than for others. When the controller randomly selects a 5-GHz channel on which power is restricted, it automatically reduces transmit power to comply with power limits for that channel.

Table 8-20 DFS-Enabled 5-GHz Channels

52 (5260 MHz)	104 (5520 MHz)	124 (5620 MHz)
56 (5280 MHz)	108 (5540 MHz)	128 (5640 MHz)
60 (5300 MHz)	112 (5560 MHz)	132 (5660 MHz)
64 (5320 MHz)	116 (5580 MHz)	136 (5680 MHz)
100 (5500 MHz)	120 (5600 MHz)	140 (5700 MHz)

Using DFS, the controller monitors operating frequencies for radar signals. If it detects radar signals on a channel, the controller takes these steps:

- It changes the access point channel to a channel that has not shown radar activity within the last 30 minutes. (The radar event is cleared after 30 minutes.) The controller selects the channel at random.
- If the channel selected is one of the channels in Table 8-20, it scans the new channel for radar signals for 60 seconds. If there are no radar signals on the new channel, the controller accepts client associations.
- It records the channel that showed radar activity as a radar channel and prevents activity on that channel for 30 minutes.
- It generates a trap to alert the network manager.

Optimizing RFID Tracking on Access Points

To optimize the monitoring and location calculation of RFID tags, you can enable tracking optimization on up to four channels within the 2.4-GHz band of an 802.11b/g access point radio. This feature allows you to scan only the channels on which tags are usually programmed to operate (such as channels 1, 6, and 11).

You can use the controller GUI or CLI to configure the access point for monitor mode and to then enable tracking optimization on the access point radio.

Using the GUI to Optimize RFID Tracking on Access Points

To optimize RFID tracking using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to configure monitor mode. The All APs > Details for page appears.

Step 3 From the AP Mode drop-down list, choose **Monitor**.

Step 4 Click **Apply** to commit your changes.

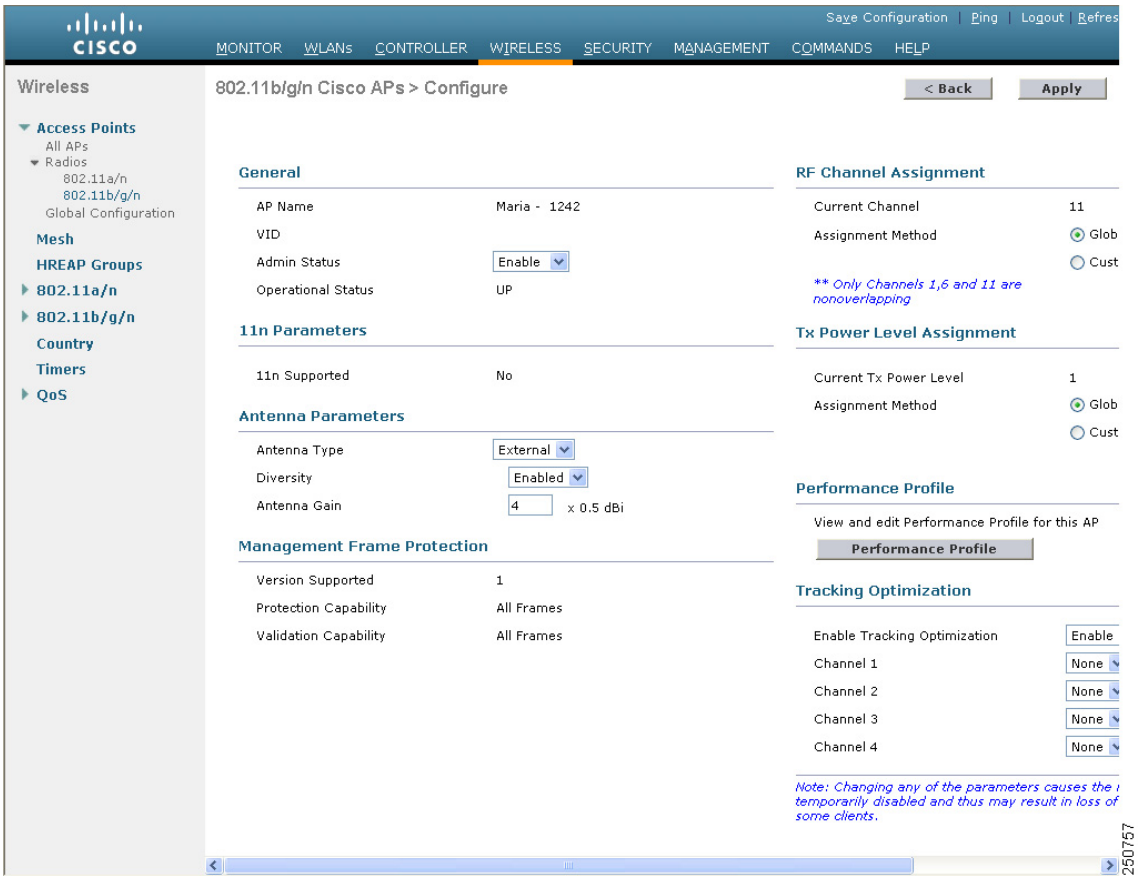
Step 5 Click **OK** when warned that the access point will be rebooted.

Step 6 Click **Save Configuration** to save your changes.

Step 7 Choose **Wireless** > **Access Points** > **Radios** > **802.11b/g/n** to open the 802.11b/g/n Radios page.

Step 8 Hover your cursor over the blue drop-down arrow for the desired access point and choose **Configure**. The 802.11b/g/n Cisco APs > Configure page appears (see Figure 8-53).

Figure 8-53 802.11b/g/n Cisco APs > Configure Page



Step 9 Disable the access point radio by choosing **Disable** from the Admin Status drop-down list and click **Apply**.

Step 10 Enable tracking optimization on the radio by choosing **Enable** from the Enable Tracking Optimization drop-down list.

Step 11 From the four Channel drop-down lists, choose the channels on which you want to monitor RFID tags.

Note You must configure at least one channel on which the tags will be monitored.

Step 12 Click **Apply** to commit your changes.

Step 13 Click **Save Configuration** to save your changes.

Step 14 To reenable the access point radio, choose **Enable** from the Admin Status drop-down list and click **Apply**.

Step 15 Click **Save Configuration** to save your changes.

Using the CLI to Optimize RFID Tracking on Access Points

To optimize RFID tracking using the controller CLI, follow these steps:

Step 1 Configure an access point for monitor mode by entering this command:

config ap mode monitor *Cisco_AP*

Step 2 When warned that the access point will be rebooted and asked if you want to continue, enter **Y**.

Step 3 Save your changes by entering this command:

save config

Step 4 Disable the access point radio by entering this command:

config 802.11b disable *Cisco_AP*

Step 5 Configure the access point to scan only the DCA channels supported by its country of operation by entering this command:

config ap monitor-mode tracking-opt *Cisco_AP*

Note To specify the exact channels to be scanned, enter the **config ap monitor-mode tracking-opt** *Cisco_AP* command in Step 6.

Note To disable tracking optimization for this access point, enter the **config ap monitor-mode no-optimization** *Cisco_AP* command.

Step 6 After you have entered the command in Step 5, you can enter this command to choose up to four specific 802.11b channels to be scanned by the access point:

config ap monitor-mode 802.11b fast-channel *Cisco_AP channel1 channel2 channel3 channel4*

Note In the United States, you can assign any value between 1 and 11 (inclusive) to the *channel* variable. Other countries support additional channels. You must assign at least one channel.

Step 7 Reenable the access point radio by entering this command:

config 802.11b enable *Cisco_AP*

Step 8 Save your changes by entering this command:

save config

Step 9 See a summary of all access points in monitor mode by entering this command:

show ap monitor-mode summary

Information similar to the following appears:

```
AP Name             Ethernet MAC         Status      Scanning Channel List
------------------ -------------------- ----------  ------------------------
AP1131:46f2.98ac    00:16:46:f2:98:ac    Tracking        1, 6, NA, NA
```

Using the CLI to Configure Probe Request Forwarding

Probe requests are 802.11 management frames sent by clients to request information about the capabilities of SSIDs. By default, access points forward acknowledged probe requests to the controller for processing. Acknowledged probe requests are probe requests for SSIDs that are supported by the access point. If desired, you can configure access points to forward both acknowledged and unacknowledged probe requests to the controller. The controller can use the information from unacknowledged probe requests to improve the location accuracy.

To configure probe request filtering and rate limiting using the controller CLI, follow these steps:

Step 1 Enable or disable the filtering of probe requests forwarded from an access point to the controller by entering this command:

config advanced probe filter {**enable** | **disable**}

If you enable probe filtering, the default filter setting, the access point forwards only acknowledged probe requests to the controller. If you disable probe filtering, the access point forwards both acknowledged and unacknowledged probe requests to the controller.

Step 2 Limit the number of probe requests sent to the controller per client per access point radio in a given interval by entering this command:

config advanced probe limit *num_probes interval*

where

- *num_probes* is the number of probe requests (from 1 to 100) forwarded to the controller per client per access point radio in a given interval.
- *interval* is the probe limit interval (from 100 to 10000 milliseconds).

The default value for *num_probes* is 2 probe requests, and the default value for *interval* is 500 milliseconds.

Step 3 Save your changes by entering this command:

save config

Step 4 See the probe request forwarding configuration by entering this command:

show advanced probe

Information similar to the following appears:

```
Probe request filtering.........................  Enabled
Probes fwd to controller per client per radio....  2
Probe request rate-limiting interval..........  500 msec
```

Retrieving the Unique Device Identifier on Controllers and Access Points

The unique device identifier (UDI) standard uniquely identifies products across all Cisco hardware product families, enabling customers to identify and track Cisco products throughout their business and network operations and to automate their asset management systems. The standard is consistent across all electronic, physical, and standard business communications. The UDI consists of five data elements:

- The orderable product identifier (PID)
- The version of the product identifier (VID)
- The serial number (SN)
- The entity name
- The product description

The UDI is burned into the EEPROM of controllers and lightweight access points at the factory. It can be retrieved through either the GUI or the CLI.

Using the GUI to Retrieve the Unique Device Identifier on Controllers and Access Points

To retrieve the UDI on controllers and access points using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **Inventory** to open the Inventory page (see Figure 8-54).

Figure 8-54 Inventory Page

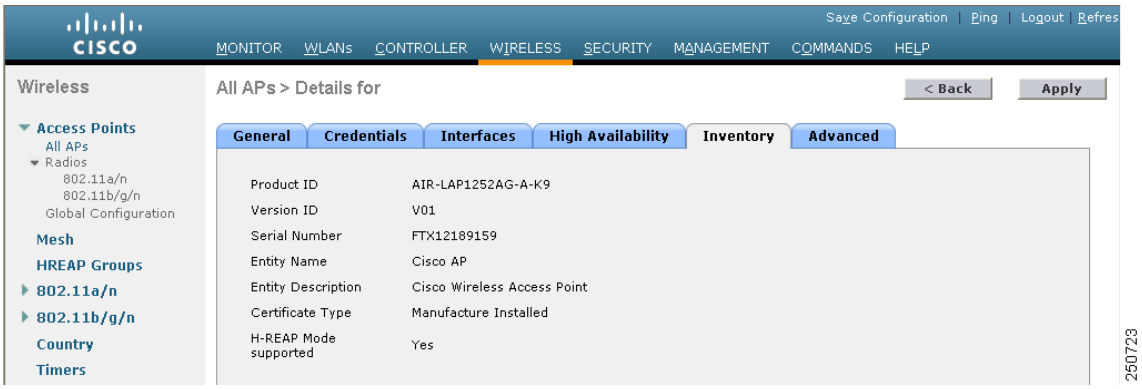
This page shows the five data elements of the controller UDI.

Step 2 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 3 Click the name of the desired access point.

Step 4 Choose the **Inventory** tab to open the All APs > Details for (Inventory) page (see Figure 8-55).

Figure 8-55 All APs > Details for (Inventory) Page



This page shows the inventory information for the access point.

Using the CLI to Retrieve the Unique Device Identifier on Controllers and Access Points

Use these commands to retrieve the UDI on controllers and access points using the controller CLI:

- **show inventory**—Shows the UDI string of the controller. Information similar to the following appears:

```
NAME: "Chassis"    , DESCR: "Cisco Wireless Controller"
PID: WS-C3750G-24PS-W24,  VID: V01,  SN: FLS0952H00F
```

- **show inventory ap** *ap_id*—Shows the UDI string of the access point specified.

Performing a Link Test

A link test is used to determine the quality of the radio link between two devices. Two types of link-test packets are transmitted during a link test: request and response. Any radio receiving a link-test request packet fills in the appropriate text boxes and echoes the packet back to the sender with the response type set.

The radio link quality in the client-to-access point direction can differ from that in the access point-to-client direction due to the asymmetrical distribution of the transmit power and receive sensitivity on both sides. Two types of link tests can be performed: a ping test and a CCX link test.

With the *ping link test*, the controller can test link quality only in the client-to-access point direction. The RF parameters of the ping reply packets received by the access point are polled by the controller to determine the client-to-access point link quality.

With the *CCX link test*, the controller can also test the link quality in the access point-to-client direction. The controller issues link-test requests to the client, and the client records the RF parameters (received signal strength indicator [RSSI], signal-to-noise ratio [SNR], and so on). of the received request packet

in the response packet. Both the link-test requestor and responder roles are implemented on the access point and controller. Not only can the access point or controller initiate a link test to a CCX v4 or v5 client, but a CCX v4 or v5 client can initiate a link test to the access point or controller.

The controller shows these link-quality metrics for CCX link tests in both directions (out— access point to client; in— client to access point):

- Signal strength in the form of RSSI (minimum, maximum, and average)
- Signal quality in the form of SNR (minimum, maximum, and average)
- Total number of packets that are retried
- Maximum retry count for a single packet
- Number of lost packets
- Data rate of a successfully transmitted packet

The controller shows this metric regardless of direction:

- Link test request/reply round-trip time (minimum, maximum, and average)

The controller software supports CCX versions 1 through 5. CCX support is enabled automatically for every WLAN on the controller and cannot be disabled. The controller stores the CCX version of the client in its client database and uses it to limit the features for this client. If a client does not support CCXv4 or v5, the controller performs a ping link test on the client. If a client supports CCXv4 or v5, the controller performs a CCX link test on the client. If a client times out during a CCX link test, the controller switches to the ping link test automatically. See the "Configuring Cisco Client Extensions" section on page 7-52 for more information on CCX.

Note CCX is not supported on the AP1030.

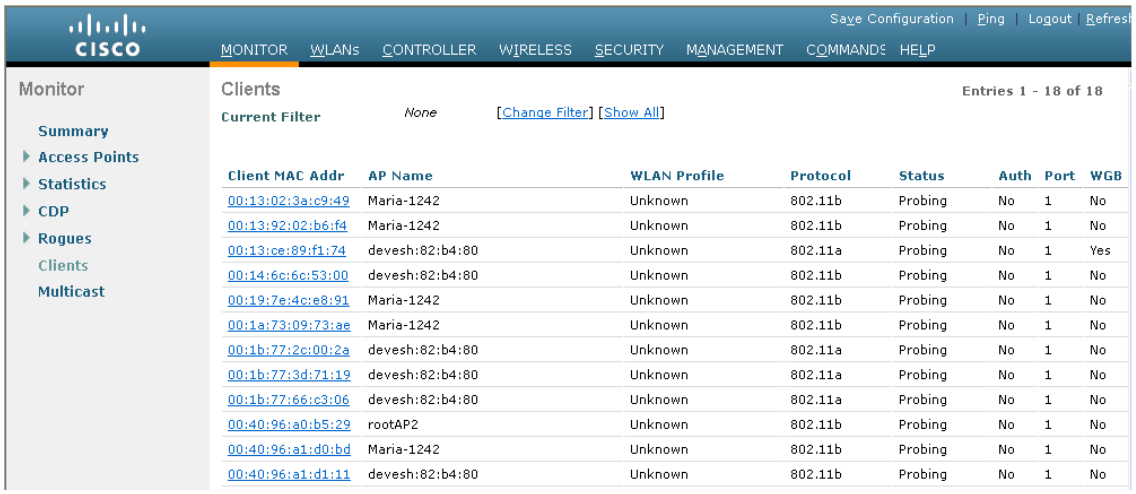
Follow the instructions in this section to perform a link test using either the GUI or the CLI.

Using the GUI to Perform a Link Test

To run a link test using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Clients** to open the Clients page (see Figure 8-56).

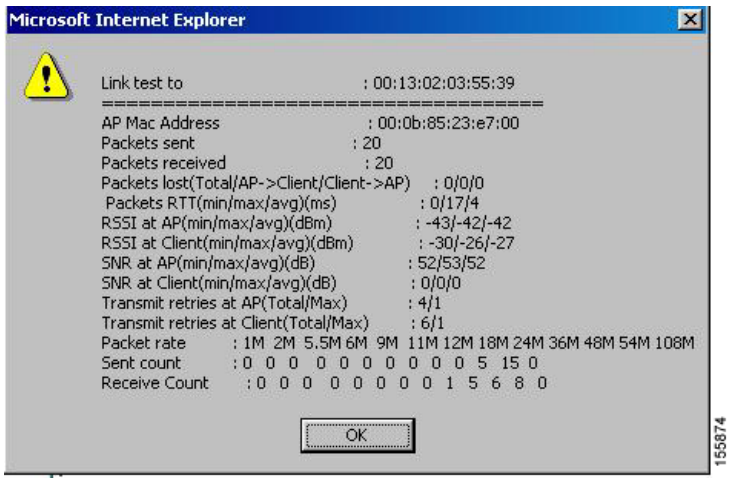
Figure 8-56 Clients Page



Step 2 Hover your cursor over the blue drop-down arrow for the desired client and choose **LinkTest**. A link test page appears (see Figure 8-57).

Note You can also access this page by clicking the MAC address of the desired client and then clicking the **Link Test** button on the top of the Clients > Detail page.

Figure 8-57 Link Test Page



This page shows the results of the CCX link test.

Note If the client and/or controller does not support CCX v4 or later releases, the controller performs a ping link test on the client instead, and a much more limited link test page appears.

Step 3 Click **OK** to exit the link test page.

Using the CLI to Perform a Link Test

Use these commands to run a link test using the controller CLI:

- Run a link test by entering this command:

  linktest *ap_mac*

  When CCX v4 or later releases is enabled on both the controller and the client being tested, information similar to the following appears:

```
CCX Link Test to 00:0d:88:c5:8a:d1.
     Link Test Packets Sent..................................... 20
     Link Test Packets Received................................. 10
     Link Test Packets Lost (Total/AP to Client/Client to AP).... 10/5/5
     Link Test Packets round trip time (min/max/average)........ 5ms/20ms/15ms
     RSSI at AP (min/max/average)............................... -60dBm/-50dBm/-55dBm
     RSSI at Client (min/max/average)........................... -50dBm/-40dBm/-45dBm
     SNR at AP (min/max/average)................................ 40dB/30dB/35dB
     SNR at Client (min/max/average)............................ 40dB/30dB/35dB
     Transmit Retries at AP (Total/Maximum)..................... 5/3
     Transmit Retries at Client (Total/Maximum)................. 4/2
     Transmit rate:  1M   2M   5.5M   6M   9M  11M 12M 18M   24M   36M  48M  54M  108M
     Packet Count:   0     0     0    0    0    0   0   0     0     2    0   18     0
     Transmit rate:  1M   2M   5.5M   6M   9M  11M 12M 18M   24M   36M  48M  54M  108M
     Packet Count:   0     0     0    0    0    0   0   0     0     2    0    8     0
```

  When CCX v4 or later releases is not enabled on either the controller or the client being tested, fewer details appear:

```
Ping Link Test to 00:0d:88:c5:8a:d1.
        Link Test Packets Sent..................... 20
        Link Test Packets Received................. 20
        Local Signal Strength...................... -49dBm
        Local Signal to Noise Ratio................ 39dB
```

- Adjust the link-test parameters that are applicable to both the CCX link test and the ping test by entering these commands from configuration mode:

  linktest frame-size *size_of_link-test_frames*

  linktest num-of-frame *number_of_link-test_request_frames_per_test*

Configuring Link Latency

You can configure link latency on the controller to measure the link between an access point and the controller. This feature can be used with all access points joined to the controller but is especially useful for hybrid-REAP and OfficeExtend access points, for which the link could be a slow or unreliable WAN connection.

Note Link latency is supported for use only with hybrid-REAP access points in connected mode. Hybrid-REAP access points in standalone mode are not supported.

Link latency monitors the round-trip time of the CAPWAP heartbeat packets (echo request and response) from the access point to the controller and back. This time can vary due to the network link speed and controller processing loads. The access point timestamps the outgoing echo requests to the controller

and the echo responses received from the controller. The access point sends this delta time to the controller as the system round-trip time. The access point sends heartbeat packets to the controller at a default interval of 30 seconds.

Note Link latency calculates the CAPWAP response time between the access point and the controller. It does not measure network latency or ping responses.

The controller displays the current round-trip time as well as a running minimum and maximum round-trip time. The minimum and maximum times continue to run as long as the controller is up or can be cleared and allowed to restart.

You can configure link latency for a specific access point using the controller GUI or CLI or for all access points joined to the controller using the CLI.

Using the GUI to Configure Link Latency

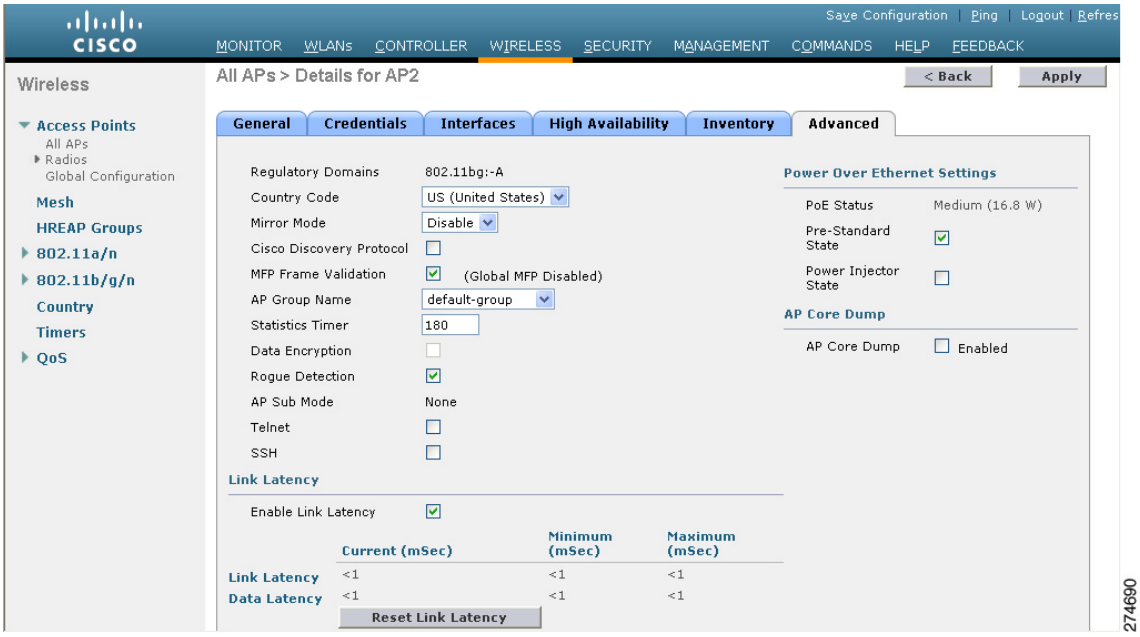
To configure link latency using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to configure link latency.

Step 3 Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 8-58).

Figure 8-58 All APs > Details for (Advanced) Page



Step 4 Select the **Enable Link Latency** check box to enable link latency for this access point or unselect it to prevent the access point from sending the round-trip time to the controller after every echo response is received. The default value is unselected.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Step 7 When the All APs page reappears, click the name of the access point again.

Step 8 When the All APs > Details for page reappears, choose the **Advanced** tab again. The link latency and data latency results appear below the Enable Link Latency check box:

- Current—The current round-trip time (in milliseconds) of CAPWAP heartbeat packets or data packets from the access point to the controller and back.
- Minimum—Since link latency has been enabled or reset, the minimum round-trip time (in milliseconds) of CAPWAP heartbeat packets or data packets from the access point to the controller and back.
- Maximum—Since link latency has been enabled or reset, the maximum round-trip time (in milliseconds) of CAPWAP heartbeat packets or data packets from the access point to the controller and back.

Step 9 To clear the current, minimum, and maximum link latency and data latency statistics on the controller for this access point, click **Reset Link Latency**.

Step 10 After the page refreshes and the All APs > Details for page reap]pears, choose the **Advanced** tab. The updated statistics appear in the Minimum and Maximum text boxes.

Using the CLI to Configure Link Latency

To configure link latency using the controller CLI, follow these steps:

Step 1 Enable or disable link latency for a specific access point or for all access points currently associated to the controller by entering this command:

config ap link-latency {**enable** | **disable**} {*Cisco_AP* | **all**}

The default value is disabled.

Note The **config ap link-latency** {**enable** | **disable**} **all** command enables or disables link latency only for access points that are currently joined to the controller. It does not apply to access points that join in the future.

Step 2 See the link latency results for a specific access point by entering this command:

show ap config general *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 1
Cisco AP Name.................................... AP1
...
AP Link Latency.................................. Enabled
 Current Delay................................... 1 ms
 Maximum Delay................................... 1 ms
 Minimum Delay................................... 1 ms
 Last updated (based on AP Up Time)............. 0 days, 05 h 03 m 25 s
```

The output of this command contains the following link latency results:

- Current Delay—The current round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back.

- Maximum Delay—Since link latency has been enabled or reset, the maximum round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back.
- Minimum Delay—Since link latency has been enabled or reset, the minimum round-trip time (in milliseconds) of CAPWAP heartbeat packets from the access point to the controller and back.

Step 3 Clear the current, minimum, and maximum link latency statistics on the controller for a specific access point by entering this command:

config ap link-latency reset *Cisco_AP*

Step 4 See the results of the reset by entering this command:

show ap config general *Cisco_AP*

Configuring the TCP MSS

If the client's maximum segment size (MSS) in a Transmission Control Protocol (TCP) three-way handshake is greater than the maximum transmission unit can handle, the client might experience reduced throughput and the fragmentation of packets. To avoid this problem in controller software release 6.0 or later releases, you can specify the MSS for all access points that are joined to the controller or for a specific access point.

When you enable this feature, the access point selects for TCP packets to and from wireless clients in its data path. If the MSS of these packets is greater than the value that you configured or greater than the default value for the CAPWAP tunnel, the access point changes the MSS to the new configured value.

Using the CLI to Configure TCP MSS

To configure the TCP MSS using the controller CLI, follow these steps:

Step 1 Enable or disable the TCP MSS on a particular access point or on all access points by entering this command:

config ap tcp-adjust-mss {**enable** | **disable**} {*Cisco_AP* | **all**} *size*

where the *size* parameter is a value between 536 and 1363 bytes. The default value varies for different clients.

Step 2 Save your changes by entering this command:

save config

Step 3 Reboot the controller in order for your change to take effect by entering this command:

reset system

Step 4 See the current TCP MSS setting for a particular access point or all access points by entering this command:

show ap tcp-mss-adjust {*Cisco_AP* | **all**}

Information similar to the following appears:

```
AP Name              TCP State  MSS Size
------------------   --------   -------
AP-1140             enabled    536
AP-1240              disabled   -
```

```
AP-1130             disabled    -
```

Configuring Power over Ethernet

When an access point that has been converted to lightweight mode (such as an AP1131 or AP1242) or a 1250 series access point is powered by a power injector that is connected to a Cisco pre-Intelligent Power Management (pre-IPM) switch, you need to configure Power over Ethernet (PoE), also known as *inline power*.

The dual-radio 1250 series access points can operate in four different modes when powered using PoE:

- 20.0 W (Full Power)—This mode is equivalent to using a power injector or an AC/DC adapter.
- 16.8 W—Both transmitters are used but at reduced power. Legacy data rates are not affected, but the M0 to M15 data rates are reduced in the 2.4-GHz band. Throughput should be minimally impacted because all data rates are still enabled. The range is affected because of the lower transmit power. All receivers remain enabled.
- 15.4 W—Only a single transmitter is enabled. Legacy data rates and M0 to M7 rates are minimally affected. M8 to M15 rates are disabled because they require both transmitters. Throughput is better than that received with legacy access points but less than the 20 and 16.8 W power modes.
- 11.0 W (Low Power)—The access point runs, but both radios are disabled.

Note When a dual-radio 1250 series access point is powered using 15.4-W PoE, it cannot operate at full functionality, which requires 20 W. The access point can operate with dual radios on 15.4-W PoE, but performance is reduced in terms of throughput and range. If full functionality is required on 15.4 W, you can remove one of the radios from the 1250 series access point chassis or disable it in controller software release 6.0 or later releases so that the other radio can operate in full 802.11n mode. After the access point radio is administratively disabled, the access point must be rebooted for the change to take effect. The access point must also be rebooted after you reenable the radio to put it into reduced throughput mode.

These modes provide the flexibility of running the 1250 series access points with the available wired infrastructure to obtain the desired level of performance. With enhanced PoE switches (such as the Cisco Catalyst 3750-E Series Switches), the 1250 series access points can provide maximum features and functionality with a minimum total cost of ownership. Alternatively, if you decide to power the access point with the existing PoE (802.3af) switches, the access point chooses the appropriate mode of operation based on whether it has one radio or two.

Note For more information on the Cisco PoE switches, see this URL:
http://www.cisco.com/en/US/prod/switches/epoe.html

Table 8-21 shows the maximum transmit power settings for 1250 series access points using PoE.

Table 8-21 Maximum Transmit Power Settings for 1250 Series Access Points Using PoE

Radio Band	Data Rates	Number of Transmitters	Cyclic Shift Diversity (CSD)	Maximum Transmit Power (dBm)[1]		
				802.3af Mode (15.4 W)	ePoE Power Optimized Mode (16.8 W)	ePoE Mode (20 W)
2.4 GHz	802.11b	1	—	20	20	20
	802.11g	1	—	17	17	17
	802.11n MCS 0-7	1	Disabled	17	17	17
		2	Enabled (default)	Disabled	14 (11 per Tx)	20 (17 per Tx)
	802.11n MCS 8-15	2	—	Disabled	14 (11 per Tx)	20 (17 per Tx)
5 GHz	802.11a	1	—	17	17	17
	802.11n MCS 0-7	1	Disabled	17	17	17
		2	Enabled (default)	Disabled	20 (17 per Tx)	20 (17 per Tx)
	802.11n MCS 8-15	2	—	Disabled	20 (17 per Tx)	20 (17 per Tx)

1. Maximum transmit power varies by channel and according to individual country regulations. See the product documentation for specific details.

Note When powered with a non-Cisco standard PoE switch, the 1250 series access point operates under 15.4 Watts. Even if the non-Cisco switch or midspan device is capable of providing higher power, the access point does not operate in enhanced PoE mode.

You can configure PoE through either the controller GUI or CLI.

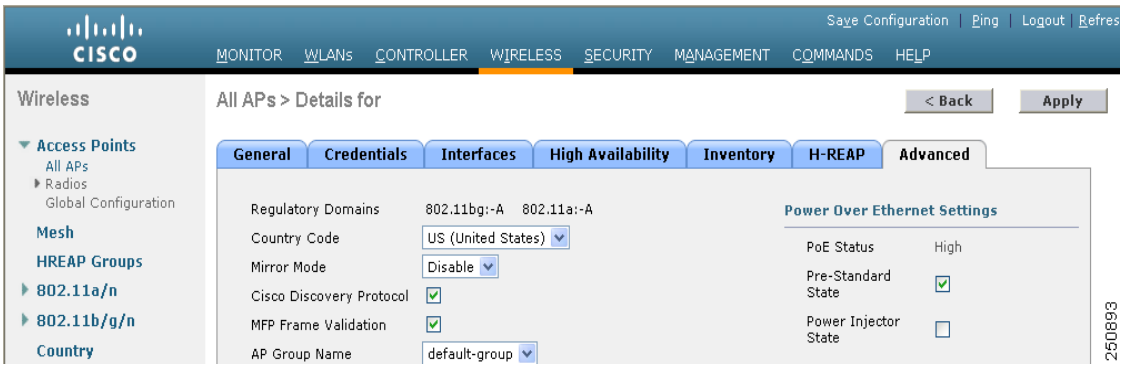
Using the GUI to Configure Power over Ethernet

To configure PoE using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Access Points** > **All APs** and then the name of the desired access point.

Step 2 Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure 8-59).

Figure 8-59 All APs > Details for (Advanced) Page



The PoE Status text box shows the power level at which the access point is operating: High (20 W), Medium (16.8 W), or Medium (15.4 W). This text box is not configurable. The controller auto-detects the access point's power source and displays the power level here.

Note This text box applies only to 1250 series access points that are powered using PoE. There are two other ways to determine if the access point is operating at a lower power level. First, the "Due to low PoE, radio is transmitting at degraded power" message appears under the Tx Power Level Assignment section on the 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page. Second, the "PoE Status: degraded operation" message appears in the controller's trap log on the Trap Logs page.

Step 3 Perform one of the following:

- Select the **Pre-standard 802.3af switches** check box if the access point is being powered by a high-power 802.3af Cisco switch. Thise switch provides more than the traditional 6 Watts of power but do not support the intelligent power management (IPM) feature.
- Unselect the **Pre-standard 802.3af switches** check box if power is being provided by a power injector. This is the default value.

Step 4 Select the **Power Injector State** check box if the attached switch does not support IPM and a power injector is being used. If the attached switch supports IPM, you do not need to select this check box.

Step 5 If you selected the Power Injector State check box in the previous step, the Power Injector Selection and Injector Switch MAC Address parameters appear. The Power Injector Selection parameter enables you to protect your switch port from an accidental overload if the power injector is inadvertently bypassed. Choose one of these options from the drop-down list to specify the desired level of protection:

- **Installed**—This option examines and remembers the MAC address of the currently connected switch port and assumes that a power injector is connected. Choose this option if your network contains older Cisco 6-Watt switches and you want to avoid possible overloads by forcing a double-check of any relocated access points.

  If you want to configure the switch MAC address, enter the MAC address in the Injector Switch MAC Address text box. If you want the access point to find the switch MAC address, leave the Injector Switch MAC Address text box blank.

Note Each time an access point is relocated, the MAC address of the new switch port fails to match the remembered MAC address, and the access point remains in low-power mode. You must then physically verify the existence of a power injector and reselect this option to cause the new MAC address to be remembered.

- **Override**—This option allows the access point to operate in high-power mode without first verifying a matching MAC address. You can use this option if your network does not contain any older Cisco 6-W switches that could be overloaded if connected directly to a 12-W access point. The advantage of this option is that if you relocate the access point, it continues to operate in high-power mode without any further configuration. The disadvantage of this option is that if the access point is connected directly to a 6-W switch, an overload occurs.

Step 6 Click **Apply** to commit your changes.

Step 7 If you have a dual-radio 1250 series access point and want to disable one of its radios in order to enable the other radio to receive full power, follow these steps:

a. Choose **Wireless > Access Points > Radios > 802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

b. Hover your cursor over the blue drop-down arrow for the radio that you want to disable and choose **Configure**.

c. On the 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page, choose **Disable** from the Admin Status drop-down list.

d. Click **Apply** to commit your changes.

e. Manually reset the access point in order for the change to take effect.

Step 8 Click **Save Configuration** to save your settings.

Using the CLI to Configure Power over Ethernet

Use these commands to configure and See PoE settings using the controller CLI:

- If your network contains any older Cisco 6-W switches that could be accidentally overloaded if connected directly to a 12-W access point, enter this command:

  config ap power injector enable {*Cisco_AP* | **all**} **installed**

  The access point remembers that a power injector is connected to this particular switch port. If you relocate the access point, you must reissue this command after the presence of a new power injector is verified.

Note Make sure CDP is enabled before entering this command. Otherwise, this command will fail. See the "Configuring the Cisco Discovery Protocol" section on page 4-96 for information on enabling CDP.

- Remove the safety checks and allow the access point to be connected to any switch port by entering this command:

  config ap power injector enable {*Cisco_AP* | **all**} **override**

You can use this command if your network does not contain any older Cisco 6-W switches that could be overloaded if connected directly to a 12-W access point. The access point assumes that a power injector is always connected. If you relocate the access point, it continues to assume that a power injector is present.

- If you know the MAC address of the connected switch port and do not want to automatically detect it using the installed option, enter this command:

  config ap power injector enable {*Cisco_AP* | **all**} *switch_port_mac_address*

- If you have a dual-radio 1250 series access point and want to disable one of its radios in order to enable the other radio to receive full power, enter this command:

  config {**802.11a** | **802.11b**} **disable** *Cisco_AP*

  Note You must manually reset the access point in order for the change to take effect.

- See the PoE settings for a specific access point by entering this command:

  show ap config general *Cisco_AP*

  Information similar to the following appears:

```
Cisco AP Identifier.............................. 1
Cisco AP Name.................................... AP1
...
PoE Pre-Standard Switch.......................... Enabled
PoE Power Injector MAC Addr...................... Disabled
Power Type/Mode.................................. PoE/Low Power (degraded mode)
...
```

  The Power Type/Mode text box shows “degraded mode” if the access point is not operating at full power.

- See the controller’s trap log by entering this command:

  show traplog

  If the access point is not operating at full power, the trap contains “PoE Status: degraded operation.”

Configuring Flashing LEDs

Controller software release 4.0 or later releases enables you to flash the LEDs on an access point in order to locate it. All IOS lightweight access points support this feature.

Use these commands to configure LED flashing from the privileged EXEC mode of the controller:

Note The output of these commands is sent only to the controller console, regardless of whether the commands were entered on the console or in a TELNET/SSH CLI session.

- Enable the controller to send commands to the access point from its CLI by entering this command:

  debug ap enable *Cisco_AP*

- Cause a specific access point to flash its LEDs for a specified number of seconds by entering this command:

  debug ap command “led flash *seconds***”** *Cisco_AP*

You can enter a value between 1 and 3600 seconds for the *seconds* parameter.

- Disable LED flashing for a specific access point by entering this command:

  debug ap command "led flash disable" *Cisco_AP*

  This command disables LED flashing immediately. For example, if you run the previous command (with the *seconds* parameter set to 60 seconds) and then disable LED flashing after only 20 seconds, the access point's LEDs stop flashing immediately.

Viewing Clients

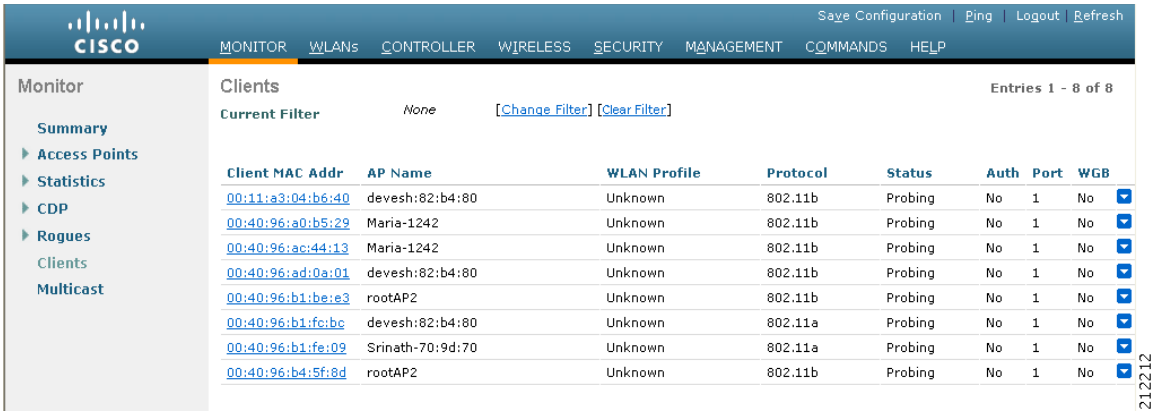
You can use the controller GUI or CLI to view information about the clients that are associated to the controller's access points.

Using the GUI to View Clients

To view client information using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Clients** to open the Clients page (see Figure 8-60).

Figure 8-60 Clients Page



This page lists all of the clients that are associated to the controller's access points. It provides the following information for each client:

- The MAC address of the client
- The name of the access point to which the client is associated
- The name of the WLAN used by the client
- The type of client (802.11a, 802.11b, 802.11g, or 802.11n)

Note If the 802.11n client associates to an 802.11a radio that has 802.11n enabled, then the client type shows as 802.11a/n. If the 802.11n client associates to an 802.11b/g radio with 802.11n enabled, then the client type shows as 802.11b/n.

- The status of the client connection
- The authorization status of the client
- The port number of the access point to which the client is associated
- An indication of whether the client is a WGB

Note See the "Cisco Workgroup Bridges" section on page 8-88 for more information on the WGB status.

Note If you want to remove or disable a client, hover your cursor over the blue drop-down arrow for that client and choose **Remove** or **Disable**, respectively. If you want to test the connection between the client and the access point, hover your cursor over the blue drop-down arrow for that client and choose **Link Test**.

Step 2 Create a filter to display only clients that meet certain criteria (such as the MAC address, status, or radio type) as follows:

a. Click **Change Filter** to open the Search Clients dialog box (see Figure 8-61).

Figure 8-61 Search Clients Dialog Box

b. Select one or more of the following check boxes to specify the criteria used when displaying clients:

- **MAC Address**—Enter a client MAC address.

  Note When you enable the MAC address filter, the other filters are disabled automatically. When you enable any of the other filters, the MAC address filter is disabled automatically.

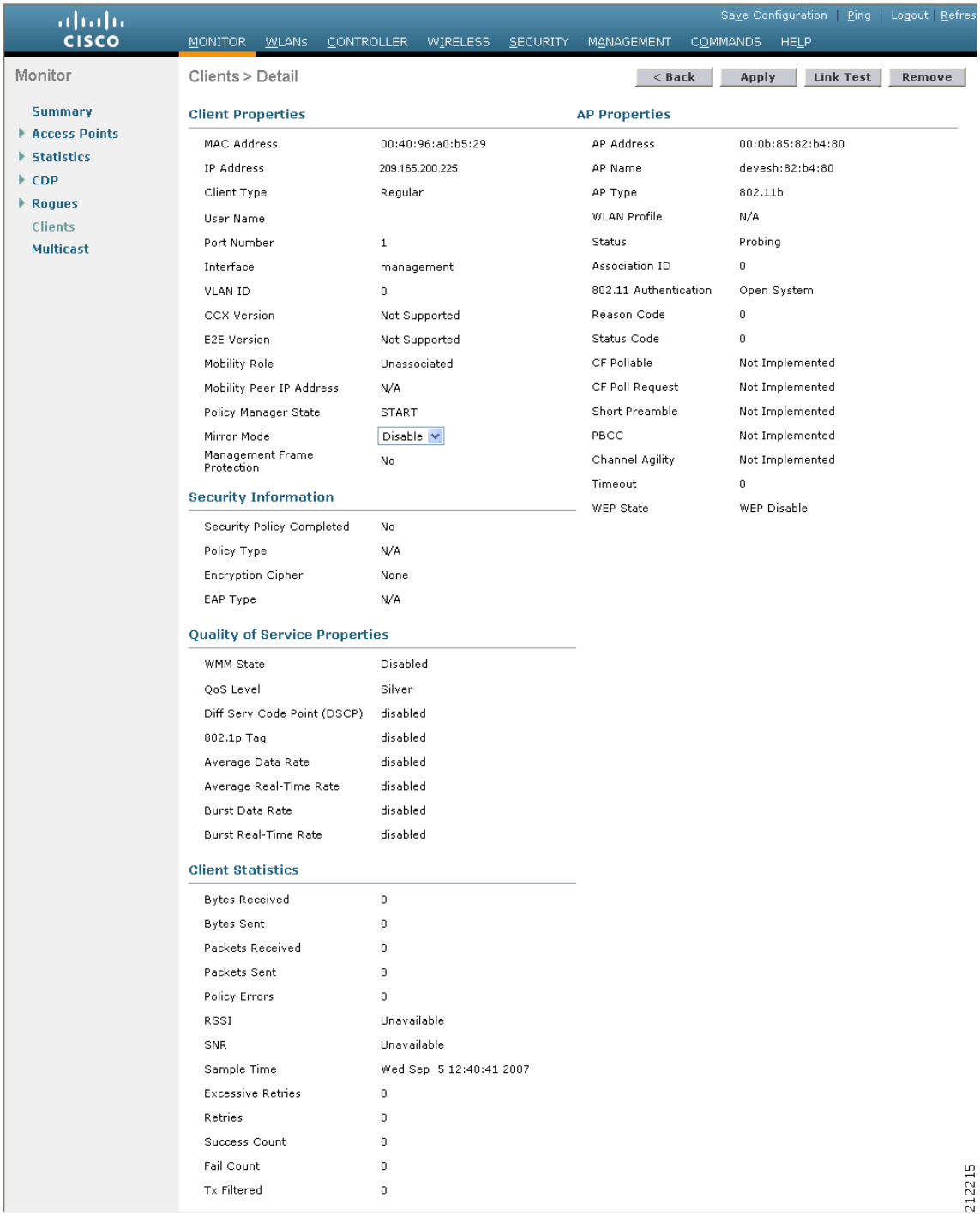
- **AP Name**—Enter the name of an access point.
- **WLAN Profile**—Choose one of the available WLAN profiles from the drop-down list.
- **Status**—Select the **Associated**, **Authenticated**, **Excluded**, and/or **Idle** check boxes.
- **Radio Type**—Choose **802.11a**, **802.11b**, **802.11g**, **802.11an**, **802.11bn** or **Mobile**.
- **WGB**—Enter the WGB clients associated to the controller's access points.

c. Click **Apply** to commit your changes. The Current Filter parameter at the top of the Clients page shows the filters that are currently applied.

Note If you want to remove the filters and display the entire client list, click **Clear Filter**.

Step 3 Click the MAC address of the client to view detailed information for a specific client. The Clients > Detail page appears (see Figure 8-62).

Figure 8-62 Clients > Detail Page



This page shows the following information:

- The general properties of the client
- The security settings of the client
- The QoS properties of the client

- Client statistics
- The properties of the access point to which the client is associated

Using the CLI to View Clients

Use these commands to view client information:

- See the clients associated to a specific access point by entering this command:

  show client ap {**802.11a** | **802.11b**} *Cisco_AP*

  Information similar to the following appears:

```
MAC Address        AP Id   Status         WLAN Id Authenticated
-----------------  ------  -------------  ---------  -------------
00:13:ce:cc:8e:b8   1     Associated      1          No
```

- See a summary of the clients associated to the controller's access points by entering this command:

  show client summary

  Information similar to the following appears:

```
Number of Clients.............................. 1

MAC Address       AP Name      Status    WLAN/Guest-Lan Auth Protocol Port Wired
----------------- ------------ ---------- --------------- ---- -------- ---- -----
00:13:02:2d:96:24 AP_1130      Associated      1         Yes  802.11a  1    No
```

- See detailed information for a specific client by entering this command:

  show client detail *client_mac*

  Information similar to the following appears:

```
Client MAC Address............................. 00:40:96:b2:a3:44
Client Username ............................... N/A
AP MAC Address................................. 00:18:74:c7:c0:90
Client State................................... Associated
Wireless LAN Id................................ 1
BSSID.......................................... 00:18:74:c7:c0:9f
Channel........................................ 56
IP Address..................................... 192.168.10.28
Association Id................................. 1
Authentication Algorithm....................... Open System
Reason Code.................................... 0
Status Code.................................... 0
Session Timeout................................ 0
Client CCX version............................. 5
Client E2E version............................. No E2E support
Diagnostics Capability......................... Supported
S69 Capability................................. Supported
Mirroring...................................... Disabled
QoS Level...................................... Silver
...
```

CHAPTER 9

Controlling Mesh Access Points

This chapter describes Cisco indoor and outdoor mesh access points and explains how to connect them to the controller and manage access point settings. It contains these sections:

Cisco Aironet Mesh Access Points

Mesh networking employs Cisco Aironet 1500 Series outdoor mesh access points and indoor mesh access points (Cisco Aironet 1040, 1130, 1140, 1240, 1250, 1260, 3500e, and 3500i series access points) along with the Cisco Wireless LAN Controller, and Cisco Wireless Control System (WCS) to provide scalable, central management, and mobility between indoor and outdoor deployments. Control and Provisioning of Wireless Access Points (CAPWAP) protocol manages the connection of mesh access points to the network.

End-to-end security within the mesh network is supported by employing Advanced Encryption Standard (AES) encryption between the wireless mesh access points and Wi-Fi Protected Access 2 (WPA2) clients. This document also outlines radio frequency (RF) components to consider when designing an outdoor network.

Controller software release 7.0.116.0 and later releases supports these Cisco Aironet mesh access points:

- Cisco Aironet 1520 series outdoor mesh access points consist of the 1522 dual-radio mesh access point and the 1524PS/Serial Backhaul multi-radio mesh access point.

Note See the *Cisco Aironet 1520 Series Outdoor Mesh Access Point Hardware Installation Guide* for details on the physical installation and initial configuration of the mesh access points at the following URL:

http://www.cisco.com/en/US/products/ps8368/tsd_products_support_series_home.html

Note AP1130 and AP1240 must be converted to operate as indoor mesh access points. See the "Converting Indoor Access Points to Mesh Access Points" section on page 9-124.

- Cisco Aironet 1550 series outdoor mesh access points consist of four models:
  - 1552E
  - 1552C
  - 1552I
  - 1552H

Note See the Cisco Mesh Access Points, Design and Deployment Guidefor details: http://www.cisco.com/en/US/docs/wireless/technology/mesh/7.0MR1/design/guide/MeshAP_70MR1.html

In the 7.0.98.0 release, indoor mesh is available on Cisco Aironet 1130 and 1240 series access points. In the 7.0.116.0 release, indoor mesh is also available on 11n access points (Cisco Aironet 1040, 1140, 1250, 1260, 3500e, and 3500i series access points).

Note All features discussed in this chapter apply to indoor (1040, 1140, 1250, 1260, 3500) and outdoor mesh access points (1500 series) unless noted otherwise. *Mesh access point* or *MAP* is hereafter used to refer to both indoor and outdoor mesh access points.

Note Cisco Aironet 1505 and 1510 access points are not supported in this release.

Note See the *Release Notes for Cisco Wireless LAN controllers and Lightweight Access Points for Release 7.0.116.0* for mesh feature summary, important notes, and software upgrade steps for migrating from 4.1.19x.xx mesh releases to controller release7.0.116.0 at this URL:

http://www.cisco.com/en/US/products/ps6366/prod_release_notes_list.html.

Access Point Roles

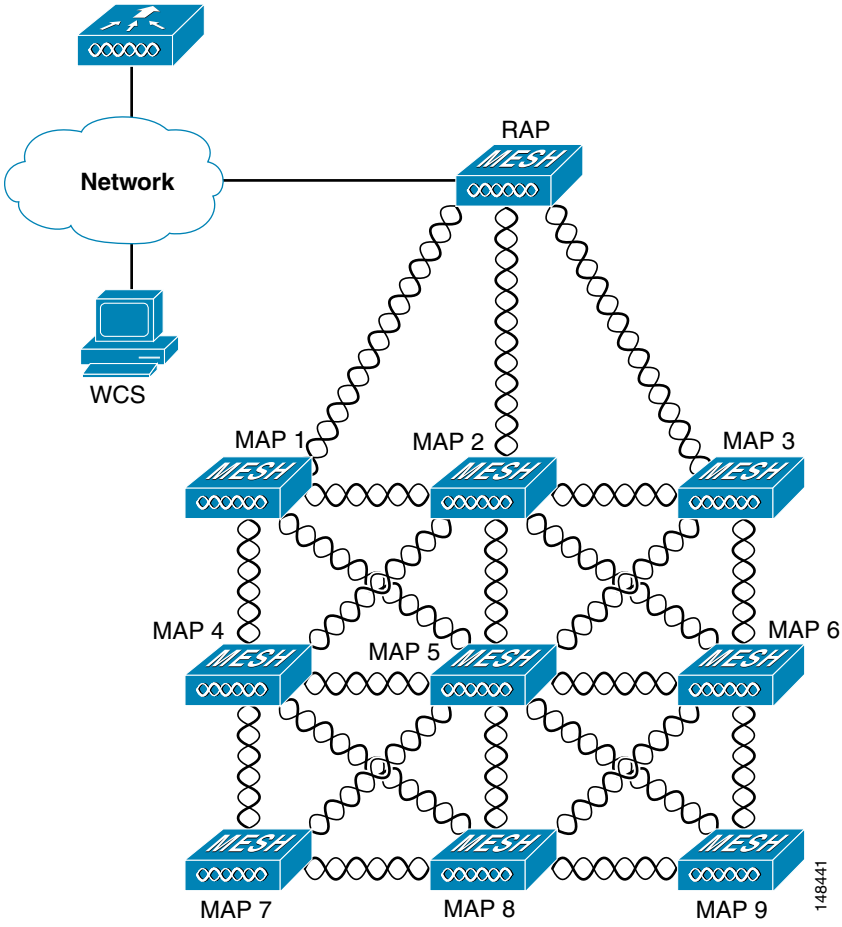
Access points within a mesh network operate as either a Root Access Point (RAP) or a Mesh Access Point (MAP).

RAPs have wired connections to their controller, and MAPs have wireless connections to their controller.

MAPs communicate among themselves and back to the RAP using wireless connections over the 802.11a radio backhaul. MAPs use the Cisco Adaptive Wireless Path Protocol (AWPP) to determine the best path through the other mesh access points to the controller.

All the possible paths between the MAPs and RAPs form the wireless mesh network. Figure 9-1 shows the relationship between RAPs and MAPs in a mesh network.

Figure 9-1 Simple Mesh Network Hierarchy



Network Access

Wireless mesh networks can simultaneously carry two different traffic types: wireless LAN client traffic and MAP Ethernet port traffic.

Wireless LAN client traffic terminates on the controller, and the Ethernet traffic terminates on the Ethernet ports of the mesh access points.

Access to the wireless LAN mesh for mesh access points is managed by:

- MAC authentication—Mesh access points are added to a database to ensure that they are allowed access to a given controller and the mesh network. See the "Converting Indoor Access Points to Mesh Access Points" section on page 9-124.

- External RADIUS authentication—Mesh access points can be externally authorized to use a RADIUS server such as Cisco ACS 4.1 and later releases that support the client authentication type of EAP-FAST with certificates. See the "Configuring RADIUS Servers" section on page 9-33.

Network Segmentation

Membership to the wireless LAN mesh network for mesh access points is controlled by the bridge group names (BGNs). Mesh access points can be placed in similar bridge groups to manage membership or provide network segmentation. See the "Configuring Antenna Gain Using the GUI" section on page 9-63.

Cisco Indoor Mesh Access Points

With the 7.0.116.0 release, indoor mesh is also available on 802.11n access points (Cisco Aironet 1040, 1140, 1250, 1260, 3500e, and 3500i series access points).

With the 7.0 release, indoor mesh is available on Cisco Aironet 1130 and 1240 series access points.

Enterprise 11n mesh is an enhancement added to the CUWN feature to work with the 802.11n access points. Enterprise 11n mesh features are compatible with non-802.11n mesh but adds higher backhaul and client access speeds. The 802.11n indoor access points are two-radio Wi-Fi infrastructure devices for select indoor deployments. One radio can be used for local (client) access for the access point and the other radio can be configured for wireless backhaul. The backhaul is supported only on the 5-GHz radio. Enterprise 11n mesh supports P2P, P2MP, and mesh types of architectures.

You have a choice of ordering indoor access points directly into the bridge mode, so that these access points can be used directly as mesh access points. If you have these access points in a local mode (nonmesh), then you have to connect these access points to the controller and change the AP mode to the bridge mode (mesh). This scenario can become cumbersome particularly if the volume of the access points being deployed is large and if the access points are already deployed in the local mode for a traditional nonmesh wireless coverage.

The Cisco indoor mesh access points are equipped with the following two simultaneously operating radios:

- 2.4-GHz radio used for client access
- 5-GHz radio used for data backhaul

The 5-GHz radio supports the 5.15 GHz, 5.25 GHz, 5.47 GHz, and 5.8 GHz bands.

Cisco Outdoor Mesh Access Points

Cisco outdoor mesh access points comprise of the Cisco Aironet 1500 series access points. The 1500 series includes 1552 11n outdoor mesh access points, 1522 dual-radio mesh access points, and 1524 multi-radio mesh access points. There are two models of the 1524, which are the following:

- The public safety model, 1524PS
- The serial backhaul model, 1524SB

Note In the 6.0 release, the AP1524SB access point was launched in A, C and N domains. In the 7.0 release, the AP1524SB access point is launched also in -E, -M, -K, -S, and -T domains.

Cisco 1500 series mesh access points are the core components of the wireless mesh deployment. AP1500s are configured by both the controller (GUI and CLI) and Cisco WCS. Communication between outdoor mesh access points (MAPs and RAPs) is over the 802.11a/n radio backhaul. Client traffic is generally transmitted over the 802.11b/g/n radio (802.11a/n can also be configured to accept client traffic), and public safety traffic (AP1524PS only) is transmitted over the 4.9-GHz radio.

The mesh access point can also operate as a relay node for other access points not directly connected to a wired network. Intelligent wireless routing is provided by the Adaptive Wireless Path Protocol (AWPP). This Cisco protocol enables each mesh access point to identify its neighbors and intelligently choose the optimal path to the wired network by calculating the cost of each path in terms9 of the signal strength and the number of hops required to get to a controller.

AP1500s are manufactured in two different configurations: cable and noncable.

- The cable configuration can be mounted to a cable strand and supports power-over-cable (POC).
- The noncable configuration supports multiple antennas. It can be mounted to a pole or building wall and supports several power options.

Uplinks support includes Gigabit Ethernet (1000BASE-T) and a small form-factor (SFP) slot that can be plugged for a fiber or cable modem interface. Both single mode and multimode SFPs up to 1000BASE-BX are supported. The cable modem can be DOCSIS 2.0 or DOCSIS/EuroDOCSIS 3.0 depending upon the type of mesh access point.

AP1500s are available in a hazardous location hardware enclosure. When configured, the AP1500 complies with safety standards for Class I, Division 2, Zone 2 hazardous locations.

Note See the *Cisco Aironet 1520 Series Lightweight Outdoor Access Point Ordering Guide* for power, mounting, antenna, and regulatory support by model: http://www.cisco.com/en/US/prod/collateral/wireless/ps5679/ps8368/product_data_sheet0900aecd8066a157.html

Mesh Deployment Modes

Mesh access points support multiple deployment modes, including the following:

- Wireless mesh
- Wireless backhaul
- Point-to-Multipoint Wireless Bridging
- Point-to-Point Wireless Bridging

Wireless Mesh Network

In a Cisco wireless outdoor mesh network, multiple mesh access points comprise a network that provides secure, scalable outdoor wireless LAN. Figure 9-2 shows an example of a simple mesh network deployment composed of mesh access point (MAPs and RAPs), controllers, and Cisco WCS.

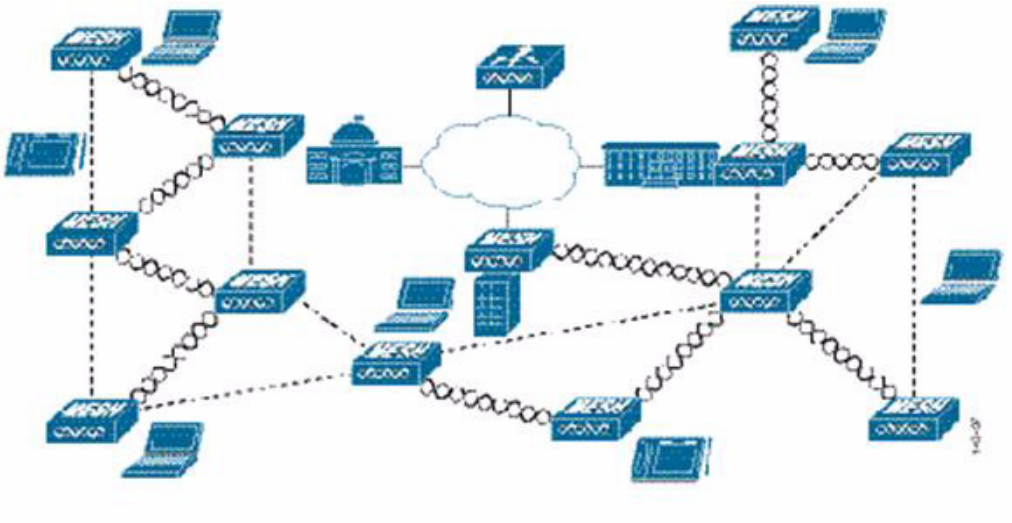
The three RAPs are connected to the wired network at each location and are located on the building roof. All the downstream access points operate as MAPs and communicate using wireless links (not shown).

Both MAPs and RAPs can provide WLAN client access; however, the location of RAPs are often not suitable for providing client access. All the three access points in Figure 9-2 are located on the building roofs and are functioning as RAPs. These RAPs are connected to the network at each location.

Some of the buildings have onsite controllers to terminate CAPWAP sessions from the mesh access points but it is not a mandatory requirement because CAPWAP sessions can be back hauled to a controller over a wide-area network (WAN) (see Figure 9-3).

Note For more details on CAPWAP, see the "Architecture Overview" section on page 9-12.

Figure 9-2 Wireless Mesh Deployment



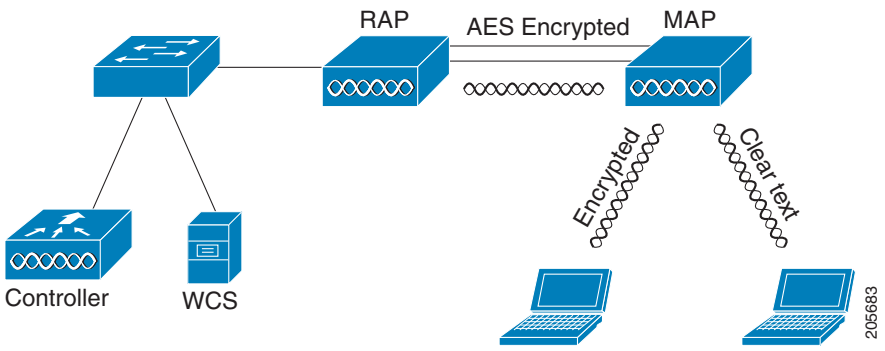
Wireless Backhaul

In a Cisco wireless backhaul network, traffic can be bridged between MAPs and RAPs. This traffic can be from wired devices that are being bridged by the wireless mesh or CAPWAP traffic from the mesh access points. This traffic is always AES encrypted when it crosses a wireless mesh link such as a wireless backhaul (see Figure 9-3).

AES encryption is established as part of the mesh access point neighbor relationship with other mesh access points. The encryption keys used between mesh access points are derived during the EAP authentication process.

Only 5 GHz backhaul is possible on all mesh access points except 1522 in which either 2.4 or 5 GHz radio can be configured as a backhaul radio (see Configuring Advanced Features, page 9-72).

Figure 9-3 Wireless Backhaul



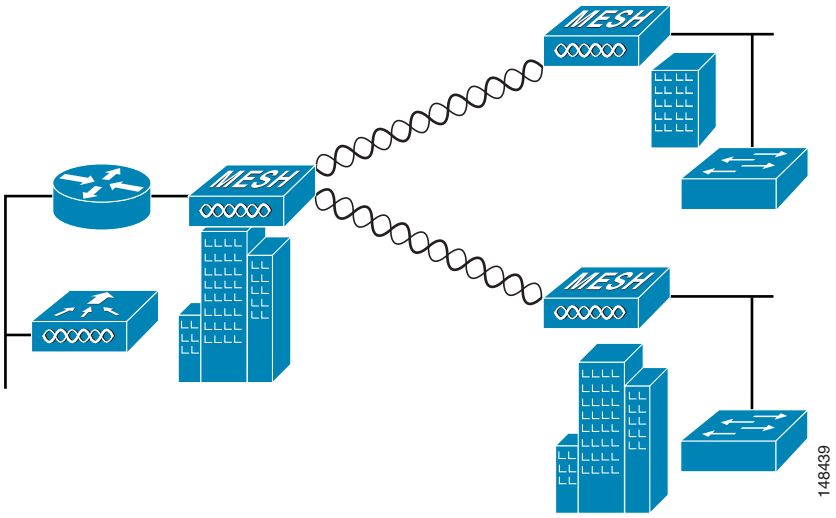
Universal Access

You can configure the backhaul on mesh access points to accept client traffic over its 802.11a radio. This feature is identified as Backhaul Client Access in the controller GUI (Monitor > Wireless). When this feature is disabled, backhaul traffic is transmitted only over the 802.11a or 802.11a/n radio and client association is allowed only over the 802.11b/g or 802.11b/g/n radio. For more information about the configuration, see the "Configuring Advanced Features" section on page 9-72.

Point-to-Multipoint Wireless Bridging

In the point-to-multipoint bridging scenario, a RAP acting as a root bridge connects multiple MAPs as nonroot bridges with their associated wired LANs. By default, this feature is disabled for all MAPs. If Ethernet bridging is used, you must enable it on the controller for the respective MAP and for the RAP. Figure 9-4 shows a simple deployment with one RAP and two MAPs, but this configuration is fundamentally a wireless mesh with no WLAN clients. Client access can still be provided with Ethernet bridging enabled, although if bridging between buildings, MAP coverage from a high rooftop might not be suitable for client access.

Figure 9-4 Point-to-Multipoint Bridging Example

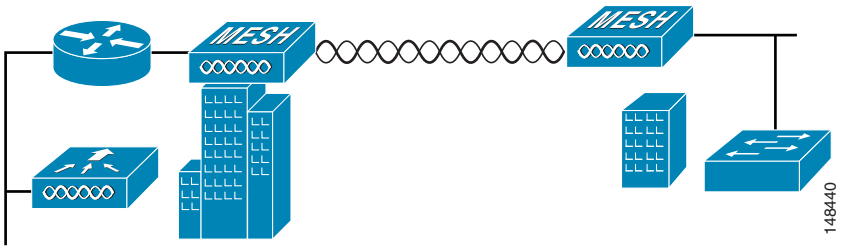


Point-to-Point Wireless Bridging

In a point-to-point bridging scenario, a 1500 Series Mesh AP can be used to extend a remote network by using the backhaul radio to bridge two segments of a switched network (see Figure 9-5). This is fundamentally a wireless mesh network with one MAP and no WLAN clients. Just as in point-to-multipoint networks, client access can still be provided with Ethernet bridging enabled, although if bridging between buildings, MAP coverage from a high rooftop might not be suitable for client access.

If you intend to use an Ethernet bridged application, we recommend that you enable the bridging feature on the RAP and on all MAPs in that segment. You must verify that any attached switches to the Ethernet ports of your MAPs are not using VLAN Trunking Protocol (VTP). VTP can reconfigure the trunked VLANs across your mesh and possibly cause a loss in connection for your RAP to its primary WLC. An incorrect configuration can take down your mesh deployment.

Figure 9-5 Point-to-Point Bridging Example



For security reasons the Ethernet port on the MAPs is disabled by default. It can be enabled only by configuring Ethernet Bridging on the Root and the respective MAPs (see Figure 9-6).

Ethernet bridging has to be enabled for the following two scenarios:

1. When you want to use the mesh nodes as bridges.
2. When you want to connect Ethernet devices such as a video camera on the MAP using its Ethernet port.

Figure 9-6 Wireless > All APs > Details

Ensure that you enable Ethernet bridging for every parent mesh AP taking the path from the mesh AP in question to the controller. For example, if you enable Ethernet bridging on MAP2 in Hop 2, then you must also enable Ethernet bridging on MAP1 (parent MAP), and on the RAP connecting to the controller.

Range Parameters have to be configured for longer links under the **Wireless > Mesh** tab. Optimum distance (in feet) should exist between the root access point (RAP) and the farthest mesh access point (MAP). Range from the RAP bridge to the MAP bridge has to be mentioned in feet (see Figure 9-7).

Figure 9-7 Configuring Range Parameters

The following global parameter applies to all mesh access points when they join the controller and all existing mesh access points in the network:

Range: 150 to 132,000 feet

Default: 12,000 feet

Configuring Mesh Range Using the CLI

To configure the distance between the nodes doing the bridging, use the **config mesh range** command (see Figure 9-9). Figure 9-8 shows how to display the mesh range by entering the **show mesh config** command.

Figure 9-8 Displaying Mesh Range Details

```
(Cisco Controller) >show mesh config

Mesh Range....................................... 12000
Backhaul with client access status.............. disabled
Background Scanning State....................... enabled

Mesh Security
   Security Mode................................ EAP
   External-Auth................................ disabled
   Use MAC Filter in External AAA server........ disabled
   Force External Authentication................ disabled

Mesh Alarm Criteria
   Max Hop Count................................ 4
   Recommended Max Children for MAP............. 10
   Recommended Max Children for RAP............. 20
   Low Link SNR................................. 12
   High Link SNR................................ 60
   Max Association Number....................... 10
   Association Interval......................... 60 minutes
   Parent Change Numbers........................ 3
   Parent Change Interval....................... 60 minutes

--More-- or (q)uit

Mesh Multicast Mode.............................. In-Out
Mesh Full Sector DFS............................. enabled


Mesh Ethernet Bridging VLAN Transparent Mode..... disabled
```

Figure 9-9 Configuring Mesh Range

```
(Cisco Controller) >config mesh range ?

<range in Feet> Configure range value.

(Cisco Controller) >config mesh range 12000 ?
(Cisco Controller) >config mesh range 12000

 Command not applicable for indoor mesh. All outdoor Mesh APs will be rebooted
 Are you sure you want to start? (y/N)n
```

Note APs reboot after you specify the range.

Note To estimate the range, you can use range calculators that are available at:

Cisco 1520 Series Outdoor Mesh Range Calculation Utility:
http://www.cisco.com/en/US/products/ps8368/products_implementation_design_guides_list.html

Range Calculator for 1550 Series Outdoor Mesh Access Points:
http://www.cisco.com/en/US/products/ps11451/products_implementation_design_guides_list.html

Assumptions for AP1522 Range Calculator

- The AP1522 Range Calculator has been edited to stay within limitations for Tx power and EIRP under the listed regulatory domains. There may be cases where it exceeds the limitations. You must verify that the installation is within the laws of the location in which it is being installed.
- When you use the AP1522 Range Calculator, available power levels change based upon the regulatory domain, the antenna (or antenna gain) selected, the modulation mode, which is based on the data rate selected (OFDM requires a lower power level in some domains). You must verify all parameters after making any parameter changes.
- Rx sensitivity in 2.4 GHz is the composite sensitivity of all three Rx paths. That is, MRC is included in 2.4 GHz. There is only one Rx for 5 GHz.
- You can choose only the channels that the access point is certified for.
- You can select only valid power levels.

Assumptions for AP1552 Range Calculator

- The AP1552 Range Calculator has been edited to stay within limitations for Tx power and EIRP under the listed regulatory domains. There may be cases where it exceeds the limitations. You must verify that the installation is within the laws of the location in which it is being installed.
- All three antenna ports must be used for external antenna models of 1552 for effective performance. Otherwise, range is significantly compromised. 1552 radios have two Tx paths and three Rx paths.
- The Tx power is the total composite power of both Tx paths.
- Rx sensitivity is the composite sensitivity of all three Rx paths. That is, MRC is included.
- The AP1552 Range Calculator assumes that ClientLink (Beamforming) is switched on.
- When you use the AP1552 Range Calculator, available power levels change based upon the regulatory domain, the antenna (or antenna gain) selected, and the data rate selected. You must verify all parameters after making any parameter changes.
- You can select a different antenna than the two that are available by default. If you enter a high gain antenna and choose a power that goes over the EIRP limit, then you get a warning and the range equals 0.
- You can choose only the channels that the access point is certified for.
- You can only select only valid power levels.

Architecture Overview

This section describes the mesh architecture overview.

CAPWAP

CAPWAP is the provisioning and control protocol used by the controller to manage access points (mesh and nonmesh) in the network. This protocol replaces LWAPP in controller software 5.2 or later releases.

Cisco Adaptive Wireless Path Protocol Wireless Mesh Routing

The Cisco Adaptive Wireless Path Protocol (AWPP) is designed specifically for wireless mesh networking. The path decisions of AWPP are based on the link quality and the number of hops.

Ease of deployment, fast convergence, and minimal resource consumption are also key components of AWPP.

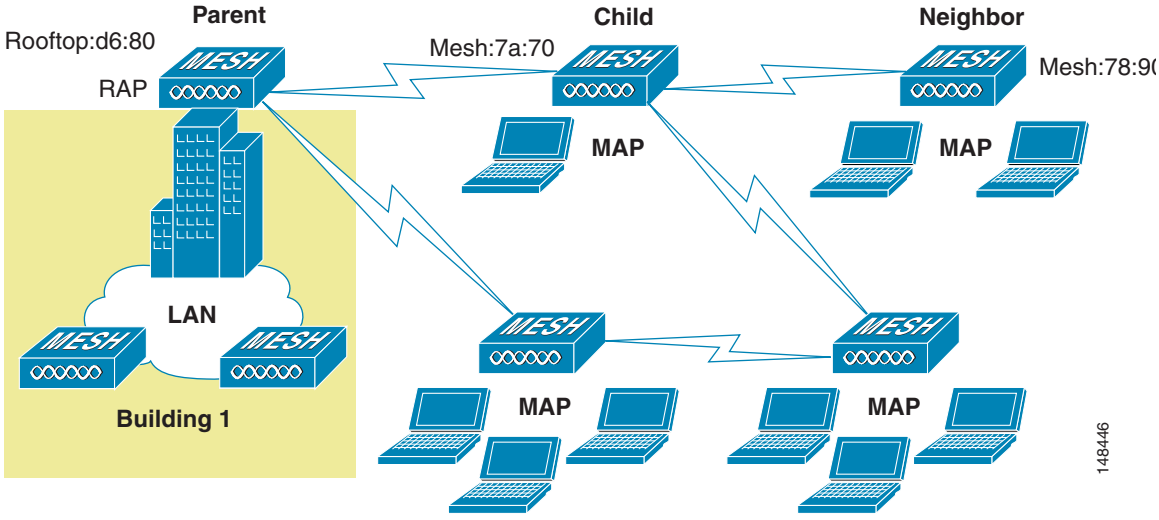
The goal of AWPP is to find the best path back to a RAP for each MAP that is part of the RAP's bridge group. To do this, the MAP actively solicits for neighbor MAPs. During the solicitation, the MAP learns all of the available neighbors back to a RAP, determines which neighbor offers the best path, and then synchronizes with that neighbor.

Mesh Neighbors, Parents, and Children

Relationships among access points with the mesh network are labeled as parent, child, or neighbor (see Figure 9-10) as follows:

- A parent access point offers the best route back to the RAP based on its ease values. A parent can be either the RAP itself or another MAP. Ease is calculated using the SNR and link hop value of each neighbor. Given multiple choices, an access point with a higher ease value is selected.
- A child access point selects the parent access point as its best route back to the RAP.
- A neighbor access point is within the radio frequency (RF) range of another access point but is not selected as its parent or a child because its *ease* values are lower than that of the parent.

Figure 9-10 Parent, Child, and Neighbor Access Points



Wireless Mesh Constraints

The following are a few system characteristics to consider when you design and build a wireless mesh network. Some of these characteristics apply to the backhaul network design and others to the CAPWAP controller design:

Wireless Backhaul Data Rate

Backhaul is used to create only the wireless connection between the access points. The backhaul interface by default is 802.11a or 802.11a/n depending upon the access point. The rate selection is important for effective use of the available RF spectrum. The rate can also affect the throughput of client devices, and throughput is an important metric used by industry publications to evaluate vendor devices.

Dynamic Rate Adaptation (DRA) introduces a process to estimate optimal transmission rate for packet transmissions. It is important to select rates correctly. If the rate is too high, packet transmissions fail resulting in communication failure. If the rate is too low, the available channel bandwidth is not used, resulting in inferior products, and the potential for catastrophic network congestion and collapse.

Data rates also affect the RF coverage and network performance. Lower data rates, for example 6 Mbps, can extend farther from the access point than can higher data rates, for example 300 Mbps. As a result, the data rate affects cell coverage and consequently the number of access points required. Different data rates are achieved by sending a more redundant signal on the wireless link, allowing data to be easily recovered from noise. The number of symbols sent out for a packet at the 1-Mbps data rate is higher than the number of symbols used for the same packet at 11 Mbps. Therefore, sending data at the lower bit rates takes more time than sending the equivalent data at a higher bit rate, resulting in reduced throughput.

A lower bit rate might allow a greater distance between MAPs, but there are likely to be gaps in the WLAN client coverage, and the capacity of the backhaul network is reduced. An increased bit rate for the backhaul network either requires more MAPs or results in a reduced SNR between MAPs, limiting mesh reliability and interconnection. For more information about configuring wireless backhaul data rate, see "Configuring Wireless Backhaul Data Rate" section on page 9-48.

Note The data rate can be set on the backhaul on a per AP basis. It is not a global command.

The required minimum LinkSNR for backhaul links per data rate is shown in Table 9-1.

Table 9-1 Backhaul Data Rates and Minimum LinkSNR Requirements

802.11a Data Rate (Mbps)	Minimum Required LinkSNR (dB)
54	31
48	29
36	26
24	22
18	18
12	16
9	15
6	14

- The required minimum LinkSNR value is driven by the data rate and the following formula: *Minimum SNR + fade margin*.

  Table 9-2 summarizes the calculation by data rate.

  - Minimum SNR refers to an ideal state of noninterference, nonnoise, and a system packet error rate (PER) of no more than 10 percent.
  - Typical fade margin is approximately 9 to 10 dB.

Table 9-2 Minimum Required LinkSNR Calculations by Data Rate

802.11n Date Rate (Mbps)	Minimum SNR (dB) +	Fade Margin =	Minimum Required LinkSNR (dB)
6	5	9	14
9	6	9	15
12	7	9	16
18	9	9	18
24	13	9	22
36	17	9	26

- If we take into account the effect of MRC for calculating Minimum Required Link SNR. Table 9-3 shows the required LinkSNR for 802.11a/g (2.4 GHz and 5 GHz) for AP1552 and 1522 with 3 Rx antennas (MRC gain).

  LinkSNR = Minimum SNR - MRC + Fade Margin (9 dB)

Table 9-3 Required LinkSNR Calculations for 802.11a/g

802.11a/g MCS (Mbps)	Modulation	Minimum SNR (dB)	MRC Gain from 3 RXs (dB)	Fade Margin (dB)	Required Link SNR (dB)
6	BPSK 1/2	5	4.7	9	9.3
9	BPSK 3/4	6	4.7	9	10.3
12	QPSK 1/2	7	4.7	9	11.3
18	QPSK 3/4	9	4.7	9	13.3
24	16QAM 1/2	13	4.7	9	17.3
36	16QAM 3/4	17	4.7	9	21.3
48	64QAM 2/3	20	4.7	9	24.3
54	64QAM 3/4	22	4.7	9	26.3

If we consider only 802.11n rates, then Table 9-4 shows LinkSNR requirements with AP1552 for 2.4 and 5 GHz.

Table 9-4 Requirements for LinkSNR with AP1552 for 2.4 and 5 GHz

No. of Spatial Streams	11n MCS	Modulation	Minimum SNR (dB)	MRC Gain from 3 RXs (dB)	Fade Margin (dB)	Link SNR (dB)
1	MCS 0	BPSK 1/2	5	4.7	9	9.3
1	MCS 1	QPSK 1/2	7	4.7	9	11.3
1	MCS 2	QPSK 3/4	9	4.7	9	13.3
1	MCS 3	16QAM 1/2	13	4.7	9	17.3
1	MCS 4	16QAM 3/4	17	4.7	9	21.3
1	MCS 5	64QAM 2/3	20	4.7	9	24.3
1	MCS 6	64QAM 3/4	22	4.7	9	26.3
1	MCS 7	64QAM 5/6	23	4.7	9	27.3
2	MCS 8	BPSK 1/2	5	1.7	9	12.3
2	MCS 9	QPSK 1/2	7	1.7	9	14.3
2	MCS 10	QPSK 3/4	9	1.7	9	16.3
2	MCS 11	16QAM 1/2	13	1.7	9	20.3
2	MCS 12	16QAM 3/4	17	1.7	9	24.3
2	MCS 13	64QAM 2/3	20	1.7	9	27.3
2	MCS 14	64QAM 3/4	22	1.7	9	29.3
2	MCS 15	64QAM 5/6	23	1.7	9	30.3

Note With two spatial streams, the MRC gain is halved, that is the MRC gain is reduced by 3 dB. This is because the system has 10 log (3/2 SS) instead of 10 log (3/1 SS). If there were to have been 3 SS with 3 RX, then the MRC gain would have been zero.

- Number of backhaul hops is limited to eight but we recommend three to four hops.

  The number of hops is recommended to be limited to three or four primarily to maintain sufficient backhaul throughput, because each mesh access point uses the same radio for transmission and reception of backhaul traffic, which means that throughput is approximately halved over every hop. For example, the maximum throughput for 24 Mbps is approximately 14 Mbps for the first hop, 9 Mbps for the second hop, and 4 Mbps for the third hop.

- Number of MAPs per RAP.

  There is no current software limitation on how many MAPs per RAP you can configure. However, it is suggested that you limit the number to 20 MAPs per RAP.

- Number of controllers
  - The number of controllers per mobility group is limited to 72.
- Number of mesh access points supported per controller. For more information, see the "Controller Planning" section.

ClientLink Technology

Many networks still support a mix of 802.11a/g and 802.11n clients. Because 802.11a/g clients (legacy clients) operate at lower data rates, the older clients can reduce the capacity of the entire network. Cisco's ClientLink technology can help solve problems related to adoption of 802.11n in mixed-client networks by ensuring that 802.11a/g clients operate at the best possible rates, especially when they are near cell boundaries.

Advanced signal processing has been added to the Wi-Fi chipset. Multiple transmit antennas are used to focus transmissions in the direction of the 802.11a/g client, increasing the downlink signal-to-noise ratio and the data rate over range, thereby reducing coverage holes and enhancing the overall system performance. This technology learns the optimum way to combine the signal received from a client and then uses this information to send packets in an optimum way back to the client. This technique is also referred to as MIMO (multiple-input multiple-output) beamforming, transmit beamforming, or cophasing, and it is the only enterprise-class and service provider-class solution in the market that does not require expensive antenna arrays.

The 802.11n systems take advantage of multipath by sending multiple radio signals simultaneously. Each of these signals, called a spatial stream, is sent from its own antenna using its own transmitter. Because there is some space between these antennas, each signal follows a slightly different path to the receiver, a situation called spatial diversity. The receiver has multiple antennas as well, each with its own radio that independently decodes the arriving signals, and each signal is combined with signals from the other receiver radios. This results in multiple data streams receiving at the same time. This enables a higher throughput than previous 802.11a/g systems, but requires an 802.11n capable client to decipher the signal. Therefore, both AP and client need to support this capability. Due to the complexity of issues, in the first generation of mainstream 802.11n chipsets, neither the AP nor client chipsets implemented 802.11n transmit beamforming. Therefore, the 802.11n standard transmit beamforming will be available eventually, but not until the next generation of chipsets take hold in the market. We intend to lead in this area going forward.

We realized that for the current generation of 802.11n APs, while the second transmit path was being well utilized for 802.11n clients (to implement spatial diversity), it was not being fully used for 802.11a/g clients. In other words, for 802.11 a/g clients, some of the capabilities of the extra transmit path was lying idle. In addition, we realized that for many networks, the performance of the installed 802.11 a/g client base would be a limiting factor on the network.

To take advantage of this fallow capacity and greatly enhance overall network capacity by bringing 802.11 a/g clients up to a higher performance level, we created an innovation in transmit beamforming technology, called ClientLink.

ClientLink uses advanced signal processing techniques and multiple transmit paths to optimize the signal received by 802.11a/g clients in the downlink direction without requiring feedback. Because no special feedback is required, Cisco ClientLink works with all existing 802.11a/g clients.

Cisco ClientLink technology effectively enables the access point to optimize the SNR exactly at the position where the client is placed. ClientLink provides a gain of almost 4 dB in the downlink direction. Improved SNR yields many benefits, such as a reduced number of retries and higher data rates. For example, a client at the edge of the cell that might previously have been capable of receiving packets at 12 Mbps could now receive them at 36 Mbps. Typical measurements of downlink performance with ClientLink show as much as 65 percent greater throughput for 802.11a/g clients. By allowing the Wi-Fi system to operate at higher data rates and with fewer retries, ClientLink increases the overall capacity of the system, which means an efficient use of spectrum resources.

ClientLink in the 1552 access points is based on ClientLink capability available in AP3500s. Therefore, the access point has the ability to beamform well to nearby clients and to update beamforming information on 802.11ACKs. Therefore, even if there is no dedicated uplink traffic, the ClientLink works well, which is beneficial to both TCP and UDP traffic streams. There are no RSSI watermarks, which the client has to cross to take advantage of this Beamforming with Cisco 802.11n access points.

ClientLink can beamform to 15 clients at a time. Therefore, the host must select the best 15 if the number of legacy clients exceeds 15 per radio. AP1552 has two radios, which means that up to 30 clients can be beamformed in time domain.

Although ClientLink is applied to legacy OFDM portions of packets, which refers to 11a/g rates (not 11b) for both indoor and outdoor 802.11n access points, there is one difference between ClientLink for indoor 11n and ClientLink for outdoor 11n. For indoor 11n access points, SW limits the affected rates to 24, 36, 48, and 54 Mbps. This is done to avoid clients sticking to a far away AP in an indoor environment. SW also does not allow ClientLink to work for those rates for 11n clients because the throughput gain is so minimal. However, there is a demonstrable gain for pure legacy clients. For outdoor 11n access points, we do need more coverage. Thus, three more additional legacy data rates lower than 24 Mbps have been added. ClientLink for outdoors is applicable to legacy data rates of 9, 12, 18, 24, 36, 48, and 54 Mbps.

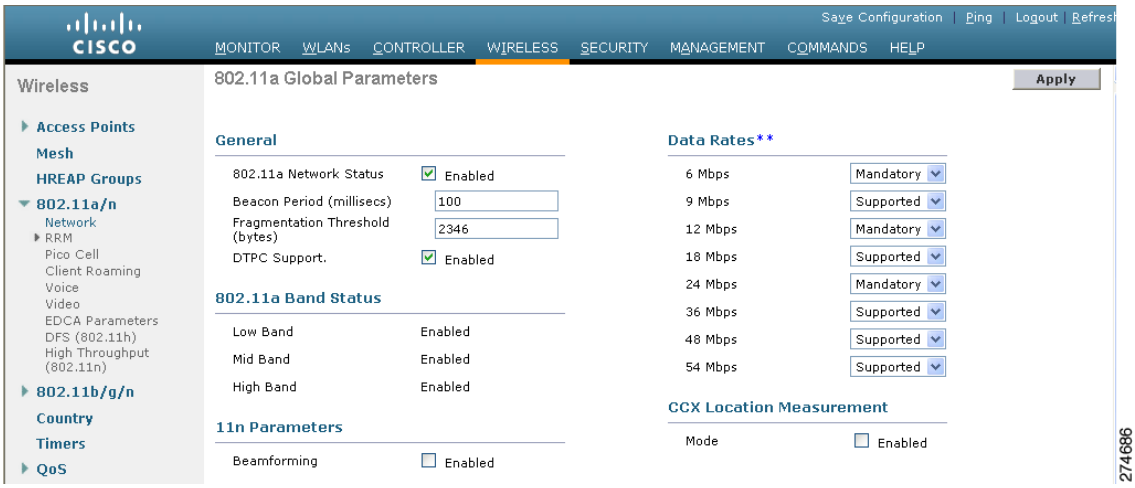
Using the GUI to Configure ClientLink

To configure ClientLink (Beamforming) using the controller GUI, follow these steps:

Step 1 Disable the 802.11a or 802.11b/g network as follows:

a. Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page (see Figure 9-11).

Figure 9-11 802.11a Global Parameters Page



b. Unselect the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 2 Select the **Beamforming** check box to globally enable beamforming on your 802.11a or 802.11g network, or leave it unselected to disable this feature. The default value is disabled.

Step 3 Reenable the network by selecting the **802.11a** (or **802.11b/g**) **Network Status** check box.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

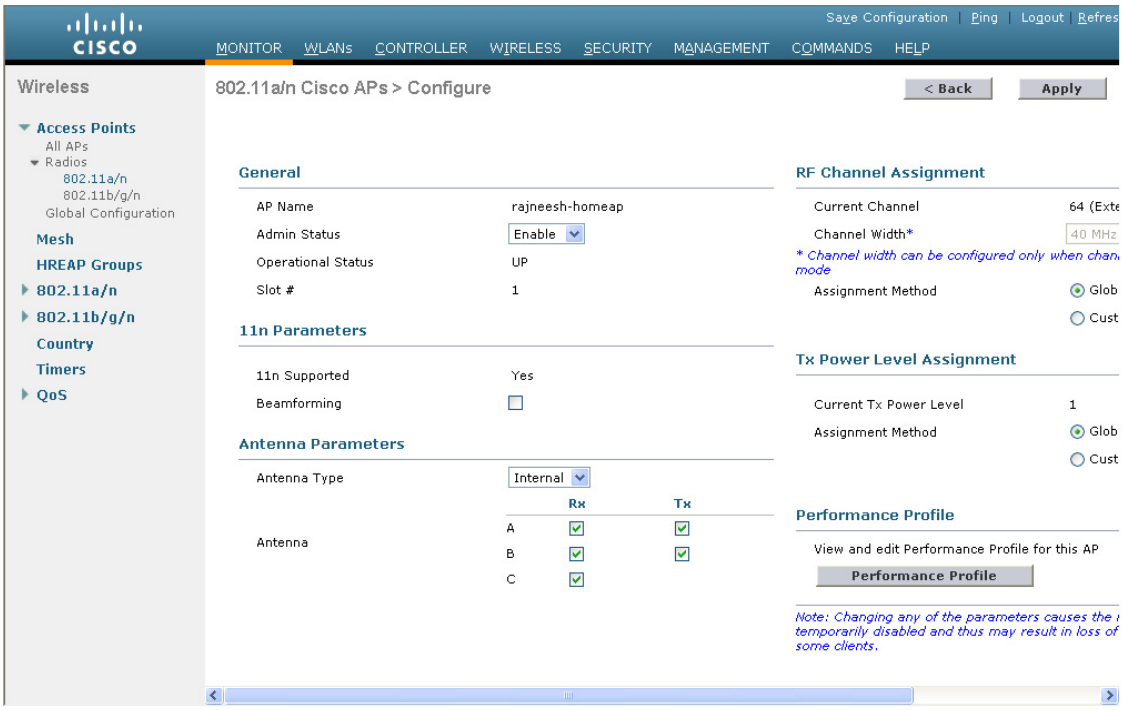
Note After you enable beamforming on the network, it is automatically enabled for all the radios applicable to that network type.

Step 6 Override the global configuration and enable or disable Beamforming for a specific access point as follows:

a. Choose **Wireless** > **Access Points** > **Radios** > **802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

b. Hover your cursor over the blue drop-down arrow for the access point for which you want to modify the radio configuration and choose **Configure**. The 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page appears (see Figure 9-12).

Figure 9-12 802.11a/n Cisco APs > Configure Page



Step 7 In the 11n Parameters section, select the **Beamforming** check box to enable beamforming for this access point or leave it unselected to disable this feature. The default value is unselected if beamforming is disabled on the network and selected if beamforming is enabled on the network.

Note If the access point does not support 802.11n, the beamforming option is not available.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure ClientLink

To configure ClientLink (Beamforming) using the controller CLI, follow these steps:

Step 1 Disable the 802.11a or 802.11b/g network by entering this command:

config {802.11a | 802.11b} disable network

Step 2 Globally enable or disable beamforming on your 802.11a or 802.11g network by entering this command:

config {802.11a | 802.11b} beamforming global {enable | disable}

The default value is disabled.

Note After you enable beamforming on the network, it is automatically enabled for all the radios applicable to that network type.

Step 3 Override the global configuration and enable or disable beamforming for a specific access point by entering this command:

config {802.11a | 802.11b} beamforming ap *Cisco_AP* **{enable | disable}**

The default value is disabled if beamforming is disabled on the network and enabled if beamforming is enabled on the network.

Step 4 Reenable the network by entering this command:

config {802.11a | 802.11b} enable network

Step 5 Save your changes by entering this command:

save config

Step 6 See the beamforming status for your network by entering this command:

show {802.11a | 802.11b}

Information similar to the following appears:

```
802.11a Network.................................. Enabled
11nSupport....................................... Enabled
      802.11a Low Band........................... Enabled
      802.11a Mid Band........................... Enabled
      802.11a High Band.......................... Enabled
...
Pico-Cell-V2 Status.............................. Disabled
TI Threshold..................................... -50
Legacy Tx Beamforming setting.................. Enabled
```

Step 7 See the beamforming status for a specific access point by entering this command:

show ap config {802.11a | 802.11b} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 14
Cisco AP Name.................................... 1250-1
Country code..................................... US  - United States
Regulatory Domain allowed by Country............. 802.11bg:-A     802.11a:-A
...
Phy OFDM parameters
      Configuration ............................. AUTOMATIC
      Current Channel ........................... 149
      Extension Channel ......................... NONE
      Channel Width.............................. 20 Mhz
      Allowed Channel List....................... 36,40,44,48,52,56,60,64,100,
        ......................................... 104,108,112,116,132,136,140,
        ......................................... 149,153,157,161,165
      TI Threshold .............................. -50
      Legacy Tx Beamforming Configuration ....... CUSTOMIZED
      Legacy Tx Beamforming ..................... ENABLED
```

Commands Related to ClientLink

The following commands are related to ClientLink:

- The following commands are to be entered in the AP console:
  - To check the status of Beamforming on the AP, enter the **show controller d0/d1** command.
  - To find a client in the AP rbf table, enter the **show interface dot110** command.

  - To check the Beamforming rate assigned on the AP, enter the **debug d0 trace print rates** command.

- The following commands on the AP console are used for troubleshooting:
  - To show that ClientLink is enabled on a radio, enter the **show controllers | inc Beam** command.

    The output is displayed as follows:

```
Legacy Beamforming: Configured Yes, Active Yes, RSSI Threshold -50 dBm
Legacy Beamforming: Configured Yes, Active Yes, RSSI Threshold -60 dBm
```

  - To show that ClientLink is Beamforming to a particular client, enter the **show interface dot11radio 1 lbf rbf** command.

    The output is displayed as follows:

```
RBF Table:
Index      Client MAC      Reserved      Valid    Tx BF     Aging
 1       0040.96BA.45A0      Yes          Yes      Yes       No
```

Controller Planning

The following items affect the number of controllers required in a mesh network:

- Mesh access points (RAPs and MAPs) in the network.

  The wired network that connects the RAP and controllers can affect the total number of access points supported in the network. If this network allows the controllers to be equally available to all access points without any impact on WLAN performance, the access points can be evenly distributed across all controllers for maximum efficiency. If this is not the case, and controllers are grouped into various clusters or PoPs, the overall number of access points and coverage are reduced.

  For example, you can have 72 Cisco 4400 Series Controllers in a mobility group, and each Cisco 4400 Series Controller supports 100 local access points, which gives a total number of 7200 possible access points per mobility group.

- Number of mesh access points (RAPs and MAPs) supported per controller. See Table 9-5.

  For clarity, nonmesh access points are referred to as *local* access points in this document.

Table 9-5 Mesh Access Point Support by Controller Model

Controller Model	Local AP Support (nonmesh)[1]	Maximum Possible Mesh AP Support	RAP	MAP	Total Mesh AP Support
5508[2]	500	500	1	499	500
			100	400	500
			150	350	500
			200	300	500
4404[3]	100	150	1	149	150
			50	100	150
			75	50	125
			100	0	100

Table 9-5 Mesh Access Point Support by Controller Model (continued)

Controller Model	Local AP Support (nonmesh)[1]	Maximum Possible Mesh AP Support	RAP	MAP	Total Mesh AP Support
2504[4]	50	50	1	49	50
			2	48	50
			5	45	50
			9	41	50
2106[3]	6	11	1	10	11
			2	8	10
			3	6	9
			4	4	8
			5	2	7
			6	0	6
2112[2]	12	12	1	11	12
			3	9	12
			6	6	12
			9	3	12
			12	0	12
2125[2]	25	25	1	24	25
			5	20	25
			10	15	25
			15	10	25
			20	5	25
			25	0	25
WiSM[3]	300	375	1	374	375
			100	275	375
			250	100	350
			300	0	300
WiSM2[3]	500	500	1	499	500
			100	400	500
			150	350	500
			200	300	500

1. Local AP support is the total number of nonmesh APs supported on the controller model.
2. For 5508, 2112, and 2125 controllers, the number of MAPs is equal to (local AP support - number of RAPs).
3. For 4404, 2106, and WiSM controllers, the number of MAPs is equal to ((local AP support - number of RAPs) x 2), not to exceed the maximum possible mesh AP support.
4. For 2504.

Note The Wireless LAN Controller modules NM and NME now support mesh 1520 series access points from Wireless LAN Controller (WLC) software release 5.2 and later releases.

Note Mesh is fully supported on Cisco 5508 Controllers. The Base License (LIC-CT508-Base) is sufficient for indoor and outdoor APs (AP152X). The WPlus License (LIC-WPLUS-SW) is merged with the base license. The WPlus License is not required for indoor mesh APs.

Mesh APs (MAPs/RAPs) are counted as full APs on Cisco 5508 Controllers.

With other controller platforms, MAPs are counted as half APs.

Data Plane Transport Layer Security (DTLS) is not supported on mesh access points.

Adding Mesh Access Points to the Mesh Network

This section assumes that the controller is already active in the network and is operating in Layer 3 mode.

Note Controller ports that the mesh access points connect to should be untagged.

Before adding a mesh access point to a network, do the following:

1. Add the MAC address of the mesh access point to the controller's MAC filter. See the "Adding MAC Addresses of Mesh Access Points to MAC Filter" section on page 9-24.
2. Define the role (RAP or MAP) for the mesh access point. See the "Defining Mesh Access Point Role" section on page 9-26.
3. Verify that Layer 3 is configured on the controller. See the "Verifying Layer 3 Configuration" section on page 9-27.
4. Configure a primary, secondary, and tertiary controller for each mesh access point. See the "Configuring Multiple Controllers Using DHCP 43 and DHCP 60" section on page 9-27.
   a. Configure a backup controller. See the "Configuring Backup Controllers" procedure on page 9-28.
5. Configure external authentication of MAC addresses using an external RADIUS server. See the "Configuring External Authentication and Authorization Using a RADIUS Server" section on page 9-33.
6. Configure global mesh parameters. See the "Configuring Global Mesh Parameters" section on page 9-35.
7. Configure universal client access. See the "Configuring Advanced Features" section on page 9-72.
8. Configure local mesh parameters. See the "Configuring Local Mesh Parameters" section on page 9-47.
9. Configure antenna parameters. See the "Configuring Antenna Gain" section on page 9-63.
10. Configure channels for serial backhaul. This step is applicable only to serial backhaul access points. See the "Backhaul Channel Deselection on Serial Backhaul Access Point" section on page 9-64.

11. Configure the DCA channels for the mesh access points. See the "Configuring Dynamic Channel Assignment" section on page 9-69 for details.
12. Configure mobility groups (if desired) and assign controllers. See Chapter 12, "Configuring Mobility Groups" in the *Cisco Wireless LAN Controller Configuration Guide, Release 5.2* at:

    http://www.cisco.com/en/US/products/ps6366/products_installation_and_configuration_guides_list.html
13. Configure Ethernet bridging (if desired). See the "Configuring Ethernet Bridging" section on page 9-52.
14. Configure advanced features such as Ethernet VLAN tagging network, video, and voice. See the "Configuring Advanced Features" section on page 9-72.

Adding MAC Addresses of Mesh Access Points to MAC Filter

You must enter the MAC address for all mesh access points that you want to use in the mesh network into the appropriate controller. A controller only responds to discovery requests from outdoor radios that appear in its authorization list. MAC filtering is enabled by default on the controller, so only the MAC addresses need to be configured. If the access point has an SSC and has been added to the AP Authorization List, then the MAC address of the AP does not need to be added to the MAC Filtering List.

You can add the mesh access point using either the GUI or the CLI.

Note You can also download the list of mesh access point MAC addresses and push them to the controller using Cisco WCS. See the *Cisco Wireless Control System Configuration Guide, Release 7.0.172.0*: http://www.cisco.com/en/US/docs/wireless/wcs/7.0MR1/configuration/guide/WCS70MR1.html

Adding the MAC Address of the Mesh Access Point to the Controller Filter List Using the GUI

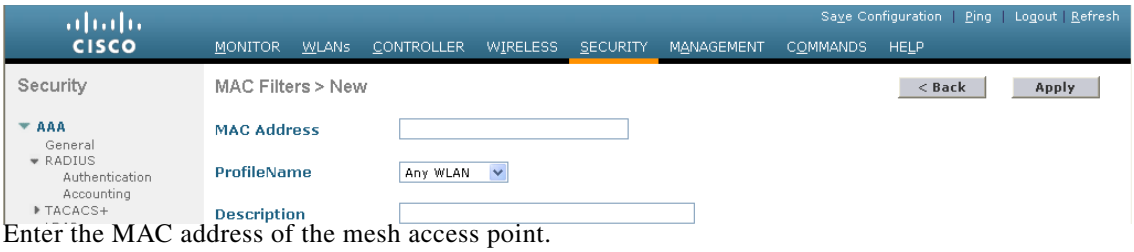
To add a MAC filter entry for the mesh access point on the controller using the controller GUI, follow these steps.

Step 1 Choose **Security** > **AAA** > **MAC Filtering**. The MAC Filtering page appears (see Figure 9-13).

Figure 9-13 MAC Filtering Page

Step 2 Click **New**. The MAC Filters > New page appears (see Figure 14).

Figure 14 MAC Filters > New Page



Step 3 Enter the MAC address of the mesh access point.

Note For 1500 series outdoor mesh access points, specify the BVI MAC address of the mesh access point into the controller as a MAC filter. For indoor mesh access points, enter the Ethernet MAC. If the required MAC address does not appear on the exterior of the mesh access point, enter the following command at the access point console to display the BVI and Ethernet MAC addresses: *sh int | i Hardware*.

Step 4 From the Profile Name drop-down list, select **Any WLAN**.

Step 5 In the Description field, specify a description of the mesh access point. The text that you enter identifies the mesh access point on the controller.

Note You might want to include an abbreviation of its name and the last few digits of the MAC address, such as ap1522:62:39:10. You can also note details on its location such as r*oof top*, *pole top*, or its cross streets.

Step 6 From the Interface Name drop-down list, choose the controller interface to which the mesh access point is to connect.

Step 7 Click **Apply** to commit your changes. The mesh access point now appears in the list of MAC filters on the MAC Filtering page.

Step 8 Click **Save Configuration** to save your changes.

Step 9 Repeat this procedure to add the MAC addresses of additional mesh access points to the list.

Adding the MAC Address of the Mesh Access Point to the Controller Filter List Using the CLI

To add a MAC filter entry for the mesh access point on the controller using the controller CLI, follow these steps:

Step 1 To add the MAC address of the mesh access point to the controller filter list, enter this command:

config macfilter add *ap_mac wlan_id interface* [*description*]

A value of zero (0) for the *wlan_id* parameter specifies any WLAN, and a value of zero (0) for the *interface* parameter specifies none. You can enter up to 32 characters for the optional *description* parameter.

Step 2 To save your changes, enter this command:

save config

Defining Mesh Access Point Role

By default, AP1500s are shipped with a radio role set to MAP. You must reconfigure a mesh access point to act as a RAP.

General Notes about MAP and RAP Association With The Controller

The general notes are as follows:

- A MAP always sets the Ethernet port as the *primary backhaul* if it is UP, and secondarily the 802.11a/n radio. This gives the network administrator time to reconfigure the mesh access point as a RAP, initially. For faster convergence on the network, we recommend that you do not connect any Ethernet device to the MAP until it has joined the mesh network.
- A MAP that fails to connect to a controller on a UP Ethernet port, sets the 802.11a/n radio as the primary backhaul. If a MAP fails to find a neighbor or fails to connect to a controller through a neighbor, the Ethernet port is set as the primary backhaul again.
- A MAP connected to a controller over an Ethernet port does not build a mesh topology (unlike a RAP).
- A RAP always sets the Ethernet port as the primary backhaul.
- If the Ethernet port is DOWN on a RAP, or a RAP fails to connect to a controller on a UP Ethernet port, the 802.11a/n radio is set as the primary backhaul for 15 minutes. Failing to find a neighbor or failing to connect to a controller via any neighbor on the 802.11a/n radio causes the primary backhaul to go into the *scan* state. The primary backhaul begins its scan with the Ethernet port.

Configuring the AP Role Using the GUI

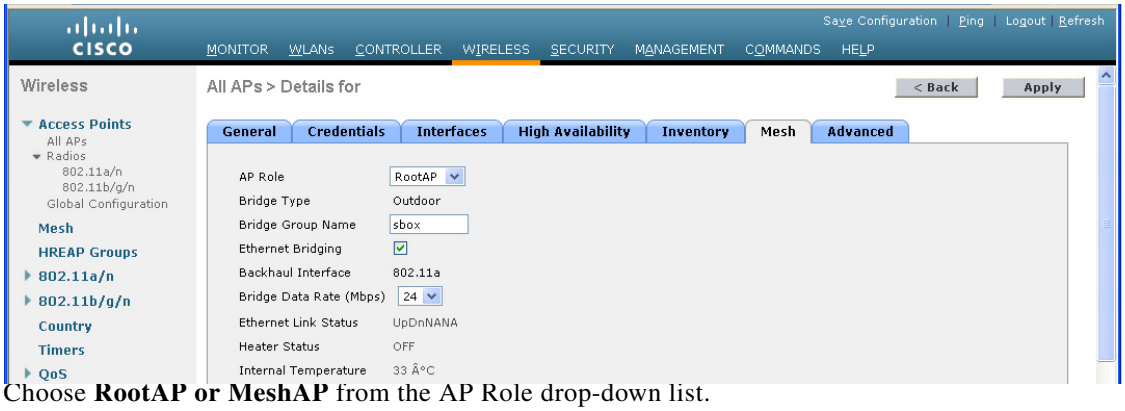
To configure the role of a mesh access point using the GUI, follow these steps:

Step 1 Click **Wireless** to open the All APs page.

Step 2 Click the name of an access point. The All APs > Details (General) page appears.

Step 3 Click the **Mesh** tab (see Figure 9-15).

Figure 9-15 All APs > Details for (Mesh) Page



Step 4 Choose **RootAP or MeshAP** from the AP Role drop-down list.

Step 5 Click **Apply** to commit your changes and to cause the access point to reboot.

Configuring the AP Role Using the CLI

To configure the role of a mesh access point using the CLI, enter the following command:

config ap role {**rootAP** | **meshAP**} *Cisco_AP*

Verifying Layer 3 Configuration

Verify that the initial controller that the mesh access point is to associate with is at Layer 3.

To verify that the controller is configured for Layer 3, follow these steps:

Step 1 Open your web browser and enter the IP address of your controller. Be sure to precede the IP address with *https://*. A login page appears.

Step 2 Specify your username and password.

The default case-sensitive username and password are *admin* and *admin*. The summary page appears.

Step 3 From the top menu bar, click **Controller**. The controller general page appears.

Step 4 Verify that the CAPWAP Transport Modes is set to Layer 3. If it is not, change it to Layer 3 and click **Apply**.

Step 5 Save the changes, if any.

Step 6 From the menu bar, click **Monitor** to return to the Monitor summary page.

Step 7 See the "Configuring Multiple Controllers Using DHCP 43 and DHCP 60" section on page 9-27 to assign a primary, secondary, and tertiary controller.

Configuring Multiple Controllers Using DHCP 43 and DHCP 60

To configure DHCP Option 43 and 60 for mesh access points in the embedded Cisco IOS DHCP server, follow these steps:

Step 1 Enter configuration mode at the Cisco IOS CLI.

Step 2 Create the DHCP pool, including the necessary parameters such as the default router and name server. The commands used to create a DHCP pool are as follows:

```
ip dhcp pool pool name
network IP Network Netmask
default-router Default router
dns-server DNS Server
```

where:

```
pool name is the name of the DHCP pool, such as AP1520
IP Network is the network IP address where the controller resides, such as 10.0.15.1
Netmask is the subnet mask, such as 255.255.255.0
Default router is the IP address of the default router, such as 10.0.0.1
DNS Server is the IP address of the DNS server, such as 10.0.10.2
```

Step 3 Add the option 60 line using the following syntax:

```
option 60 ascii "VCI string"
```

For the VCI string, use one of the values below. The quotation marks must be included.

```
For Cisco 1550 series access points, enter "Cisco AP c1550"
For Cisco 1520 series access points, enter "Cisco AP c1520"
For Cisco 1240 series access points, enter "Cisco AP c1240"
For Cisco 1130 series access points, enter "Cisco AP c1130"
```

Step 4 Add the option 43 line using the following syntax:

option 43 hex hex string

The hex string is assembled by concatenating the TLV values shown below:

Type + *Length* + *Value*

Type is always f1(hex). *Length* is the number of controller management IP addresses times 4 in hex. *Value* is the IP address of the controller listed sequentially in hex.

For example, suppose that there are two controllers with management interface IP addresses 10.126.126.2 and 10.127.127.2. The type is *f1(hex)*. The length is *2 * 4 = 8 = 08 (hex)*. The IP addresses translate to *0a7e7e02* and *0a7f7f02*. Assembling the string then yields *f1080a7e7e020a7f7f02*.

The resulting Cisco IOS command added to the DHCP scope is listed below:

option 43 hex f1080a7e7e020a7f7f02

Configuring Backup Controllers

A single controller at a centralized location can act as a backup for mesh access points when they lose connectivity with the primary controller in the local region. Centralized and regional controllers need not be in the same mobility group. Using the controller GUI or CLI, you can specify the IP addresses of the backup controllers, which allows the mesh access points to fail over to controllers outside of the mobility group.

You can also configure primary and secondary backup controllers (which are used if primary, secondary, or tertiary controllers are not specified or are not responsive) for all access points connected to the controller as well as various timers, including the heartbeat timer and discovery request timers.

Note The fast heartbeat timer is not supported on mesh access points. The fast heartbeat timer is only configured on access points in local and hybrid-REAP modes.

The mesh access point maintains a list of backup controllers and periodically sends primary discovery requests to each entry on the list. When the mesh access point receives a new discovery response from a controller, the backup controller list is updated. Any controller that fails to respond to two consecutive primary discovery requests is removed from the list. If the mesh access point's local controller fails, it chooses an available controller from the backup controller list in this order: primary, secondary, tertiary, primary backup, and secondary backup. The mesh access point waits for a discovery response from the first available controller in the backup list and joins the controller if it receives a response within the time configured for the primary discovery request timer. If the time limit is reached, the mesh access point assumes that the controller cannot be joined and waits for a discovery response from the next available controller in the list.

Note When a mesh access point's primary controller comes back online, the mesh access point disassociates from the backup controller and reconnects to its primary controller. The mesh access point falls back to its primary controller and not to any secondary controller for which it is configured. For example, if a mesh access point is configured with primary, secondary, and tertiary controllers, it fails over to the tertiary controller when the primary and secondary controllers become unresponsive and waits for the primary controller to come back online so that it can fall back to the primary controller. The mesh access point does not fall back from the tertiary controller to the secondary controller if the secondary controller comes back online; it stays connected to the tertiary controller until the primary controller comes back up.

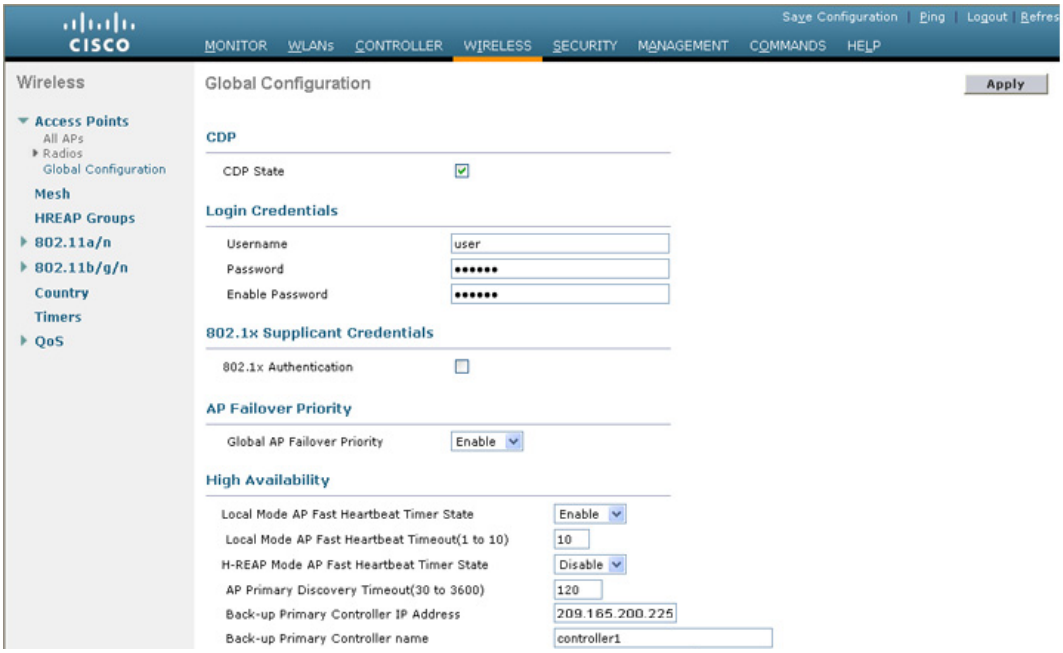
Note If you inadvertently configure a controller that is running software release 6.0 with a failover controller that is running a different software release (such as 4.2, 5.0, 5.1, or 5.2), the mesh access point might take a long time to join the failover controller because the mesh access point starts the discovery process in LWAPP and then changes to CAPWAP discovery.

Configuring Backup Controllers Using the GUI

Using the controller GUI, follow these steps to configure primary, secondary, and tertiary controllers for a specific mesh access point and to configure primary and secondary backup controllers for all mesh access points:

Step 1 Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page. (See Figure 9-16.)

Figure 9-16 Global Configuration Page



Note The fast heartbeat timer is not supported on mesh access points.

Step 2 In the AP Primary Discovery Timeout field, enter a value between 30 and 3600 seconds (inclusive) to configure the access point primary discovery request timer. The default value is 120 seconds.

Step 3 If you want to specify a primary backup controller for all access points, specify the IP address of the primary backup controller in the Back-up Primary Controller IP Address field and the name of the controller in the Back-up Primary Controller Name field.

Note The default value for the IP address is 0.0.0.0, which disables the primary backup controller.

Step 4 If you want to specify a secondary backup controller for all access points, specify the IP address of the secondary backup controller in the Back-up Secondary Controller IP Address field and the name of the controller in the Back-up Secondary Controller Name field.

Note The default value for the IP address is 0.0.0.0, which disables the secondary backup controller.

Step 5 Click **Apply** to commit your changes.

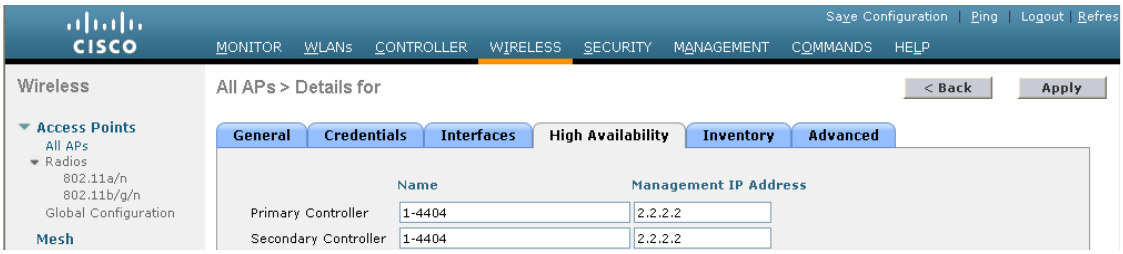
Step 6 If you want to configure primary, secondary, and tertiary backup controllers for a specific point, follow these steps:

a. Choose **Access Points > All APs** to open the All APs page.

b. Click the name of the access point for which you want to configure primary, secondary, and tertiary backup controllers.

c. Click the **High Availability** tab. (See Figure 9-17.)

Figure 9-17 All APs > Details for (High Availability) Page



d. If desired, specify the name and IP address of the primary backup controller for this access point in the Primary Controller fields.

Note Specifying an IP address for the backup controller is optional in this step and the next two steps. If the backup controller is outside the mobility group to which the mesh access point is connected (the primary controller), then you need to provide the IP address of the primary, secondary, or tertiary controller, respectively. The controller name and IP address must belong to the same primary, secondary, or tertiary controller. Otherwise, the mesh access point cannot join the backup controller.

e. If desired, specify the name and IP address of the secondary backup controller for this mesh access point in the Secondary Controller fields.

f. If desired, specify the name and IP address of the tertiary backup controller for this mesh access point in the Tertiary Controller fields.

g. No change is required to the AP Failover Priority value. The default value for mesh access points is *critical* and it cannot be modified.

h. Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Configuring Backup Controllers Using the CLI

Using the controller CLI, follow these steps to configure primary, secondary, and tertiary controllers for a specific mesh access point and to configure primary and secondary backup controllers for all mesh access points.

Step 1 To configure a primary controller for a specific mesh access point, enter this command:

config ap primary-base *controller_name Cisco_AP* [*controller_ip_address*]

Note The *controller_ip_address* parameter in this command and the next two commands is optional. If the backup controller is outside the mobility group to which the mesh access point is connected (the primary controller), then you need to provide the IP address of the primary, secondary, or tertiary controller, respectively. In each command, the *controller_name* and *controller_ip_address* must belong to the same primary, secondary, or tertiary controller. Otherwise, the mesh access point cannot join the backup controller.

Step 2 To configure a secondary controller for a specific mesh access point, enter this command:

config ap secondary-base *controller_name Cisco_AP* [*controller_ip_address*]

Step 3 To configure a tertiary controller for a specific mesh access point, enter this command:

config ap tertiary-base *controller_name Cisco_AP* [*controller_ip_address*]

Step 4 To configure a primary backup controller for all mesh access points, enter this command:

config advanced backup-controller primary *backup_controller_name backup_controller_ip_address*

Step 5 To configure a secondary backup controller for all mesh access points, enter this command:

config advanced backup-controller secondary *backup_controller_name backup_controller_ip_address*

Note To delete a primary or secondary backup controller entry, enter **0.0.0.0** for the controller IP address.

Step 6 To configure the mesh access point primary discovery request timer, enter this command:

config advanced timers ap-primary-discovery-timeout *interval*

where *interval* is a value between 30 and 3600 seconds. The default value is 120 seconds.

Step 7 To configure the mesh access point discovery timer, enter this command:

config advanced timers ap-discovery-timeout *interval*

where *interval* is a value between 1 and 10 seconds (inclusive). The default value is 10 seconds.

Step 8 To configure the 802.11 authentication response timer, enter this command:

config advanced timers auth-timeout *interval*

where *interval* is a value between 10 and 600 seconds (inclusive). The default value is 10 seconds.

Step 9 To save your changes, enter this command:

save config

Step 10 To view a mesh access point's configuration, enter these commands:

- **show ap config general** *Cisco_AP*
- **show advanced backup-controller**
- **show advanced timers**
- **show mesh config**

Information similar to the following appears for the **show ap config general** *Cisco_AP* command:

```
Cisco AP Identifier.............................. 1
Cisco AP Name.................................... AP5
Country code..................................... US  - United States
Regulatory Domain allowed by Country............. 802.11bg:-AB    802.11a:-AB
AP Country code.................................. US  - United States
AP Regulatory Domain............................. 802.11bg:-A    802.11a:-N
Switch Port Number .............................. 1
MAC Address...................................... 00:13:80:60:48:3e
IP Address Configuration......................... DHCP
IP Address....................................... 1.100.163.133
...
Primary Cisco Switch Name........................ 1-4404
Primary Cisco Switch IP Address.................. 2.2.2.2
Secondary Cisco Switch Name...................... 1-4404
Secondary Cisco Switch IP Address................ 2.2.2.2
Tertiary Cisco Switch Name....................... 2-4404
Tertiary Cisco Switch IP Address................. 1.1.1.4
```

Information similar to the following appears for the **show advanced backup-controller** command:

```
AP primary Backup Controller .................... controller1 10.10.10.10
AP secondary Backup Controller ............... 0.0.0.0
```

Information similar to the following appears for the **show advanced timers** command:

```
Authentication Response Timeout (seconds)........ 10
Rogue Entry Timeout (seconds).................... 1300
AP Heart Beat Timeout (seconds).................. 30
AP Discovery Timeout (seconds)................... 10
AP Primary Discovery Timeout (seconds)........... 120
```

Information similar to the following appears for the **show mesh config** command:

```
Mesh Range....................................... 12000
Backhaul with client access status............... disabled
Background Scanning State........................ enabled
Mesh Security
Security Mode.............................. EAP
External-Auth.............................. disabled
Use MAC Filter in External AAA server......... disabled
Force External Authentication................. disabled
Mesh Alarm Criteria
Max Hop Count.............................. 4
Recommended Max Children for MAP.............. 10
```

```
Recommended Max Children for RAP.............. 20
Low Link SNR.................................. 12
High Link SNR................................. 60
Max Association Number........................ 10
Association Interval.......................... 60 minutes
Parent Change Numbers......................... 3
Parent Change Interval........................ 60 minutes
Mesh Multicast Mode........................... In-Out
Mesh Full Sector DFS.......................... enabled
Mesh Ethernet Bridging VLAN Transparent Mode..... enabled
```

Configuring External Authentication and Authorization Using a RADIUS Server

External authorization and authentication of mesh access points using a RADIUS server such as Cisco ACS (4.1 and later) is supported in release 5.2 and later releases. The RADIUS server must support the client authentication type of EAP-FAST with certificates.

Before you employ external authentication within the mesh network, ensure that you make these changes:

- The RADIUS server to be used as an AAA server must be configured on the controller.
- The controller must also be configured on the RADIUS server.
- Add the mesh access point configured for external authorization and authentication to the user list of the RADIUS server.
  - For additional details, see the "Adding a Username to a RADIUS Server" section on page 9-34.
- Configure EAP-FAST on the RADIUS server and install the certificates. EAP-FAST authentication is required if mesh access points are connected to the controller using an 802.11a interface; the external RADIUS servers need to trust Cisco Root CA 2048. For information about installing and trusting the CA certificates, see the "Configuring RADIUS Servers" section on page 9-33.

Note If mesh access points connect to a controller using a Fast Ethernet or Gigabit Ethernet interface, only MAC authorization is required.

Note This feature also supports local EAP and PSK authentication on the controller.

Configuring RADIUS Servers

To install and trust the CA certificates on the RADIUS server, follow these steps:

Step 1 Download the CA certificates for Cisco Root CA 2048 from the following locations:

- http://www.cisco.com/security/pki/certs/crca2048.cer
- http://www.cisco.com/security/pki/certs/cmca.cer

Step 2 Install the certificates as follows:

a. From the CiscoSecure ACS main menu, click **System Configuration > ACS Certificate Setup > ACS Certification Authority Setup**.

b. In the **CA certificate file** box, type the CA certificate location (path and name). For example: *C:\Certs\crca2048.cer.*

c. Click **Submit**.

Step 3 Configure the external RADIUS servers to trust the CA certificate as follows:

a. From the CiscoSecure ACS main menu, choose **System Configuration > ACS Certificate Setup > Edit Certificate Trust List**. The Edit Certificate Trust List appears.

b. Select the check box next to the **Cisco Root CA 2048 (Cisco Systems)** certificate name.

c. Click **Submit**.

d. To restart ACS, choose **System Configuration > Service Control**, and then click **Restart**.

Note For additional configuration details on Cisco ACS servers, see the following:

- http://www.cisco.com/en/US/products/sw/secursw/ps2086/products_installation_and_configuration_guides_list.html (Windows)
- http://www.cisco.com/en/US/products/sw/secursw/ps4911/ (UNIX)

Adding a Username to a RADIUS Server

Add MAC addresses of mesh access point that are authorized and authenticated by external RADIUS servers to the user list of that server *prior* to enabling RADIUS authentication for a mesh access point.

For remote authorization and authentication, EAP-FAST uses the manufacturer's certificate (CERT) to authenticate the child mesh access point. Additionally, this manufacturer certificate-based identity serves as the username for the mesh access point in user validation.

For Cisco IOS-based mesh access points, in addition to adding the MAC address to the user list, you need to enter the *platform_name_string–Ethernet_MAC_address* string to the user list (for example, c1240-001122334455). The controller first sends the MAC address as the username; if this first attempt fails, then the controller sends the *platform_name_string–Ethernet_MAC_address* string as the username.

Note If you enter only the *platform_name_string–Ethernet_MAC_address* string to the user list, you will see a first-try failure log on the AAA server; however, the Cisco IOS-based mesh access point will still be authenticated on the second attempt using the *platform_name_string–Ethernet_MAC_address* string as the username.

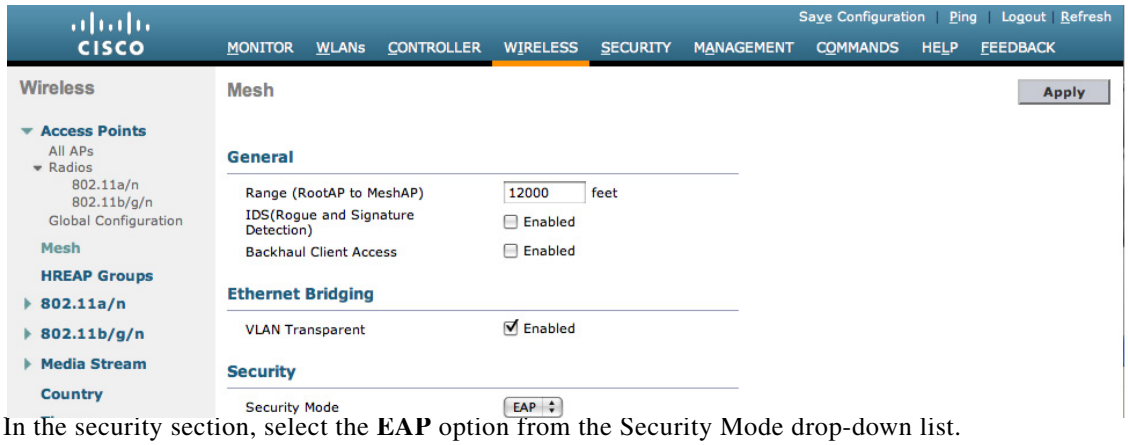
Note The password must match the username (for example, *c1520-001122334455).*

Enabling External Authentication of Mesh Access Points Using the GUI

To enable external authentication for a mesh access point using the GUI, follow these steps:

Step 1 Choose **Wireless > Mesh**. The Mesh page appears (see Figure 9-18).

Figure 9-18 Mesh Page



Step 2 In the security section, select the **EAP** option from the Security Mode drop-down list.

Step 3 Select the **Enabled** check boxes for the External MAC Filter Authorization and Force External Authentication options.

Step 4 Click **Apply**.

Step 5 Click **Save Configuration**.

Enable External Authentication of Mesh Access Points Using the CLI

To enable external authentication for mesh access points using the CLI, enter the following commands:

1. **config mesh security eap**
2. **config macfilter mac-delimiter colon**
3. **config mesh security rad-mac-filter enable**
4. **config mesh radius-server *index* enable**
5. **config mesh security force-ext-auth enable** (Optional)

View Security Statistics Using the CLI

To view security statistics for mesh access points using the CLI, enter the following command:

show mesh security-stats *Cisco_AP*

Use this command to display packet error statistics and a count of failures, timeouts, and association and authentication successes as well as reassociations and reauthentications for the specified access point and its child.

Configuring Global Mesh Parameters

This section provides instructions to configure the mesh access point to establish a connection with the controller including:

- Setting the maximum range between RAP and MAP (not applicable to indoor MAPs).
- Enabling a backhaul to carry client traffic.
- Defining if VLAN tags are forwarded or not.
- Defining the authentication mode (EAP or PSK) and method (local or external) for mesh access points including security settings (local and external authentication).

You can configure the necessary mesh parameters using either the GUI or the CLI. All parameters are applied globally.

Configuring Global Mesh Parameters Using the GUI

To configure global mesh parameters using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Mesh** (see Figure 9-19).

Figure 9-19 Mesh Page

Step 2 Modify the mesh parameters as appropriate. Table 9-6 describes each parameter.

Table 9-6 Global Mesh Parameters

Parameter	Description
Range (RootAP to MeshAP)	The optimum distance (in feet) that should exist between the root access point (RAP) and the mesh access point (MAP). This global parameter applies to all mesh access points when they join the controller and all existing mesh access points in the network. **Range:** 150 to 132,000 feet **Default:** 12,000 feet **Note** After this feature is enabled, all mesh access points reboot.
IDS (Rogue and Signature Detection)	When you enable this feature, IDS reports are generated for all traffic on the client access only and not on the backhaul. When you disable this feature, no IDS reports are generated, which preserves bandwidth on the backhaul. You have to use the following command to enable or disable it on the mesh APs: `config mesh ids-state {enable | disable}` **Note** 2.4GHz IDS is activated with the global IDS settings on the controller.
Backhaul Client Access	**Note** This parameter applies to mesh access points with two or more radios (1552, 1524SB, 1522, 1240, 1130, and 11n indoor mesh APs) *excluding* the 1524PS. When Universal Client Access is enabled, it allows wireless client association over the backhaul radio. Generally, backhaul radio is a 5-GHz radio for most of the mesh access points except for 1522 where backhaul can be 2.4 GHz. This means that a backhaul radio can carry both backhaul traffic and client traffic. When Universal Client Access is disabled, only backhaul traffic is sent over the backhaul radio and client association is only over the second radio(s). **Default:** Disabled **Note** After this feature is enabled, all mesh access points reboot.

Table 9-6 Global Mesh Parameters (continued)

Parameter	Description
VLAN Transparent	This feature determines how a mesh access point handles VLAN tags for Ethernet bridged traffic. **Note** Refer to the "Configuring Advanced Features" section on page 9-72 for overview and additional configuration details. If VLAN Transparent is enabled, then VLAN tags are not handled and packets are bridged as untagged packets. **Note** No configuration of Ethernet ports is required when VLAN transparent is enabled. The Ethernet port passes both tagged and untagged frames without interpreting the frames. If VLAN Transparent is disabled, then all packets are handled according to the VLAN configuration on the port (trunk, access, or normal mode). **Note** If the Ethernet port is set to Trunk mode, then Ethernet VLAN tagging must be configured. Refer to "Enabling Ethernet Bridging Using the GUI" section on page 9-53. **Note** For an overview of normal, access, and trunk Ethernet port use, refer to the "Ethernet Port Notes" section on page 9-75. **Note** To use VLAN tagging, you must uncheck the VLAN Transparent check box. **Note** VLAN Transparent is enabled as a default to ensure a smooth software upgrade from 4.1.192.xxM releases to release 5.2. Release 4.1.192.xxM does not support VLAN tagging (see Figure 9-19). **Default:** Enabled.
Security Mode	Defines the security mode for mesh access points: Pre-Shared Key (PSK) or Extensible Authentication Protocol (EAP). **Note** EAP must be selected if external MAC filter authorization using a RADIUS server is configured. **Note** Local EAP or PSK authentication is performed within the controller if the External MAC Filter Authorization parameter is disabled (check box unchecked). **Options:** PSK or EAP **Default:** EAP

Table 9-6 Global Mesh Parameters (continued)

Parameter	Description
External MAC Filter Authorization	MAC filtering uses the local MAC filter on the controller by default. When external MAC filter authorization is enabled, if the MAC address is not found in the local MAC filter, then the MAC address in the external RADIUS server is used. This protects your network against rogue mesh access points by preventing mesh access points that are not defined on the external server from joining. Before employing external authentication within the mesh network, the following configuration is required: • The RADIUS server to be used as an AAA server must be configured on the controller. • The controller must also be configured on the RADIUS server. • The mesh access point configured for external authorization and authentication must be added to the user list of the RADIUS server. – For remote authorization and authentication, EAP-FAST uses the manufacturer's certificate (CERT) to authenticate the child mesh access point. Additionally, this manufacturer certificate-based identity serves as the username for the mesh access point in user validation. – For IOS-based mesh access points (1130, 1240, 1522, 1524), the platform name of the mesh access point is located in front of its Ethernet address within the certificate; therefore, their username for external RADIUS servers is *platform_name_string–Ethernet MAC address* such as *c1520-001122334455*. • The certificates must be installed and EAP-FAST must be configured on the RADIUS server. **Note** When this capability is not enabled, by default, the controller authorizes and authenticates mesh access points using the MAC address filter. **Default:** Disabled.
Force External Authorization	When enabled along with *EAP* and *External MAC Filter Authorization* parameters, external authorization and authentication of mesh access points is done by default by an external RADIUS server (such as Cisco 4.1 and later). The RADIUS server overrides local authentication of the MAC address by the controller which is the default. **Default:** Disabled.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Configuring Global Mesh Parameters Using the CLI

To configure global mesh parameters including authentication methods using the controller CLI, follow these steps.

Note See the "Configuring Global Mesh Parameters Using the GUI" section on page 9-36 for descriptions, valid ranges, and default values of the parameters used in the CLI commands.

Step 1 To specify the maximum range (in feet) of all mesh access points in the network, enter this command:

config mesh range *feet*

To see the current range, enter the **show mesh range** command.

Step 2 To enable or disable IDS reports for all traffic on the backhaul, enter this command:

config mesh ids-state {**enable** | **disable**}

Step 3 To specify the rate (in Mbps) at which data is shared between access points on the backhaul interface, enter this command:

config ap bhrate {*rate* | **auto**} *Cisco_AP*

Step 4 To enable or disable client association on the primary backhaul (802.11a) of a mesh access point, enter these commands:

config mesh client-access {**enable** | **disable**}

config ap wlan {**enable** | **disable**} **802.11a** *Cisco_AP*

config ap wlan {add | delete} 802.11a *wlan_id Cisco_AP*

Step 5 To enable or disable VLAN transparent, enter this command:

config mesh ethernet-bridging VLAN-transparent {**enable** | **disable**}

Step 6 To define a security mode for the mesh access point, enter one of the following commands:

a. To provide local authentication of the mesh access point by the controller, enter this command:

config mesh security {eap | psk}

b. To store the MAC address filter in an external RADIUS server for authentication instead of the controller (local), enter these commands:

config macfilter mac-delimiter colon

config mesh security rad-mac-filter enable

config mesh radius-server *index* enable

c. To provide external authentication on a RADIUS server and define a local MAC filter on the controller, enter these commands:

config mesh security eap

config macfilter mac-delimiter colon

config mesh security rad-mac-filter enable

config mesh radius-server *index* enable

config mesh security force-ext-auth enable

d. To provide external authentication on a RADIUS server using a MAC username (such as *c1520-123456*) on the RADIUS server, enter these commands:

config macfilter mac-delimiter colon

config mesh security rad-mac-filter enable

config mesh radius-server *index* enable

config mesh security force-ext-auth enable

Step 7 To save your changes, enter this command:

save config

Viewing Global Mesh Parameter Settings Using the CLI

Use these commands to obtain information on global mesh settings:

- **show mesh client-access**—When Universal Client Access is enabled, it allows wireless client association over the backhaul radio. Generally, backhaul radio is a 5-GHz radio for most of the mesh access points except for 1522 where backhaul can be 2.4 GHz. This means that a backhaul radio can carry both backhaul traffic and client traffic.

  When Universal Client Access is disabled, only backhaul traffic is sent over the backhaul radio and client association is only over the second radio(s).

```
controller >show mesh client-access
Backhaul with client access status: enabled
```

- **show mesh ids-state**—Shows the status of the IDS reports on the backhaul as either enabled or disabled.

```
controller >show mesh ids-state
Outdoor Mesh IDS(Rogue/Signature Detect): .... Disabled
```

- **show mesh config**—Displays global configuration settings.

```
(Cisco Controller) > show mesh config
Mesh Range..................................... 12000
Mesh Statistics update period.................. 3 minutes
Backhaul with client access status............. disabled
Background Scanning State...................... enabled
Backhaul Amsdu State........................... disabled

Mesh Security
    Security Mode.............................. EAP
    External-Auth.............................. disabled
    Use MAC Filter in External AAA server..... disabled
    Force External Authentication.............. disabled

Mesh Alarm Criteria
    Max Hop Count.............................. 4
    Recommended Max Children for MAP........... 10
    Recommended Max Children for RAP........... 20
    Low Link SNR............................... 12
    High Link SNR.............................. 60
    Max Association Number..................... 10
    Association Interval....................... 60 minutes
```

```
    Parent Change Numbers..................... 3
    Parent Change Interval.................... 60 minutes

Mesh Multicast Mode.......................... In-Out
Mesh Full Sector DFS......................... enabled

Mesh Ethernet Bridging VLAN Transparent Mode..... enabled
```

Universal Client Access

When Universal Client Access is enabled, it allows wireless client association over the backhaul radio. Generally, backhaul radio is a 5-GHz radio for most of the mesh access points except for 1522 where backhaul can be 2.4 GHz. This means that a backhaul radio can carry both backhaul traffic and client traffic.

When Universal Client Access is disabled, only backhaul traffic is sent over the backhaul radio and client association is only over the second radio(s).

Note Universal Client Access is disabled by default.

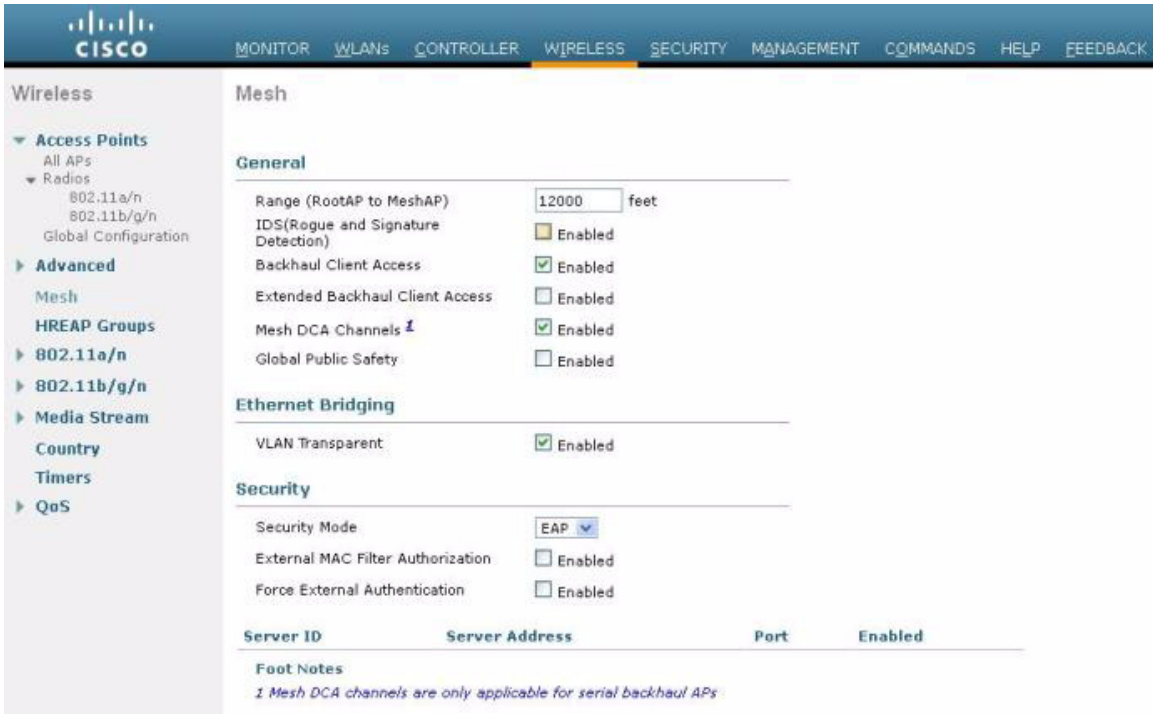
After this feature is enabled, all mesh access points reboot.

This feature is applicable to mesh access points with two or more radios (1552, 1524SB, 1522, Indoor APs in mesh mode) excluding the 1524PS.

Configuring Universal Client Access using the GUI

Figure 9-20 shows how to enable Universal Client Access using the GUI. You will be prompted that the AP will reboot if you enable Universal Client Access.

Figure 9-20 Configuring Universal Client Access using the GUI



Configuring Universal Client Access using the CLI

Use the following command to enable Universal Client Access:

```
(Cisco Controller)> config mesh client-access enable
```

The following message is displayed:

```
All Mesh APs will be rebooted
Are you sure you want to start? (y/N)
```

Universal Client Access on Serial Backhaul Access Points

With universal client access, you can have client access on the backhaul 802.11a radios in addition to the backhaul functionality. This feature is applicable to mesh access points with two or more radios (1552, 1524SB, 1522, Indoor APs in mesh mode) excluding the 1524PS.

The dual 5-GHz Universal Client Access feature is intended for the serial backhaul access point platform, which has three radio slots. The radio in slot 0 operates in the 2.4-GHz band and is used for client access. The radios in slot 1 and slot 2 operate in the 5-GHz band and are primarily used for backhaul. However, with the Universal Client Access feature, clients were allowed to associate over the slot 1 radio. But slot 2 radio was used only for backhaul. With the 7.0 release, client access over the slot 2 radio is allowed with this Dual 5-GHz Universal Access feature.

By default, client access is disabled over both the backhaul radios. Follow the guidelines to enable or disable client access on the radio slots that constitute 5-GHz radios, irrespective of the radios being used as downlinks or uplinks:

- You can enable client access on slot 1 even if client access on slot 2 is disabled.
- You can enable client access on slot 2 only when client access on slot 1 is enabled.

- If you disable client access on slot 1, client access on slot 2 is automatically disabled on the CLI.
- To disable only the extended client access (on the slot 2 radio), use the GUI.
- All the mesh access points reboot whenever client access is enabled or disabled.

The two 802.11a backhaul radios use the same MAC address. There may be instances where a WLAN maps to the same BSSID on more than one slot. Client access on the slot 2 radio is referred to as Extended Universal Access (EUA) in this document.

You can configure Extended Universal Access using one of the following methods:

- "Configuring Extended Universal Access Using the GUI" section on page 9-44
- "Configuring Extended Universal Access Using the CLI" section on page 9-46
- "Configuring Extended Universal Access from the Wireless Control System (WCS)" section on page 9-47

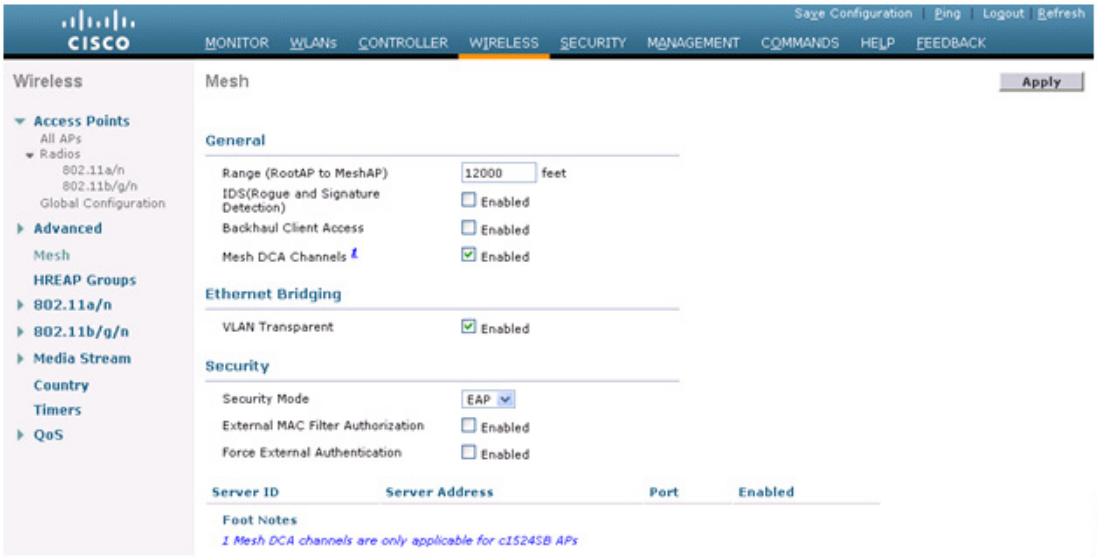
Configuring Extended Universal Access Using the GUI

To configure the Extended Universal Access, follow these steps:

Step 1 Choose **Controller > Wireless > Mesh**.

The Controller GUI when Backhaul Client Access is disabled page appears as shown in Figure 9-21.

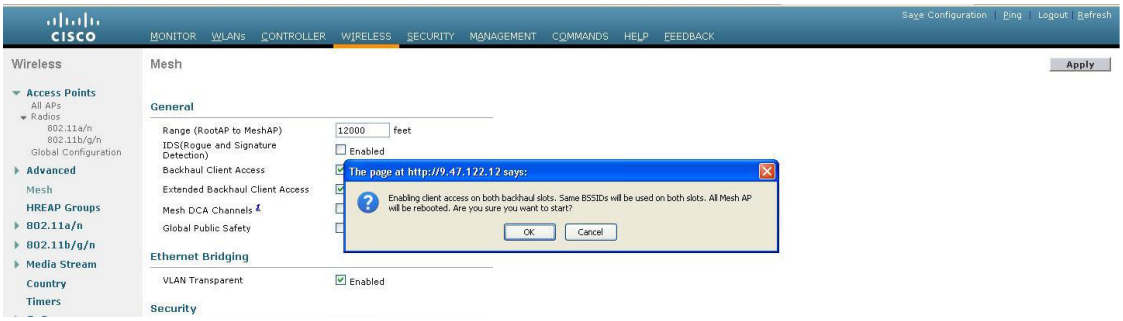
Figure 9-21 Advanced Controller Settings for Mesh Page



Step 2 Select the **Backhaul Client Access** check box to display the Extended Backhaul Client Access check box.

Step 3 Select the **Extended Backhaul Client Access** check box and click **Apply**. A message appears as shown in Figure 9-22.

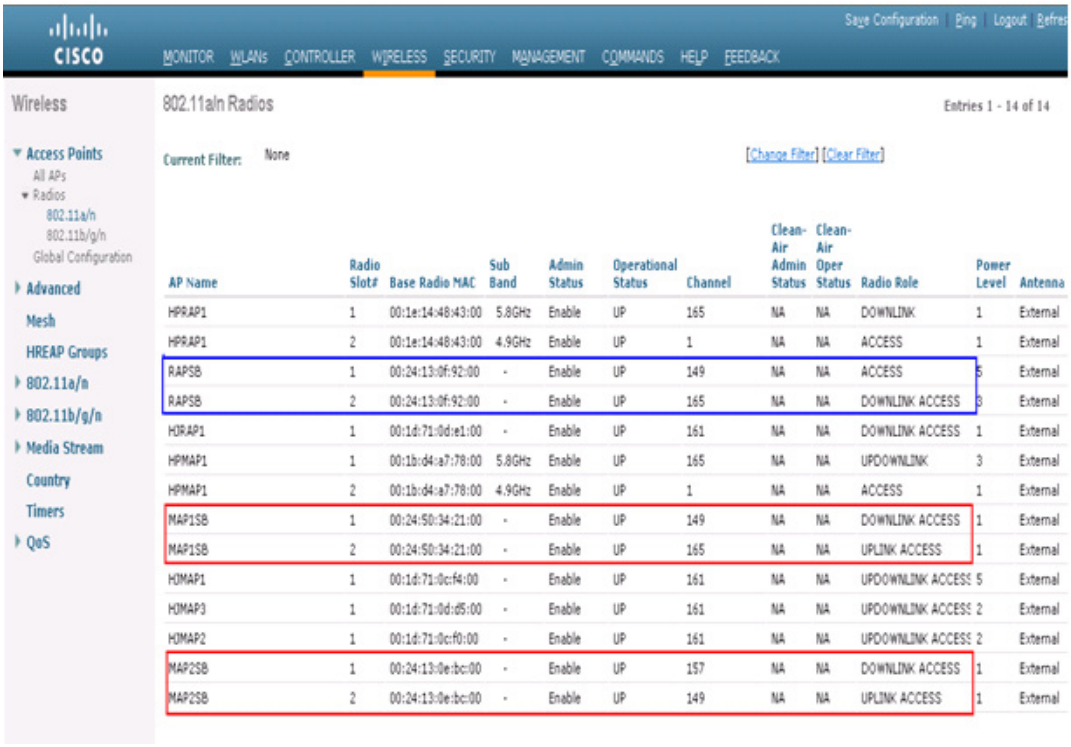
Figure 9-22 Advanced Controller Settings for Mesh Page



Step 4 Click **OK**.

After EUA is enabled, 802.11a radios are displayed as shown in Figure 9-23.

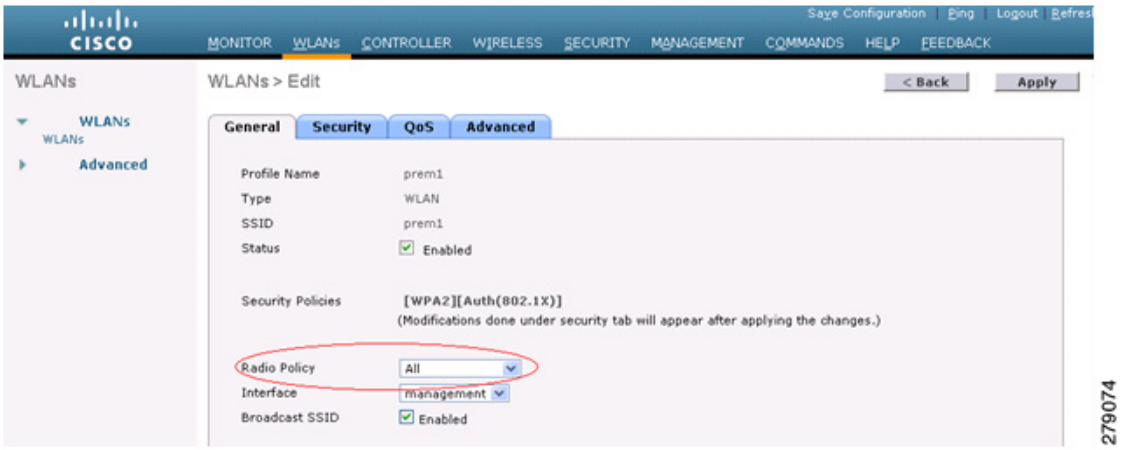
Figure 9-23 802.11a Radios after EUA is Enabled



Slot 2 in the 5-GHz radio in the RAPSB (serial backhaul) that is used to extend the backhaul in the DOWNLINK direction is displayed as DOWNLINK ACCESS, where slot 1 in the 5-GHz radio in the RAPSB that is used for client access is displayed as ACCESS. Slot 2 in the 5-GHz radio in the MAPSB that is used for the UPLINK is displayed as UPLINK ACCESS, and slot 1 in the MAPSB is used for the DOWNLINK ACCESS with an omnidirectional antenna that also provides the client access.

Create WLAN on the WLC with the appropriate SSID mapped to the correct interface (VLAN). After you create a WLAN, it is applied to all the radios by default. If you want to enable client access only on 802.11a radios, then choose only the appropriate radio policy from the list shown in Figure 9-24.

Figure 9-24 Radio Policy Selection



Configuring Extended Universal Access Using the CLI

- Go to the Controller prompt and enter the **config mesh client-access enable extended** command.

  The following message is displayed:

  ```
  Enabling client access on both backhaul slots
  Same BSSIDs will be used on both slots
  All Mesh Serial Backhaul APs will be rebooted
  Are you sure you want to start? (y/N)
  ```

- Enter the **show mesh client-access** command to know the status of the backhaul with client access and the backhaul with client access extended.

  The status is displayed as follows:

  ```
  Backhaul with client access status: enabled
  Backhaul with client access extended status(3 radio AP): enabled
  ```

- There is no explicit command to disable client access only on slot 2 (EUA). You have to disable client access on both the backhaul slots by entering the following command:

  config mesh client-access disable

  The following message is displayed:

  ```
  All Mesh APs will be rebooted
  Are you sure you want to start? (y/N)
  ```

- You can disable EUA from the GUI without disturbing client access on the slot 1 radio, but all 1524SB access points will be rebooted.

  It is possible to enable client access only on slot 1 and not on slot 2 by entering the following command:

  config mesh client-access enable

  The following message is displayed:

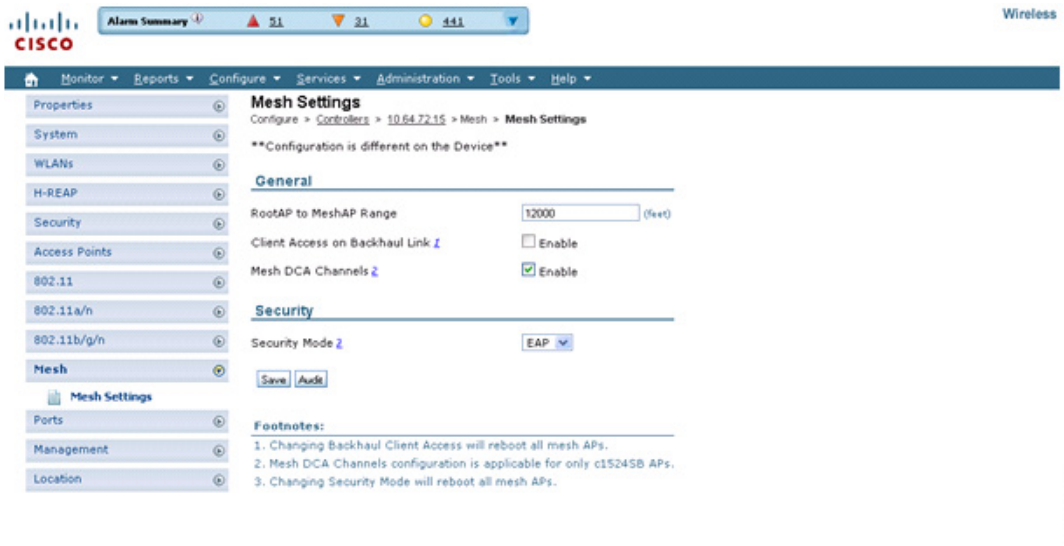
  ```
  All Mesh APs will be rebooted
  Are you sure you want to start? (y/N)
  ```

Configuring Extended Universal Access from the Wireless Control System (WCS)

Step 1 Choose **Controllers** > *Controller IP Address* > **Mesh** > **Mesh Settings**.

The WCS Mesh page when Backhaul Client Access is disabled appears as shown in Figure 9-25.

Figure 9-25 Mesh Settings Page



Step 2 Select the **Client Access on Backhaul Link** check box to display the Extended Backhaul Client Access check box.

Step 3 Select the **Extended Backhaul Client Access** check box and click **Apply**. A message appears indicating the possible results of enabling the Extended Backhaul Client Access.

Step 4 Click **OK** to continue.

Configuring Local Mesh Parameters

After configuring global mesh parameters, you must configure the following local mesh parameters for these specific features if in use in your network:

- Backhaul Data Rate. See the "Configuring Wireless Backhaul Data Rate" section on page 9-48.
- Ethernet Bridging. See the "Configuring Ethernet Bridging" section on page 9-52.
- Bridge Group Name. See the"Configuring Ethernet Bridging" section on page 9-52.
- Workgroup Bridge. See the "Configuring Workgroup Bridges" section on page 9-84.
- Public Safety Band Settings. See the "Configuring Public Safety Band Settings" section on page 9-56.

- Cisco 3200 Series Association and Interoperability. See the "Table 9-10 identifies mesh access points and their respective frequency bands that support WGB." section on page 9-93.
- Power and Channel Setting. See the"Configuring Power and Channel Settings" section on page 9-60.
- Antenna Gain Settings. See the "Configuring Antenna Gain" section on page 9-63.
- Dynamic Channel Assignment. See the "Configuring Dynamic Channel Assignment" section on page 9-69.

Configuring Wireless Backhaul Data Rate

Backhaul is used to create only the wireless connection between the access points. The backhaul interface by default is 802.11a or 802.11a/n depending upon the access point. The rate selection is important for effective use of the available RF spectrum. The rate can also affect the throughput of client devices, and throughput is an important metric used by industry publications to evaluate vendor devices.

Dynamic Rate Adaptation (DRA) introduces a process to estimate optimal transmission rate for packet transmissions. It is important to select rates correctly. If the rate is too high, packet transmissions fail resulting in communication failure. If the rate is too low, the available channel bandwidth is not used, resulting in inferior products, and the potential for catastrophic network congestion and collapse.

Data rates also affect the RF coverage and network performance. Lower data rates, for example 6 Mbps, can extend farther from the access point than can higher data rates, for example 300 Mbps. As a result, the data rate affects cell coverage and consequently the number of access points required. Different data rates are achieved by sending a more redundant signal on the wireless link, allowing data to be easily recovered from noise. The number of symbols sent out for a packet at the 1-Mbps data rate is higher than the number of symbols used for the same packet at 11 Mbps. Therefore, sending data at the lower bit rates takes more time than sending the equivalent data at a higher bit rate, resulting in reduced throughput.

In the controller release 5.2, the default data rate for the mesh 5-GHz backhaul is 24 Mbps. It remains the same with 6.0 and 7.0 controller releases.

With the 6.0 controller release, mesh backhaul can be configured for 'Auto' data rate. Once configured, the access point picks the highest rate where the next higher rate cannot be used because of conditions not being suitable for that rate and not because of conditions that affect all rates. That is, once configured, each link is free to settle down to the best possible rate for its link quality.

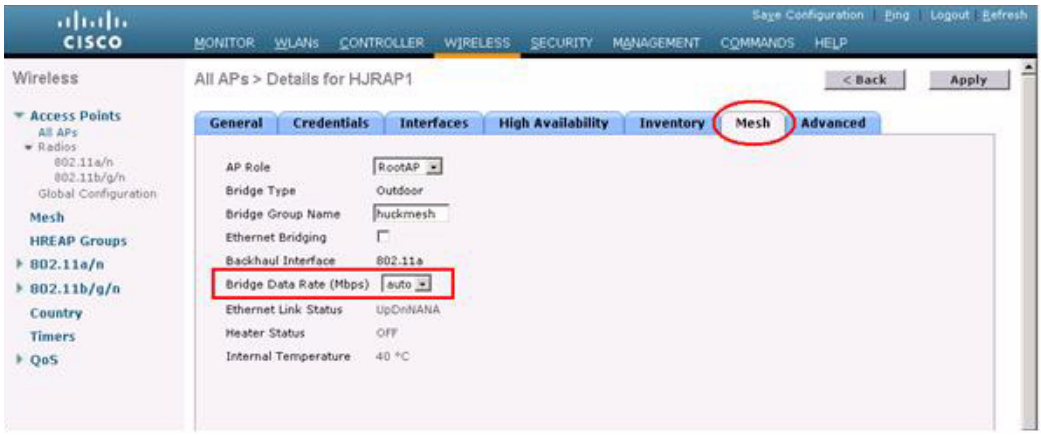
We recommend that you configure the mesh backhaul to Auto.

For example, if mesh backhaul chose 48 Mbps, then this decision is taken after ensuring that we cannot use 54 Mbps as there is not enough SNR for 54 and not because some just turned the microwave oven on which affects all rates.

A lower bit rate might allow a greater distance between MAPs, but there are likely to be gaps in the WLAN client coverage, and the capacity of the backhaul network is reduced. An increased bit rate for the backhaul network either requires more MAPs or results in a reduced SNR between MAPs, limiting mesh reliability and interconnection.

Figure 9-26 shows the RAP using the "auto" backhaul data rate, and it is currently using 54 Mbps with its child MAP.

Figure 9-26 Bridge Rate Set to Auto



Note The data rate can be set on the backhaul on a per-AP basis. It is not a global command.

Related Commands

Use these commands to obtain information about backhaul:

- **config ap bhrate**—Configures the Cisco Bridge backhaul Tx rate.

  The syntax is as follows:

  ```
  (controller) > config ap bhrate backhaul-rate ap-name
  ```

Note Preconfigured data rates for each AP (RAP=18 Mbps, MAP1=36 Mbps) are preserved after the upgrade to 6.0 or later software releases.

Before you upgrade to the 6.0 release, if you have the backhaul data rate configured to any data rate, then the configuration is preserved.

The following example shows how to configure a backhaul rate of 36000 Kbps on a RAP:

```
(controller) > config ap bhrate 36000 HPRAP1
```

- **show ap bhrate**—Displays the Cisco Bridge backhaul rate.

  The syntax is as follows:

  ```
  (controller) > show ap bhrate ap-name
  ```

- **show mesh neigh summary**—Displays the link rate summary including the current rate being used in backhaul

  Example:

  ```
  (controller) > show mesh neigh summary HPRAP1

  AP Name/Radio     Channel     Rate     Link-Snr     Flags      State
  ---------------- --------   --------   -------     -----      -----
  00:0B:85:5C:B9:20 0          auto        4       0x10e8fcb8   BEACON
  00:0B:85:5F:FF:60 0          auto        4       0x10e8fcb8   BEACON DEFAULT
  00:0B:85:62:1E:00 165        auto        4       0x10e8fcb8   BEACON
  OO:0B:85:70:8C:A0 0          auto        1       0x10e8fcb8   BEACON
  HPMAP1            165        54          40      0x36         CHILD BEACON
  ```

```
HJMAP2          0          auto          4        0x10e8fcb8    BEACON
```

Backhaul capacity and throughput depends upon the type of the AP, that is, if it is 802.11a/n or only 802.11a, number of backhaul radios it has, and so on.

In AP1524 SB, Slot 2 in the 5-GHz radio in the RAP is used to extend the backhaul in the downlink direction, whereas Slot 2 in the 5-GHz radio in the MAP is used for backhaul in the uplink. We recommend using a directional antenna with the Slot 2 radio. MAPs extend Slot 1 radio in the downlink direction with Omni or directional antenna also providing client access. Client access can be provided on the Slot 2 radio from the 7.0 release onwards.

AP1524SB provides you with better throughput, and throughput rarely degrades after the first hop. The performance of AP1524SB is better than AP1522 and AP1524PS because these APs have only a single radio for the backhaul uplink and downlink (see Figure 9-27, Figure 9-28, Figure 9-29, and Figure 9-30).

Figure 9-27 1524SB TCP Downstream Rate Auto

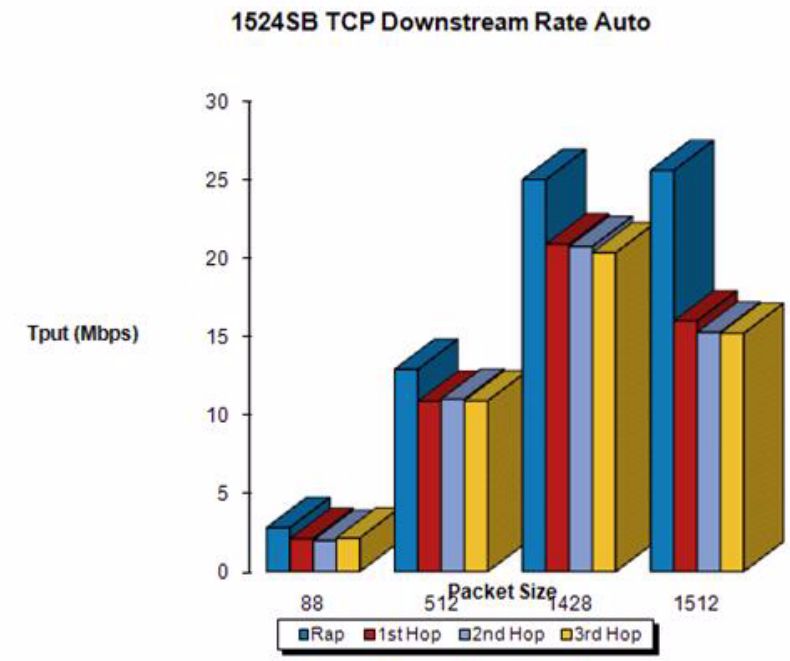
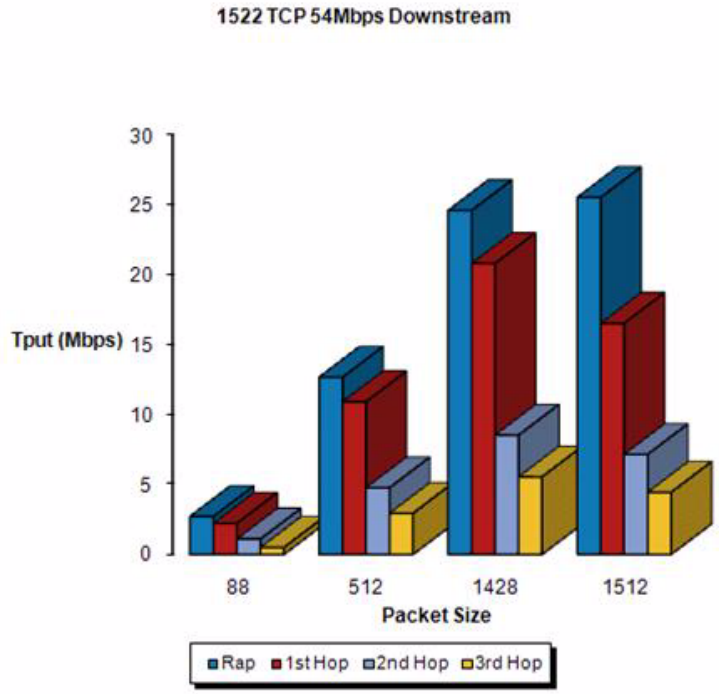


Figure 9-28 1522 TCP 54 Mbps Downstream



Note With DRA, each hop uses the best possible data rate for the backhaul. The data rate can be changed on a per-AP basis.

Figure 9-29 1524SB TCP Downstream Rate Auto

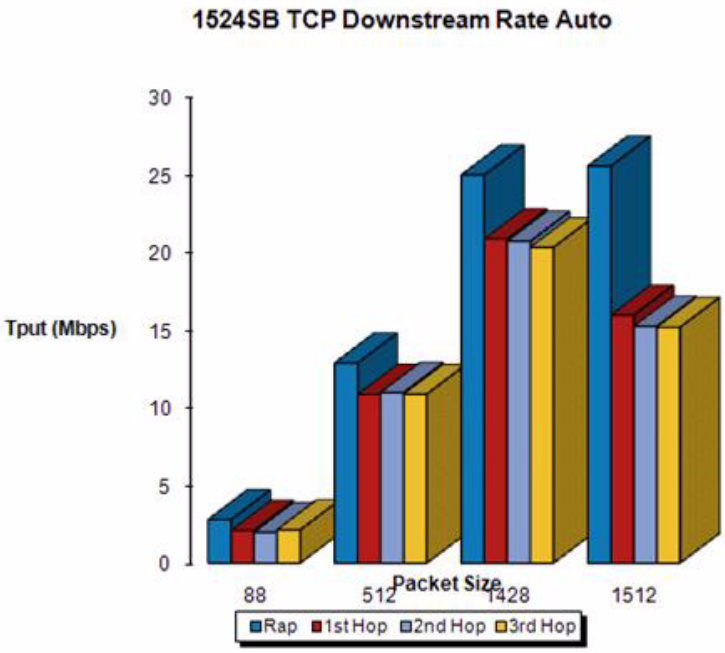
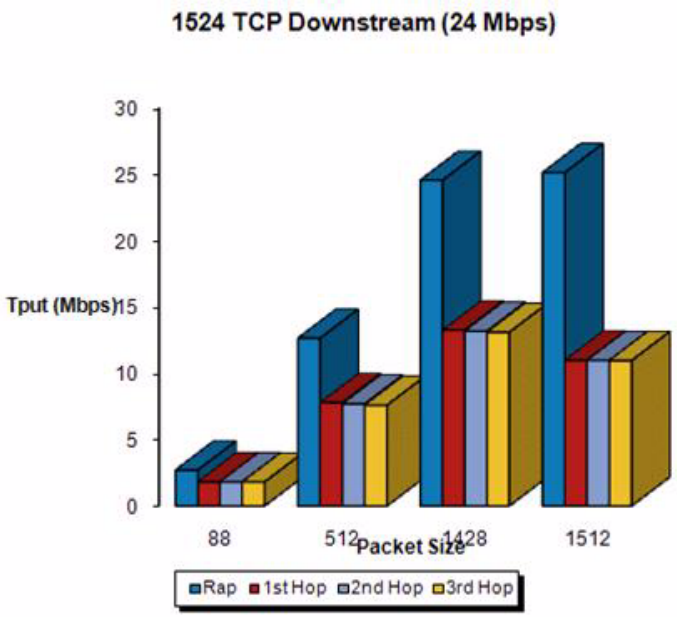


Figure 9-30 1524 TCP Downstream (24 Mbps)



Note Using 1552 802.11n provides you higher throughput and more capacity. It offers a very fat backhaul pipe to start with from the RAP.

Figure 9-31 AP1552 Backhaul Throughput

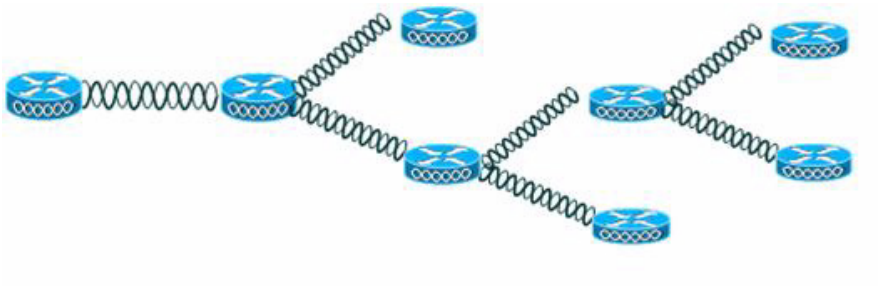


Table 9-7 AP1552 Backhaul capacity

HOPS	RAP	One	Two	Three	Four
Maximum Throughput (20 MHz BH)	112 Mbps	83 Mbps	41 Mbps	25 Mbps	15 Mbps
Maximum Throughput (40 MHz BH)	206 Mbps	111 Mbps	94 Mbps	49 Mbps	35 Mbps

Configuring Ethernet Bridging

For security reasons, the Ethernet port on all MAPs is disabled by default. It can be enabled only by configuring Ethernet bridging on the root and its respective MAP.

Note Exceptions are allowed for a few protocols even though Ethernet bridging is disabled. For example, the following protocols are allowed:

– Spanning Tree Protocol (STP)
– Address Resolution Protocol (ARP)
– Control And Provisioning of Wireless Access Points (CAPWAP)
– Bootstrap Protocol (BOOTP) packets

Due to the exceptions and to prevent loop issues, we recommend that you do not connect two MAPs to each other over their Ethernet ports, unless they are configured as trunk ports on different native VLANs, and each is connected to a similarly configured switch.

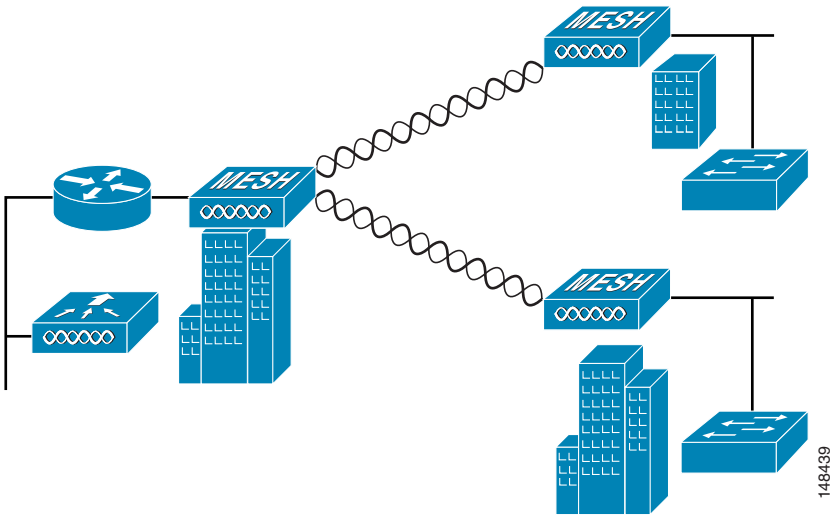
Ethernet bridging has to be enabled for two scenarios:

1. When you want to use the mesh nodes as bridges. (See Figure 9-32.)

   Note You do not need to configure VLAN tagging to use Ethernet bridging for point-to-point and point-to-multipoint bridging deployments.

2. When you want to connect any Ethernet device such as a video camera on the MAP using its Ethernet port. This is the first step to enable VLAN tagging.

Figure 9-32 Point-to-Multipoint Bridging



Enabling Ethernet Bridging Using the GUI

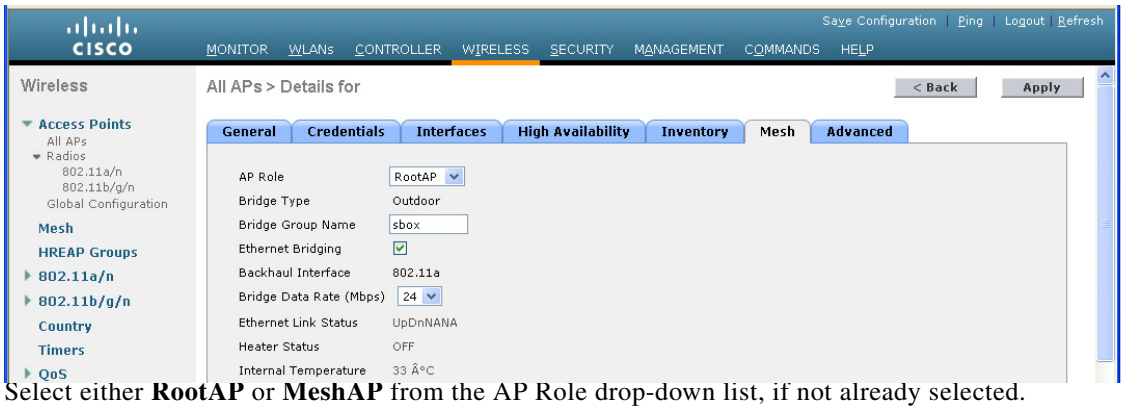
To enable Ethernet bridging on a RAP or MAP using the GUI, follow these steps:

Step 1 Choose **Wireless > All APs**.

Step 2 Click the AP name link of the mesh access point on which you want to enable Ethernet bridging.

Step 3 At the details page, select the **Mesh** tab. (See Figure 9-33.)

Figure 9-33 All APs > Details for (Mesh) Page



Step 4 Select either **RootAP** or **MeshAP** from the AP Role drop-down list, if not already selected.

Step 5 Select the **Ethernet Bridging** check box to enable Ethernet bridging or deselect it to disable this feature.

Step 6 Click **Apply** to commit your changes. An Ethernet Bridging section appears at the bottom of the page listing each of the Ethernet ports of the mesh access point.

Step 7 Ensure that you enable Ethernet bridging for every parent mesh AP taking the path from the mesh AP in question to the controller. For example, if you enable Ethernet bridging on MAP2 in Hop 2, then you must also enable Ethernet bridging on MAP1 (parent MAP), and on the RAP connecting to the controller.

Configuring Bridge Group Names

Bridge group names (BGNs) control the association of mesh access points. BGNs can logically group radios to avoid two networks on the same channel from communicating with each other. The setting is also useful if you have more than one RAP in your network in the same sector (area). BGN is a string of 10 characters maximum.

A BGN of *NULL VALUE* is assigned by default by manufacturing. Although not visible to you, it allows a mesh access point to join the network prior to your assignment of your network-specific BGN.

If you have two RAPs in your network in the same sector (for more capacity), we recommend that you configure the two RAPs with the same BGN, but on different channels.

Configuring BGN Using the CLI

To configure a BGN, follow these steps:

Step 1 Using the CLI, enter the following command:

```
(Cisco Controller) >config ap bridgegroupname set SEVT1 HJMAP3
Setting bridgegroupname on an AP permanently restricts the APs to which it may c
onnect, use with caution.
Are you sure you want to continue? (y/n) n


AP bridgegroupname not changed!
```

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Note The mesh access point reboots after a BGN configuration.

Caution Exercise caution when you configure a BGN on a live network. Always start a BGN assignment from the farthest-most node (last node, bottom of mesh tree) and move up toward the RAP to ensure that no mesh access points are dropped due to mixed BGNs (old and new BGNs) within the same network.

Step 2 To verify the BGN, enter the following command:

(Cisco controller) > **show ap config general** *AP_Name*

Information similar to the following is displayed.

```
(Cisco Controller 1) >show ap config general AP1552RAP1

Cisco AP Identifier.............................. 122
Cisco AP Name.................................... AP1552RAP1
Country code..................................... US  - United States
Regulatory Domain allowed by Country............. 802.11bg:-A     802.11a:-A, outdoor mesh -AB
AP Country code.................................. US  - United States
AP Regulatory Domain............................. 802.11bg:-A    802.11a:-A
Switch Port Number .............................. 1
MAC Address...................................... 58:bc:27:c5:53:00
IP Address Configuration......................... DHCP
IP Address....................................... 10.51.1.68
IP NetMask....................................... 255.255.255.0
Gateway IP Addr.................................. 10.51.1.1
NAT External IP Address.......................... None
CAPWAP Path MTU.................................. 1485
Telnet State..................................... Disabled
Ssh State........................................ Disabled
Cisco AP Location................................ default location
Cisco AP Group Name.............................. default-group
Primary Cisco Switch Name........................ SEVT-CONTROLLER
Primary Cisco Switch IP Address.................. 10.51.1.10
Secondary Cisco Switch Name......................
Secondary Cisco Switch IP Address................ Not Configured
Tertiary Cisco Switch Name.......................
Tertiary Cisco Switch IP Address................. Not Configured
Administrative State ............................ ADMIN_ENABLED
Operation State ................................. REGISTERED
Mirroring Mode .................................. Disabled
AP Mode ......................................... Bridge
AP Role ......................................... RootAP
Ethernet Bridging ............................... Disabled
Bridge GroupName ................................ fenway
Public Safety ................................... Enabled
```

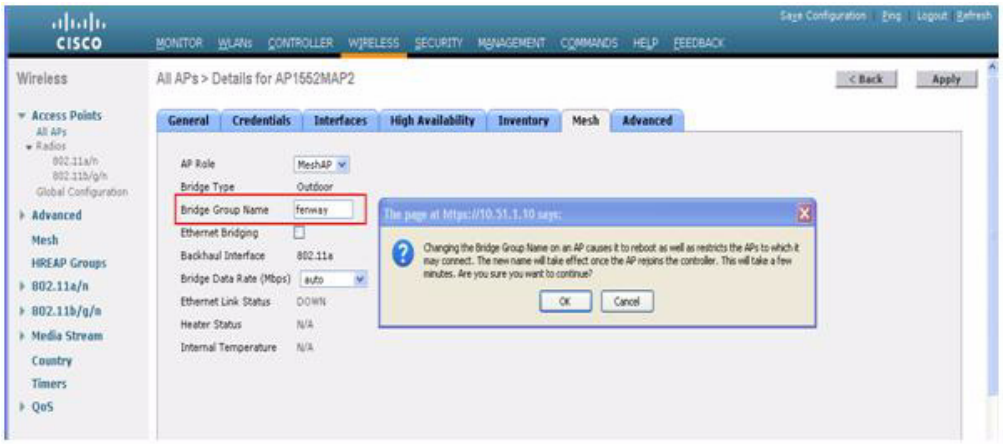
Verifying BGN Using the GUI

To verify BGN using the GUI, follow these steps:

Step 1 Click **Wireless > Access Points >** *AP Name*. the details page for the selected mesh access point appears.

Step 2 Click the **Mesh** tab. Details for the mesh access point including the BGN appears. (See Figure 9-34.)

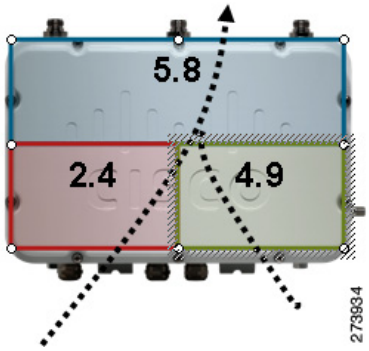
Figure 9-34 AP Name > Mesh



Configuring Public Safety Band Settings

A public safety band (4.9 GHz) is supported on the AP1522 and AP1524PS. (See Figure 9-35.)

Figure 9-35 AP 1524PS Diagram Showing Radio Placement



- For the AP1524PS, the 4.9-GHz radio is independent of the 5-GHz radio and is not used for backhaul. The 5.8 GHz is used only for backhaul, and there is no client access possible on it. On the AP1524PS, the 4.9-GHz band is enabled by default.
  - In Japan, 4.9 GHz is enabled by default as 4.9 GHz is unlicensed.
- For AP1522s, you can enable the 4.9-GHz public safety band on the backhaul. This step can only be done at the global level and cannot be done on a per mesh access point basis.
  - For client access on the 4.9-GHz band on the AP1522, you have to enable the feature *universal client access*.
- For public safety-only deployments, the AP1522 and the AP1524PS must each be connected to its own separate RAP-based tree. For such deployments, the 1522 must use the 4.9-GHz backhaul and the 1524PS must be in its own RAP tree and use the 5.8-GHz backhaul.
- In some parts of the world including the USA, you can only have public safety traffic on the 4.9-GHz backhaul. Check the destination countries compliance before installing.

The 4.9-GHz subband radio on the AP1524PS supports public safety channels within the 5-MHz (channels 1 to 10), 10-MHz (channels 11 to 19), and 20-MHz (channels 20 to 26) bandwidths.

- The following data rates are supported within the 5 MHz bandwidth: 1.5, 2.25, 3, 4.5, 6, 9, 12, and 13.5 Mbps. The default rate is 6 Mbps.
- The following data rates are supported within the 10-MHz bandwidth: 3, 4.5, 6, 9, 12, 18, 24, and 27 Mbps. The default rate is 12 Mbps.

Note

- Those AP1522s with serial numbers prior to FTX1150XXXX do **not** support 5 and 10 MHz channels on the 4.9-GHz radio; however, a 20-MHz channel is supported.
- Those AP1522s with serial numbers after FTX1150XXXX support 5, 10, and 20 MHz channels.

Enabling the 4.9-GHz Band

When you attempt to enable the 4.9-GHz band, you get a warning that the band is a licensed band in most parts of the world. (See Figure 9-36.)

Figure 9-36 Public Safety Warning During Configuration

```
(Cisco Controller) >config mesh public-safety ?

enable          Enable/Disable 4.9GHz Public Safety Bands for Mesh AP.

disable         Enable/Disable 4.9GHz Public Safety Bands for Mesh AP.

(Cisco Controller) >config mesh public-safety enable ?

all             For All Cisco AP

(Cisco Controller) >config mesh public-safety enable all

4.9GHz is a licensed frequency band in -A domain for public-safety usage
 Are you sure you want to continue? (y/N)y

        Global Public Safety State: Already configured, Configuring Local States
...


(Cisco Controller) >config mesh public-safety enable HJRap1

Public Safety can't be configured on individual Cisco APs.
```

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- To verify that a public safety band is on the mesh access point using the CLI, enter the following command:

```
(Cisco controller) show mesh public-safety
Global Public Safety status: enabled
```

- To verify that a public safety band is on the mesh access point using the GUI:

  Wireless > Access Points > 802.11a radio > *Configure* (from the Antenna drop-down list)

Configuring Interoperability with Cisco 3200

Cisco AP1522 and AP1524PS can interoperate with the Cisco 3200 on the public safety channel (4.9-GHz) as well as the 2.4-GHz access and 5.8-GHz backhaul.

The Cisco 3200 creates an *in-vehicle network* in which devices such as PCs, surveillance cameras, digital video recorders, printers, PDAs, and scanners can share wireless networks such as cellular or WLAN based services back to the main infrastructure. This feature allows data collected from in-vehicle deployments such as a police cars to be integrated into the overall wireless infrastructure.

This section provides configuration guidelines and step-by-step instructions for configuring interoperability between the Cisco 3200 and the AP1522 and the AP1524PS.

For specific interoperability details between series 1130, 1240, and 1520 (1522, 1524PS) mesh access points and Cisco 3200, see Table 9-8.

Table 9-8 Mesh Access Points and Cisco 3200 Interoperability

Mesh Access Point Model	Cisco 3200 Model
1552, 1522[1]	c3201[2], c3202[3], c3205[4]
1524PS	c3201, c3202
1524SB, 1130, 1240, Indoor 802.11n mesh access points	c3201, c3205

1. Universal access must be enabled on the AP1522 if connecting to a Cisco 3200 on the 802.11a radio or 4.9-GHz band.
2. Model c3201 is a Cisco 3200 with a 802.11b/g radio (2.4-GHz).
3. Model c3202 is a Cisco 3200 with a 4-9-GHz subband radio.
4. Model c3205 is a Cisco 3200 with a 802.11a radio (5.8-GHz subband).

Configuration Guidelines for Public Safety 4.9-GHz Band

For the AP1522 or AP1524PS and Cisco 3200 to interoperate on the public safety network, the following configuration guidelines must be met:

Client access must be enabled on the backhaul (mesh global parameter). This feature is not supported on the AP1524PS.

Public safety must be enabled globally on all mesh access points (MAPs) in the mesh network.

The channel number assignment on the AP1522 or AP1524PS must match those on the Cisco 3200 radio interfaces:

Channels 20 (4950 GHz) through 26 (4980 GHz) and subband channels 1 through 19 (5 and 10 MHz) are used for Cisco 3200 interoperability. This configuration change is made on the controller. No changes are made to the mesh access point configuration.

Channel assignments are only made to the RAP. Updates to the MAP are propagated by the RAP.

The default channel width for Cisco 3200s is 5 MHz. You must *either* change the channel width to 10 or 20 MHz to enable WGBs to associate with the AP1522 and AP1524PS *or* change the channel on the AP1522 or AP1524PS to a channel in the 5-MHz band (channels 1 to 10) or 10-MHz band (channels 11 to 19).

Radio (802.11a) must be disabled when configuring channels and then reenabled when using the CLI. When using the GUI, enabling and disabling of the 802.11a radio for channel configuration is not required.

Cisco 3200s can scan channels *within* but not across the 5, 10 or 20-MHz bands.

Enabling AP1522 to Associate with Cisco 3200 Using the GUI

To enable AP1522 to associate with Cisco 3200, follow these steps:

Step 1 To enable the backhaul for client access, choose **Wireless > Mesh** to access the Mesh page.

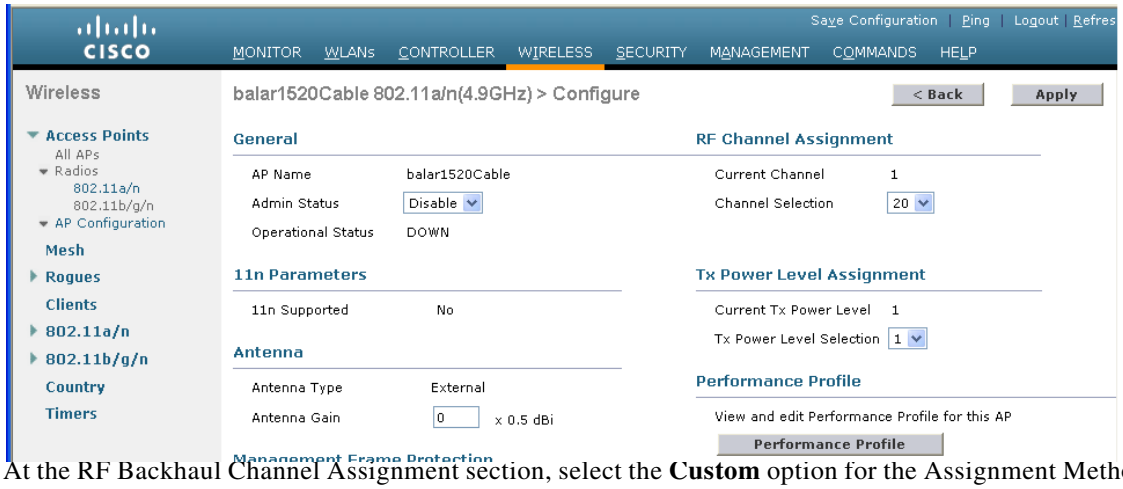
Step 2 Select the Backhaul Client Access **Enabled** check box to allow wireless client association over the 802.11a radio. Click **Apply**.

Note You are prompted with a message to allow reboot of all the mesh access points to enable Backhaul Client Access on a network. Click **OK**.

Step 3 To assign the channel to use for the backhaul (channels 20 through 26), click **Wireless > Access Points > Radio** and select **802.11a/n** from the Radio subheading. A summary page for all 802.11a radios displays.

Step 4 At the Antenna drop-down list for the appropriate RAP, select **Configure.** The Configure page seen in Figure 9-37 is displayed.

Figure 9-37 Wireless > Access Points > Radio > 802.11 a/n > Configure Page



Step 5 At the RF Backhaul Channel Assignment section, select the **Custom** option for the Assignment Method option and select any channel between 1 and 26.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Enabling 1522 and 1524PS Association with Cisco 3200 Using the CLI

To enable an AP1522 or AP1524PS to associate with Cisco 3200, follow these steps:

Step 1 To enable client access mode on the AP1522, enter this command:

config mesh client-access enable

Step 2 To enable the public safety on a global basis, enter this command:

config mesh public-safety enable *all*

Step 3 To enable the public safety channels, enter these commands:

a. On the AP1522, enter these commands:

config 802.11a disable *Cisco_MAP*

config 802.11a channel ap *Cisco_MAP channel number*

config 802.11a enable *Cisco_MAP*

b. On the AP1524PS, enter these commands:

config 802.11–a49 disable *Cisco_MAP*

config 802.11–a49 channel ap *Cisco_MAP channel number*

config 802.11–a49 enable *Cisco_MAP*

Note Enter the **config 802.11–a58 enable** *Cisco_MAP* command to enable a 5.8-GHz radio.

Note For both the AP1522 and AP1524PS, *channel number* is equal to any value 1 to 26.

Step 4 To save your changes, enter this command:

save config

Step 5 To verify your configuration, enter these commands:

show mesh public-safety

show mesh client-access

show ap config 802.11a summary (1522 only)

show ap config 802.11–a49 summary (1524PS only)

Note Enter the **show config 802.11-a58 summary** command to display configuration details for a 5.8-GHz radio.

Configuring Power and Channel Settings

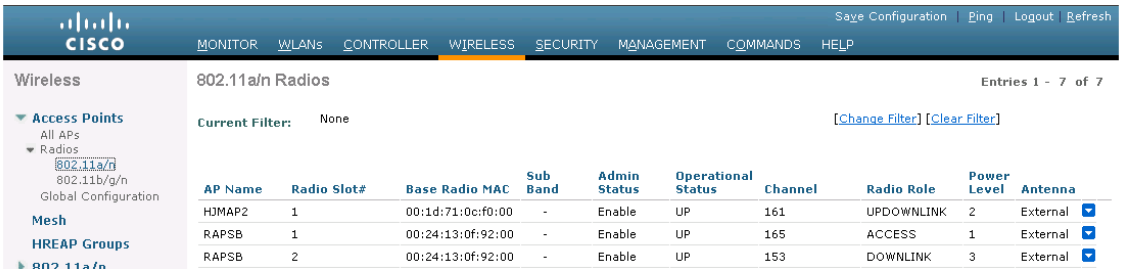
The backhaul channel (802.11a/n) can be configured on a RAP. MAPs tune to the RAP channel. The local access can be configured independently for MAP.

Configuring Power and Channel Settings Using the GUI

To configure power and channel using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > 802.11a/n** (see Figure 9-38).

Figure 9-38 Access Points > 802.11a/n Radios Page

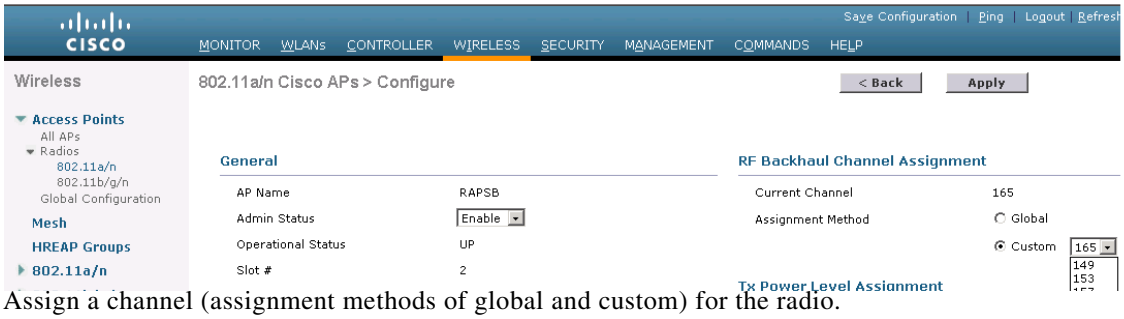


Note In Figure 9-38, radio slots are displayed for each radio. For an AP1524SB, the 802.11a radio will display for slots 1 and 2 that operate in the 5-GHz band. For an AP1524PS, the 802.11a radio will display for slots 1 and 2, operating in the 5-GHz and 4.9-GHz bands respectively.

Step 2 Select **configure** from the Antenna drop-down list for the 802.11a/n radio. The Configure page is displayed (see Figure 9-39).

Note For the 1524SB, select the Antenna drop-down list for a RAP with a radio role of downlink.

Figure 9-39 802.11a/n Cisco APs > Configure Page



Step 3 Assign a channel (assignment methods of global and custom) for the radio.

Note When you assign a channel to the AP1524SB, choose the **Custom** assignment method, and select one of the supported channels for the 5-GHz band.

Step 4 Assign Tx power levels (global and custom) for the radio.

There are five selectable power levels for the 802.11a backhaul for AP1500s.

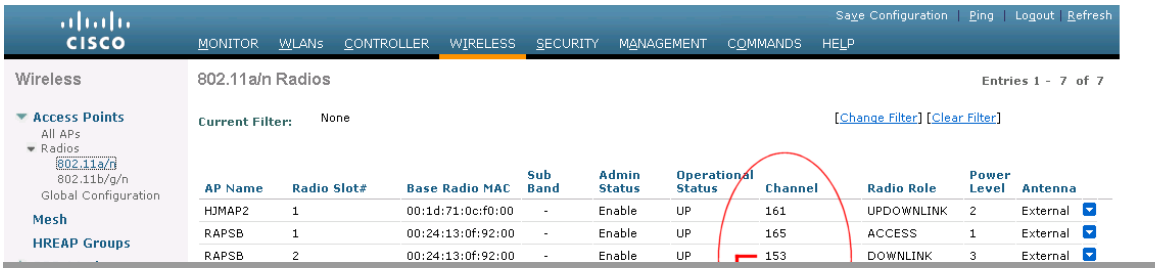
Note The default Tx power level on the backhaul is the highest power level (Level 1).

Note Radio Resource Management (RRM) is OFF (disabled) by default. RRM cannot be turned ON (enabled) for the backhaul.

Step 5 Click **Apply** when power and channel assignment are complete.

Step 6 From the 802.11a/n Radios page, verify that channel assignments were made correctly (see Figure 9-40).

Figure 9-40 Channel Assignment



Configuring the Channels on the Serial Backhaul Using the CLI

To configure channels on the serial backhaul of the RAP using the controller CLI, follow these steps:

Step 1 To configure the backhaul channel on the radio in slot 2 of the RAP, enter this command:

config slot 2 channel ap *Cisco_RAPSB channel*

The available channels for the 5.8-GHz band are 149, 153, 157, 161, and 165.

Step 2 To configure the transmit power level on the radio in slot 2 of the RAP, enter this command:

config slot 2 txPower ap *Cisco_RAPSB power*

Valid values are 1 through 5; the default value is 1.

Step 3 To display the configurations on the mesh access points, enter these commands:

- **show mesh path** *MAP*

  Information similar to the following appears:

```
AP Name/Radio   Channel   Rate    Link-Snr     Flags        State
MAP1SB          161       auto    60           0x10ea9d54   UPDATED NEIGH PARENT BEACON
RAPSB           153       auto    51           0x10ea9d54   UPDATED NEIGH PARENT BEACON

RAPSB is a Root AP.
```

- **show mesh backhaul** *RAPSB*

  Information similar to the following appears:

```
Current Backhaul Slot(s)..................... 1, 2,

Basic Attributes for Slot 1
    Radio Type.............................. RADIO_TYPE_80211a
    Radio Role.............................. ACCESS
    Administrative State ................... ADMIN_ENABLED
    Operation State ........................ UP
    Current Tx Power Level ................. 1
    Current Channel ........................ 165
    Antenna Type............................ EXTERNAL_ANTENNA
    External Antenna Gain (in .5 dBm units)..... 0

Basic Attributes for Slot 2
    Radio Type.............................. RADIO_TYPE_80211a
    Radio Role.............................. RADIO_DOWNLINK
    Administrative State ................... ADMIN_ENABLED
    Operation State ........................ UP
```

```
Current Tx Power Level ..................... 3
Current Channel ............................ 153
Antenna Type................................ EXTERNAL_ANTENNA
External Antenna Gain (in .5 dBm units)..... 0
```

- **show ap channel** *MAP1SB*

  Information similar to the following appears:

```
802.11b/g Current Channel ................. 11
Slot Id ................................... 0
Allowed Channel List....................... 1,2,3,4,5,6,7,8,9,10,11
802.11a(5.8Ghz) Current Channel ........... 161
Slot Id ................................... 1
Allowed Channel List....................... 149,153,157,161,165
802.11a(5.8Ghz) Current Channel ........... 153
Slot Id ................................... 2
Allowed Channel List....................... 149,153,157,161,165
```

Configuring Antenna Gain

You must configure the antenna gain for the mesh access point to match that of the antenna installed using the controller GUI or controller CLI.

Configuring Antenna Gain Using the GUI

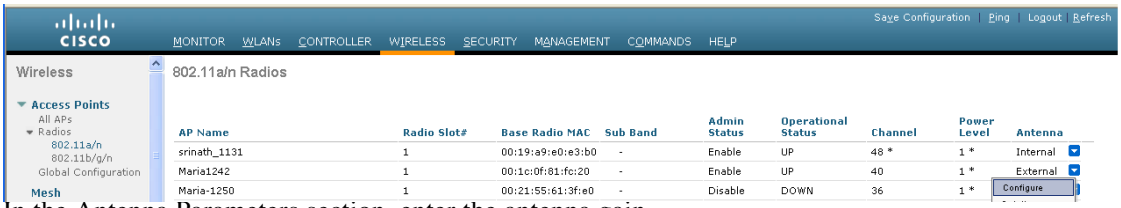
To configure antenna parameters using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > Radio > 802.11a/n** to open the 802.11a/n Radios page.

Step 2 For the mesh access point antenna you want to configure, hover the mouse over the blue arrow (far right) to display antenna options. Choose **Configure**. (See Figure 9-41.)

Note Only external antennas have configurable gain settings.

Figure 9-41 802.11a/n Radios Page

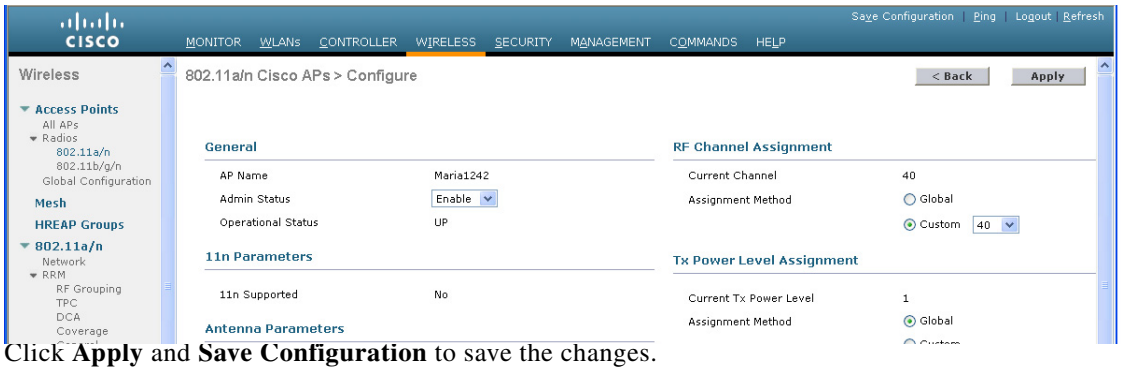


Step 3 In the Antenna Parameters section, enter the antenna gain.

The gain is entered in 0.5 dBm units. For example, 2.5 dBm = 5. (See Figure 9-42.)

Note The entered gain value must match that value specified by the vendor for that antenna.

Figure 9-42 802.11 a/n Cisco APs > Configure Page



Step 4 Click **Apply** and **Save Configuration** to save the changes.

Configuring Antenna Gain Using the CLI

Enter this command to configure the antenna gain for the 802.11a backhaul radio using the controller CLI:

config 802.11a antenna extAntGain *antenna_gain AP_name*

where gain is entered in 0.5-dBm units (for example, 2.5 dBm =5).

Backhaul Channel Deselection on Serial Backhaul Access Point

This feature is applicable to mesh APs with two 5-GHz radios, such as 1524SB (serial backhaul).

The backhaul channel deselection feature helps you to restrict the set of channels available to be assigned for the serial backhaul MAPs and RAPs. Because 1524SB MAP channels are automatically assigned, this feature helps in regulating the set of channels that get assigned to mesh access points. For example, if you do not want channel 165 to get assigned to any of the 1524SB mesh access points, you need to remove channel 165 from the DCA list and enable this feature.

When you remove certain channels from the DCA list and enable the **mesh backhaul dca-channel** command, those channels will not be assigned to any serial backhaul access points in any scenario. Even if a radar is detected on all channels within the DCA list channels, the radio will be shut down rather than moved to channels outside it. A trap message is sent to the WCS, and the message is displayed showing that the radio has been shut down because of DFS. You will not be able to assign channels to the serial backhaul RAP outside of the DCA list with the **config mesh backhaul dca-channels enable** command enabled. However, this is not case for the APs with one 5-GHz radio such as 1552, 1522, and 1524PS APs. For these APs, you can assign any channel outside of the DCA list for a RAP, and the controller/AP can also select a channel outside of the DCA list if no radar-free channel is available from the list.

This feature is best suited in an interoperability scenario with indoor mesh access points or workgroup bridges that support a channel set that is different from outdoor access points. For example, channel 165 is supported by outdoor access points but not by indoor access points in the -A domain. By enabling the backhaul channel deselection feature, you can restrict the channel assignment to only those channels that are common to both indoor and outdoor access points.

Note Channel deselection is applicable to 7.0 and later releases.

In some scenarios, there may be two linear tracks or roads for mobility side by side. Because channel selection of MAPs happens automatically, there can be a hop at a channel, which is not available on the autonomous side, or the channel has to be skipped when the same or adjacent channel is selected in a neighborhood access point that belongs to a different linear chain.

Configuring Backhaul Channel Deselection Using the GUI

To configure the backhaul channel deselection, follow these steps:

Step 1 Choose **Controller > Wireless > 802.11a/n > RRM > DCA**

The Dynamic Channel Assignment Algorithm page appears.

Step 2 Select one or more channels to include in the DCA list.

The channels included in the DCA list will not be assigned to the access points associated to this controller during automatic channel assignment.

Step 3 Choose **Wireless > Mesh**

The Mesh page appears.

Step 4 Select the Mesh DCA Channels check box to enable the backhaul channel deselection using the DCA list. This option is applicable for serial backhaul access points.

Step 5 After you enable the backhaul deselection option, choose **Wireless > Access Points > Radios > 802.11a/n** to configure the channel for the RAP downlink radio.

Step 6 From the list of access points, click on the Antenna drop-down list for a RAP and choose **Configure**.

The Configure page appears.

Step 7 In the RF Backhaul Channel assignment section, choose **Custom**.

Step 8 Select a channel for the RAP downlink radio from the drop-down list, which appears when you choose **Custom**.

Step 9 Click **Apply** to apply and save the backhaul channel deselection configuration changes.

Configuring Backhaul Channel Deselection Using the CLI

To configure backhaul channel deselection using CLI, follow these steps:

Step 1 From the controller prompt, enter the **show advanced 802.11a channel** command to review the channel list already configured in the DCA list.

```
(Controller) > show advanced 802.11a channel
Automatic Channel Assignment
  Channel Assignment Mode..................... AUTO
  Channel Update Interval..................... 600 seconds
  Anchor time (Hour of the day)............... 0
  Channel Update Contribution................. SNI..
  CleanAir Event-driven RRM option............ Enabled
  CleanAir Event-driven RRM sensitivity....... Medium
  Channel Assignment Leader................... 09:2b:16:28:00:03
  Last Run.................................... 286 seconds ago
  DCA Sensitivity Level....................... MEDIUM (15 dB)
  DCA 802.11n Channel Width................... 20 MHz
  DCA Minimum Energy Limit.................... -95 dBm
```

```
  Channel Energy Levels
    Minimum..................................... unknown
    Average..................................... unknown
    Maximum..................................... unknown
  Channel Dwell Times
    Minimum..................................... 0 days, 17 h 02 m 05 s
    Average..................................... 0 days, 17 h 46 m 07 s
    Maximum..................................... 0 days, 18 h 28 m 58 s
  802.11a 5 GHz Auto-RF Channel List

--More-- or (q)uit
    Allowed Channel List........................ 36,40,44,48,52,56,60,64,116,
                                                 140
    Unused Channel List......................... 100,104,108,112,120,124,128,
                                                 132,136
  DCA Outdoor AP option....................... Disabled
```

Step 2 To add a channel to the DCA list, enter the **config advanced 802.11a channel add** *channel number* command, where *channel number* is the channel number that you want to add to the DCA list.

You can also delete a channel from the DCA list by entering the **config advanced 802.11a channel delete** *channel number* command, where *channel number* is the channel number that you want to delete from the DCA list.

Before you add or delete a channel to or from the DCA list, ensure that the 802.11a network is disabled.

- To disable the 802.11a network, enter the following command:

  config 802.11a disable network

- To enable the 802.11a network, enter the following command:

  config 802.11a enable network

You cannot directly delete a channel from the DCA list if it is assigned to any 1524 RAP. To delete a channel assigned to a RAP, you must first change the channel assigned to the RAP and then enter the **config advanced 802.11a channel delete** *channel number* command from the controller.

The following is a sample output of the **add channel** and **delete channel** commands:

```
(Controller) > config 802.11a disable network

Disabling the 802.11a network may strand mesh APs. Are you sure you want to continue?
(y/n)y


(Controller) > config advanced 802.11a channel add 132


(Controller) > config advanced 802.11a channel delete 116

802.11a 5 GHz Auto-RF:
Allowed Channel List........................ 36,40,44,48,52,56,60,64,116,
                                             132,140
DCA channels for cSerial Backhaul Mesh APs is enabled.
DCA list should have at least 3 non public safety channels supported by Serial Backhaul
Mesh APs.
Otherwise, the Serial Backhaul Mesh APs can get stranded.
Are you sure you want to continue? (y/N)y


Failed to delete channel.
Reason: Channel 116 is configured for one of the Serial Backhaul RAPs.
Disable mesh backhaul dca-channels or configure a different channel for Serial Backhaul
RAPs.
```

```
(Controller) > config advanced 802.11a channel delete 132

  802.11a 5 GHz Auto-RF:
Allowed Channel List..................... 36,40,44,48,52,56,60,64,116,132,140
DCA channels for Serial Backhaul Mesh APs is enabled.
DCA list should have at least 3 non public safety channels supported by Serial Backhaul
Mesh APs.
Otherwise, the Serial Backhaul Mesh APs can get stranded.
Are you sure you want to continue? (y/N)y

(Controller) > config 802.11a enable network
```

Step 3 After a suitable DCA list has been created, enter the **config mesh backhaul dca-channels enable** command to enable the backhaul channel deselection feature for mesh access points.

You can enter the **config mesh backhaul dca-channels disable** command if you want to disable the backhaul channel deselection feature for mesh access points.

It is not required that you disable 802.11a network to enable or disable this feature.

The following is a sample output:

```
(Controller) > config mesh backhaul dca-channels enable
  802.11a 5 GHz Auto-RF:
    Allowed Channel List.......................... 36,40,44,48,52,56,60,64,116,
                                                   140
Enabling DCA channels for c1524 mesh APs will limit the channel set to the DCA channel
list.
DCA list should have at least 3 non public safety channels supported by Serial Backhaul
Mesh APs.
Otherwise, the Serial Backhaul Mesh APs can get stranded.
Are you sure you want to continue? (y/N)y

(Controller) > config mesh backhaul dca-channels disable
```

Step 4 To check the current status of the backhaul channel deselection feature, enter the **show mesh config** command.

The following is a sample output:

```
(Controller) > show mesh config

Mesh Range..................................... 12000
Mesh Statistics update period.................. 3 minutes
Backhaul with client access status............. enabled
Background Scanning State...................... enabled
Backhaul Amsdu State........................... disabled

Mesh Security
   Security Mode............................... PSK
   External-Auth............................... enabled
      Radius Server 1.......................... 209.165.200.240
   Use MAC Filter in External AAA server..... disabled
   Force External Authentication.............. disabled

Mesh Alarm Criteria
   Max Hop Count............................... 4
   Recommended Max Children for MAP............ 10
   Recommended Max Children for RAP............ 20
   Low Link SNR................................ 12
   High Link SNR............................... 60
   Max Association Number...................... 10
```

```
   Association Interval.......................... 60 minutes
   Parent Change Numbers......................... 3

--More-- or (q)uit
   Parent Change Interval........................ 60 minutes


Mesh Multicast Mode............................... In-Out
Mesh Full Sector DFS.............................. enabled


Mesh Ethernet Bridging VLAN Transparent Mode..... enabled

Mesh DCA channels for Serial Backhaul APs................ disabled
```

Step 5 Enter the **config slot** *slot number* **channel ap** *ap-name channel number* command to assign a particular channel to the 1524 RAP downlink radio.

- *slot number* refers to the slot of the downlink radio to which the channel is assigned.
- *ap-name* refers to the name of the access point on which the channel is configured.
- *channel number* refers to the channel that is assigned to a slot on the access point.

Slot 2 of the 1524 RAP acts as a downlink radio. If backhaul channel deselection is enabled, you can assign only those channels that are available in the DCA list the access point.

The following is a sample output:

```
(Controller) > config slot 2 channel ap Controller-RAP2-1524 136
Mesh backhaul dca-channels is enabled. Choose a channel from the DCA list.
(Controller) > config slot 2 channel ap Controller-RAP2-1524 140
```

Backhaul Channel Deselection Guidelines

Follow these guidelines when configuring backhaul channel deselection:

- Channels for serial backhaul RAP 11a access radio and both 11a radios of serial backhaul MAPs are assigned automatically. You cannot configure these channels.
- Look out for trap logs on the controller. In case of radar detection and subsequent channel change, messages similar to below appear:

  ```
  Channel changed for Base Radio MAC: 00:1e:bd:19:7b:00 on 802.11a
  radio. Old channel: 132. New Channel: 116. Why: Radar. Energy
  before/after change: 0/0. Noise before/after change: 0/0.
  Interference before/after change: 0/0.

  Radar signals have been detected on channel 132 by 802.11a radio
  with MAC: 00:1e:bd:19:7b:00 and slot 2
  ```

- For every serial backhaul AP, channels on downlink and uplink radios should always be noninterfering (for example, if the uplink is channel 104, the 100, 104, and 108 channels cannot be assigned for a downlink radio on that AP). An alternate adjacent channel is also selected for an 11a access radio on RAP.
- If radar signals are detected on all channels except the uplink radio channel, the downlink radio will be shut down and the uplink radio will act as both an uplink and a downlink (that is, the behavior is similar to 1522 APs in this case).

- Radar detection is cleared after 30 minutes. Any radio that is shut down because of radar detection should be back up and operational after this duration.
- There is a 60-second silent period immediately after moving to a DFS-enabled channel (irrespective of whether the channel change is because of radar detection or user configured in case of a RAP) during which the AP scans for radar signals without transmitting anything. A small period (60 seconds) of downtime may occur because of radar detection, if the new channel is also DFS-enabled. If radar detection occurs again on the new channel during the silent period, the parent changes its channel without informing the child AP because it is not allowed to transmit during the silent period. In this case, the child AP dissociates and goes back to scan mode, rediscovers the parent on the new channel and then joins back, which causes a slightly longer (approximately 3 minutes) downtime.
- For a RAP, the channel for the downlink radio is always selected from within the DCA list, irrespective of whether the backhaul channel deselection feature is enabled or not. The behavior is different for a MAP because the MAP can pick any channel that is allowed for that domain, unless the backhaul channel deselection feature is enabled. We recommend that you have quite a few channels added to the 802.11a DCA channel list to prevent any radios getting shut down because of a lack of channels even if the backhaul channel deselection feature is not in use.
- Because the DCA list that was used for the RRM feature is also used for mesh APs through the backhaul channel deselection feature, keep in mind that any addition or deletion of channels from the DCA list will affect the channel list input to the RRM feature for nonmesh access points as well. RRM is off for mesh.
- For -M domain APs, a slightly longer time interval (25 to 50 percent more time than usual) may be required for the mesh network to come up because there is a longer list of DFS-enabled channels in the -M domain, which each AP scans before joining the parent.

Configuring Dynamic Channel Assignment

Using the controller GUI, follow these steps to specify the channels that the dynamic channel assignment (DCA) algorithm considers when selecting the channels to be used for RRM scanning. This functionality is helpful when you know that the clients do not support certain channels because they are legacy devices or they have certain regulatory restrictions.

The steps outlined in this section are only relevant to mesh networks.

Step 1 To disable the 802.11a/n or 802.11b/g/n network, follow these steps:

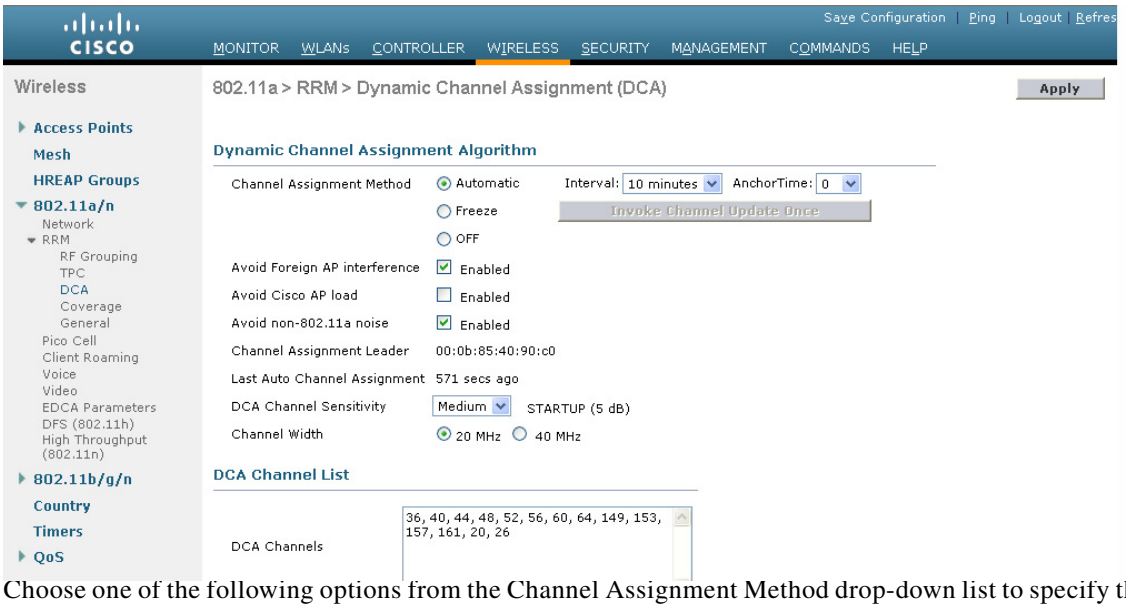
a. Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Deselect the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 2 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **DCA** to open the 802.11a (or 802.11b/g) > RRM > Dynamic Channel Assignment (DCA) page. (See Figure 9-43.)

Figure 9-43 802.11a > RRM > Dynamic Channel Assignment (DCA) Page



Step 3 Choose one of the following options from the Channel Assignment Method drop-down list to specify the controller's DCA mode:

- **Automatic**—Causes the controller to periodically evaluate and, if necessary, update the channel assignment for all joined mesh access points. This is the default value.
- **Freeze**—Causes the controller to evaluate and update the channel assignment for all joined mesh access points, if necessary, but only when you click **Invoke Channel Update Once**.

Note The controller does not evaluate and update the channel assignment immediately after you click **Invoke Channel Update Once**. It waits for the next interval to elapse.

- **OFF**—Turns off DCA and sets all mesh access point radios to the first channel of the band, which is the default value. If you choose this option, you must manually assign channels on all radios.

Step 4 From the Interval drop-down list, choose one of the following options to specify how often the DCA algorithm is allowed to run: 10 minutes, 1 hour, 2 hours, 3 hours, 4 hours, 6 hours, 8 hours, 12 hours, or 24 hours. The default value is 10 minutes.

Step 5 From the AnchorTime drop-down list, choose a number to specify the time of day when the DCA algorithm is to start. The options are numbers between 0 and 23 (inclusive) representing the hour of the day from 12:00 a.m. to 11:00 p.m.

Step 6 Select the **Avoid Foreign AP Interference** check box to cause the controller's RRM algorithms to consider 802.11 traffic from foreign access points (those access points not included in your wireless network) when assigning channels to lightweight access points, or deselect it to disable this feature. For example, RRM may adjust the channel assignment to have access points avoid channels close to foreign access points. The default value is checked.

Step 7 Select the **Avoid Cisco AP Load** check box to cause the controller's RRM algorithms to consider 802.11 traffic from Cisco lightweight access points in your wireless network when assigning channels, or deselect it to disable this feature. For example, RRM can assign better reuse patterns to access points that carry a heavier traffic load. The default value is deselected.

Step 8 Select the **Avoid Non-802.11a (802.11b) Noise** check box to cause the controller's RRM algorithms to consider noise (non-802.11 traffic) in the channel when assigning channels to lightweight access points, or deselect it to disable this feature. For example, RRM may have access points avoid channels with significant interference from nonaccess point sources, such as microwave ovens. The default value is checked.

Step 9 From the DCA Channel Sensitivity drop-down list, choose one of the following options to specify how sensitive the DCA algorithm is to environmental changes such as signal, load, noise, and interference when determining whether to change channels:

- **Low**—The DCA algorithm is not particularly sensitive to environmental changes.
- **Medium**—The DCA algorithm is moderately sensitive to environmental changes.
- **High**—The DCA algorithm is highly sensitive to environmental changes.

The default value is *Medium*. The DCA sensitivity thresholds vary by radio band, as noted in Table 9-9.

Table 9-9 DCA Sensitivity Thresholds

Option	2.4-GHz DCA Sensitivity Threshold	5-GHz DCA Sensitivity Threshold
High	5 dB	5 dB
Medium	15 dB	20 dB
Low	30 dB	35 dB

Step 10 For 802.11a/n networks only, choose one of the following Channel Width options to specify the channel bandwidth supported for all 802.11n radios in the 5-GHz band:

- **20 MHz**—The 20-MHz channel bandwidth (default)

Note To override the globally configured DCA channel width setting, you can statically configure an access point's radio for 20-MHz mode on the 802.11a/n Cisco APs > Configure page. If you ever change the static RF channel assignment method to Global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using.

This page also shows the following nonconfigurable channel parameter settings:

- **Channel Assignment Leader**—The MAC address of the RF group leader, which is responsible for channel assignment.
- **Last Auto Channel Assignment**—The last time RRM evaluated the current channel assignments.

Step 11 In the DCA Channel List section, the DCA Channels field shows the channels that are currently selected. To choose a channel, select its check box in the Select column. To exclude a channel, deselect its check box.

Range:
802.11a—36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140, 149, 153, 157, 161, 165, 190, 196
802.11b/g—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Default:
802.11a—36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140, 149, 153, 157, 161
802.11b/g—1, 6, 11

Note These extended UNII-2 channels in the 802.11a band do not appear in the channel list: 100, 104, 108, 112, 116, 132, 136, and 140. If you have Cisco Aironet 1500 series mesh access points in the -E regulatory domain, you must include these channels in the DCA channel list before you start operation. If you are upgrading from a previous release, verify that these channels are included in the DCA channel list. To include these channels in the channel list, select the **Extended UNII-2 Channels** check box.

Step 12 If you are using AP1500s in your network, you must set the 4.9-GHz channels in the 802.11a band on which they are to operate. The 4.9-GHz band is for public safety client access traffic only. To choose a 4.9-GHz channel, select its check box in the Select column. To exclude a channel, deselect its check box.

Range:
802.11a—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26

Default**:**
802.11a—20, 26

Step 13 Click **Apply** to commit your changes.

Step 14 To reenable the 802.11a or 802.11b/g network, follow these steps:

a. Click **Wireless** > **802.11a/n** or **802.11b/g/n** > **Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Select the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 15 Click **Save Configuration** to save your changes.

To see why the DCA algorithm changed channels, click **Monitor** and then **View All** under Most Recent Traps. The trap provides the MAC address of the radio that changed channels, the previous channel and the new channel, the reason why the change occurred, the energy before and after the change, the noise before and after the change, and the interference before and after the change.

Configuring Advanced Features

This section includes the following topics:

Using the 2.4-GHz Radio for Backhaul

Until the 7.0 release, mesh used the 5-GHz radio for backhaul, and the 2.4-GHz radio was used only for client access. The reasons for using only the 5-GHz radio for backhaul are as follows:

- More channels are available
- More EIRP is available
- Less interference occurs
- Most of the client access occurs over the 2.4-GHz band

However, under certain conditions, such as dense foliage areas, you might have needed to use the 2.4-GHz band for a backhaul because it has better penetration.

With the 7.0.116.0 release, you can configure an entire mesh network to use a single backhaul that can be either 5 GHz or 2.4 GHz.

Caution This feature is available only for AP1522 (two radios). This feature should be used only after exploring the 5-GHz backhaul option.

Caution We recommend that you use 5 GHz as the first option and use 2.4 GHz only if the 5-GHz option does not work.

Changing the Backhaul from 5 GHz to 2.4 GHz

When you specify only the RAP name as an argument to the command, the whole mesh sector changes to 2.4 GHz or 5 GHz backhaul. The warning messages indicate the change in backhaul, whether it is from 2.4 GHz to 5 GHz or vice versa.

Note The 2.4-GHz backhaul cannot be configured using the controller user interface, but only through the CLI.

To change the backhaul from 5 GHz to 2.4 GHz, follow these steps:

Step 1 To change the backhaul, enter the following command:

```
(Cisco Controller) > config mesh backhaul slot 0 enable RAP
```

The following message appears;

```
Warning! Changing backhaul slot will bring down the mesh for renegotiation!!!
After backhaul is changed, 5 GHz client access channels need to be changed manually

Are you sure you want to continue? (y/N)
```

Step 2 Press **y**.

Note When you change the 5-GHz backhaul to local client access, the 5-GHz client access frequencies on all the APs are the same, because the backhaul frequency is ported on these 5-GHz radios for client access. You need to configure these channels for a better frequency planning.

Changing the Backhaul from 2.4 GHz to 5 GHz

To change the backhaul from 2.4 GHz to 5 GHz, follow these steps:

Step 1 To change the backhaul, enter the following command:

```
(Cisco Controller) > config mesh backhaul slot 1 enable RAP
```

The following message appears:

```
Warning! Changing backhaul slot will bring down the mesh for renegotiation!!!
Are you sure you want to continue? (y/N)
```

Step 2 Press **y**.

Note You cannot configure the 2.4-GHz backhaul using the controller GUI, but you can configure the 2.4-GHz backhaul using the CLI.

Verifying the Current Backhaul in Use

To verify the current backhaul in use, enter the following command:

```
(Cisco Controller) > show mesh backhaul AP_name
```

Note For a 5-GHz backhaul, dynamic frequency selection (DFS) occurs only on 5 GHz and not on 2.4 GHz. The mechanism, which differs for RAP and MAP, is called a coordinated change mechanism.

When 5 GHz is converted to client access from the backhaul or 2.4 GHz is being used as backhaul, DFS works similar to how it works for a local mode AP. DFS is detected on a 5-GHz client access, and the request is sent to the controller for a new channel. Mesh adjacency is not affected for the 2.4-GHz backhaul.

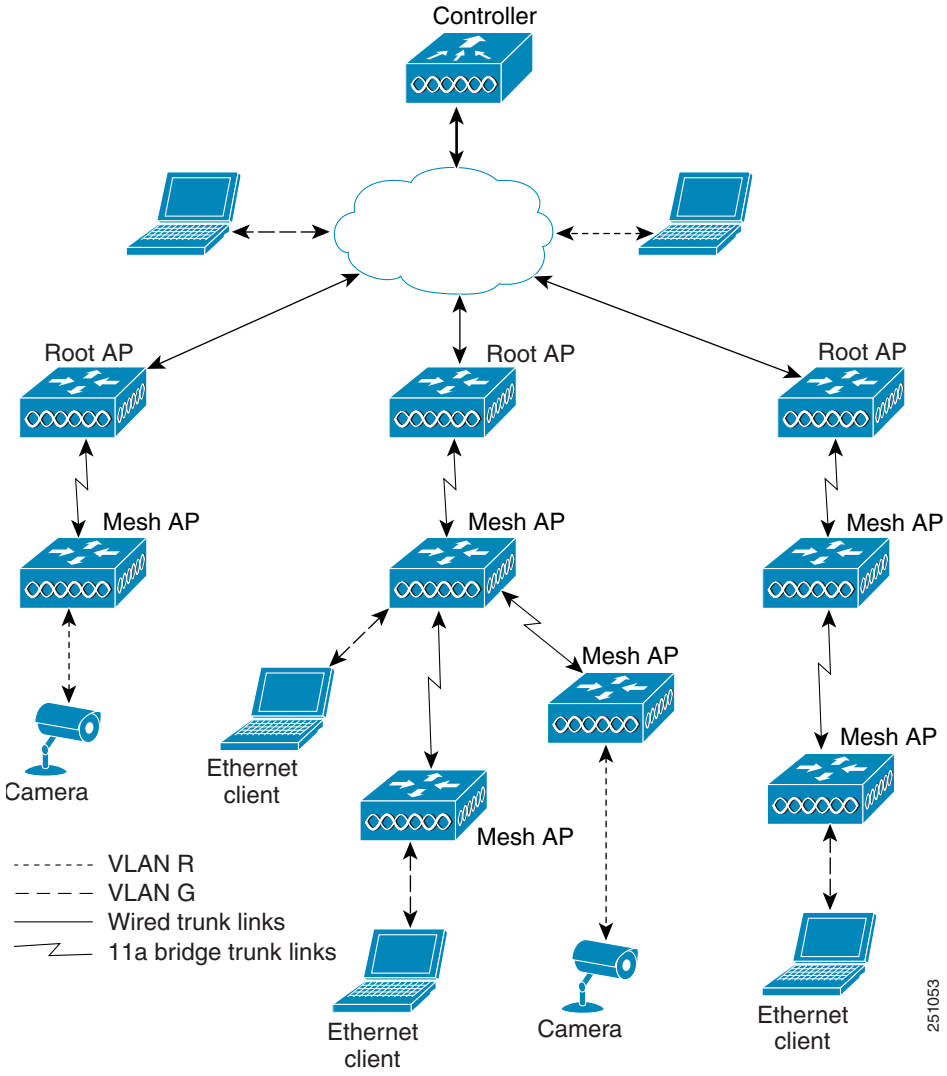
Note Universal client access is available on the 2.4-GHz backhaul.

Configuring Ethernet VLAN Tagging

Ethernet VLAN tagging allows specific application traffic to be segmented within a wireless mesh network and then forwarded (bridged) to a wired LAN (access mode) or bridged to another wireless mesh network (trunk mode).

A typical public safety access application that uses Ethernet VLAN tagging is the placement of video surveillance cameras at various outdoor locations within a city. Each of these video cameras has a wired connection to a MAP. The video of all these cameras is then streamed across the wireless backhaul to a central command station on a wired network (see Figure 9-44).

Figure 9-44 Ethernet VLAN Tagging



Ethernet Port Notes

Ethernet VLAN tagging allows Ethernet ports to be configured as normal, access, or trunk in both indoor and outdoor implementations:

Note When VLAN Transparent is disabled, the default Ethernet port mode is normal. VLAN Transparent must be disabled for VLAN tagging to operate and to allow configuration of Ethernet ports. To disable VLAN Transparent, which is a global parameter, see the "Configuring Global Mesh Parameters" section on page 9-35.

- Normal mode—In this mode, the Ethernet port does not accept or send any tagged packets. Tagged frames from clients are dropped.

  Use the normal mode in applications when only a single VLAN is in use or there is no need to segment traffic in the network across multiple VLANs.

- Access Mode—In this mode, only untagged packets are accepted. All incoming packets are tagged with user-configured VLANs called access-VLANs.

  Use the access mode for applications in which information is collected from devices connected to the MAP, such as cameras or PCs, and then forwarded to the RAP. The RAP then applies tags and forwards traffic to a switch on the wired network.

- Trunk mode—This mode requires the user to configure a native VLAN and an allowed VLAN list (no defaults). In this mode, both tagged and untagged packets are accepted. Untagged packets are accepted and are tagged with the user-specified native VLAN. Tagged packets are accepted if they are tagged with a VLAN in the allowed VLAN list.

- Use the trunk mode for bridging applications such as forwarding traffic between two MAPs that reside on separate buildings within a campus.

Ethernet VLAN tagging operates on Ethernet ports that are not used as backhauls.

Ethernet VLAN Tagging Guidelines

Follow these guidelines for Ethernet tagging:

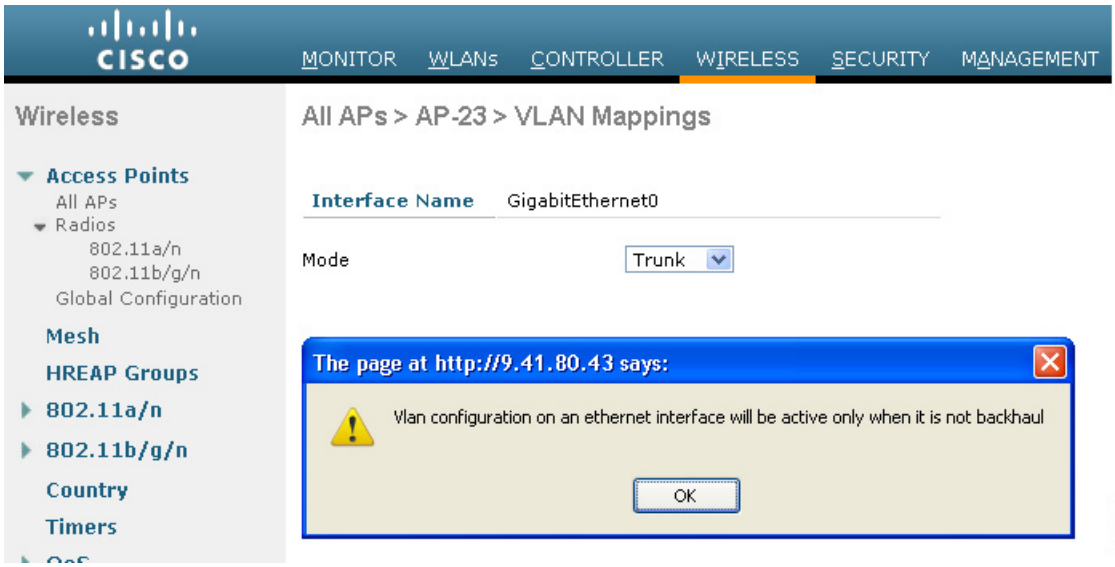
- For security reasons, the Ethernet port on a mesh access point (RAP and MAP) is disabled by default. It is enabled by configuring Ethernet bridging on the mesh access point port.
- Ethernet bridging must be enabled on all the mesh access points in the mesh network to allow Ethernet VLAN tagging to operate.
- VLAN mode must be set as non-VLAN transparent (global mesh parameter). See the "Configuring Global Mesh Parameters Using the CLI" section on page 9-40. VLAN transparent is enabled by default. To set as non-VLAN transparent, you must deselect the VLAN transparent option in the global mesh parameters page (see Figure 9-45).

Figure 9-45 Wireless > Mesh Page

- VLAN tagging can only be configured on Ethernet interfaces as follows:
  - On AP1500s, three of the four ports can be used as secondary Ethernet interfaces: port 0-PoE in, port 1-PoE out, and port 3- fiber. Port 2 - cable cannot be configured as a secondary Ethernet interface.
  - In Ethernet VLAN tagging, port 0-PoE in on the RAP is used to connect to the trunk port of the switch of the wired network. Port 1-PoE out on the MAP is used to connect to external devices such as video cameras.

- Backhaul interfaces (802.11a radios) act as primary Ethernet interfaces. Backhauls function as trunks in the network and carry all VLAN traffic between the wireless and wired network. No configuration of primary Ethernet interfaces is required.
- For indoor mesh networks, the VLAN tagging feature functions as it does for outdoor mesh networks. Any access port that is not acting as a backhaul is *secondary* and can be used for VLAN tagging.
- VLAN tagging cannot be implemented on RAPs because the RAPs do not have a secondary Ethernet port, and the primary port is used as a backhaul. However, VLAN tagging can be enabled on MAPs with a single Ethernet port because the Ethernet port on a MAP does not function as a backhaul and is therefore a secondary port.
- No configuration changes are applied to any Ethernet interface acting as a backhaul. A warning displays if you attempt to modify the backhaul's configuration. The configuration is only applied after the interface is no longer acting as a backhaul (see Figure 9-46).

Figure 9-46 Warning Message Displays for Backhaul Configuration Attempts



- No configuration is required to support VLAN tagging on any 802.11a backhaul Ethernet interface within the mesh network as follows:
  - This includes the RAP uplink Ethernet port. The required configuration occurs automatically using a registration mechanism.
  - Any configuration changes to an 802.11a Ethernet link acting as a backhaul are ignored and a warning results. When the Ethernet link no longer functions as a backhaul, the modified configuration is applied.
- VLAN configuration is not allowed on port-02-cable modem port of AP1500s (wherever applicable). VLANs can be configured on ports 0 (PoE-in), 1 (PoE-out), and 3 (fiber).
- Up to 16 VLANs are supported on each sector. The cumulative number of VLANs supported by a RAP's children (MAP) cannot exceed 16.
- The switch port connected to the RAP must be a trunk:
  - The trunk port on the switch and the RAP trunk port must match.
  - The RAP must always connect to the native VLAN ID 1 on a switch. The RAP's primary Ethernet interface is by default the native VLAN of 1.

  - The switch port in the wired network that is attached to the RAP (port 0–PoE in) must be configured to accept tagged packets on its trunk port. The RAP forwards all tagged packets received from the mesh network to the wired network.
  - No VLANs, other than those destined for the mesh sector, should be configured on the switch trunk port.
- A configured VLAN on a MAP Ethernet port cannot function as a Management VLAN.
- Configuration is effective only when a mesh access point is in the CAPWAP RUN state and VLAN-Transparent mode is disabled.
- Whenever there roaming or a CAPWAP restart, an attempt is made to apply configuration again.

VLAN Registration

To support a VLAN on a mesh access point, all the uplink mesh access points must also support the same VLAN to allow segregation of traffic that belongs to different VLANs. The activity by which an mesh access point communicates its requirements for a VLAN and gets response from a parent is known as VLAN registration.

Note VLAN registration occurs automatically. No user intervention is required.

VLAN registration is summarized below:

1. Whenever an Ethernet port on a mesh access point is configured with a VLAN, the port requests its parent to support that VLAN.
2. If the parent is able to support the request, it creates a bridge group for the VLAN and propagates the request to its parent. This propagation continues until the RAP is reached.
3. When the request reaches the RAP, it checks whether it is able to support the VLAN request. If yes, the RAP creates a bridge group and a subinterface on its uplink Ethernet interface to support the VLAN request.
4. If the mesh access point is not able to support the VLAN request by its child, at any point, the mesh access point replies with a negative response. This response is propagated to downstream mesh access points until the mesh access point that requested the VLAN is reached.
5. Upon receiving negative response from its parent, the requesting mesh access point defers the configuration of the VLAN. However, the configuration is stored for future attempts. Given the dynamic nature of mesh, another parent and its uplink mesh access points might be able to support it in the case of roaming or a CAPWAP reconnect.

Enabling Ethernet VLAN Tagging Using the GUI

You must enable Ethernet bridging before you can configure VLAN tagging. See the "Configuring Ethernet Bridging" procedure on page 9-52.

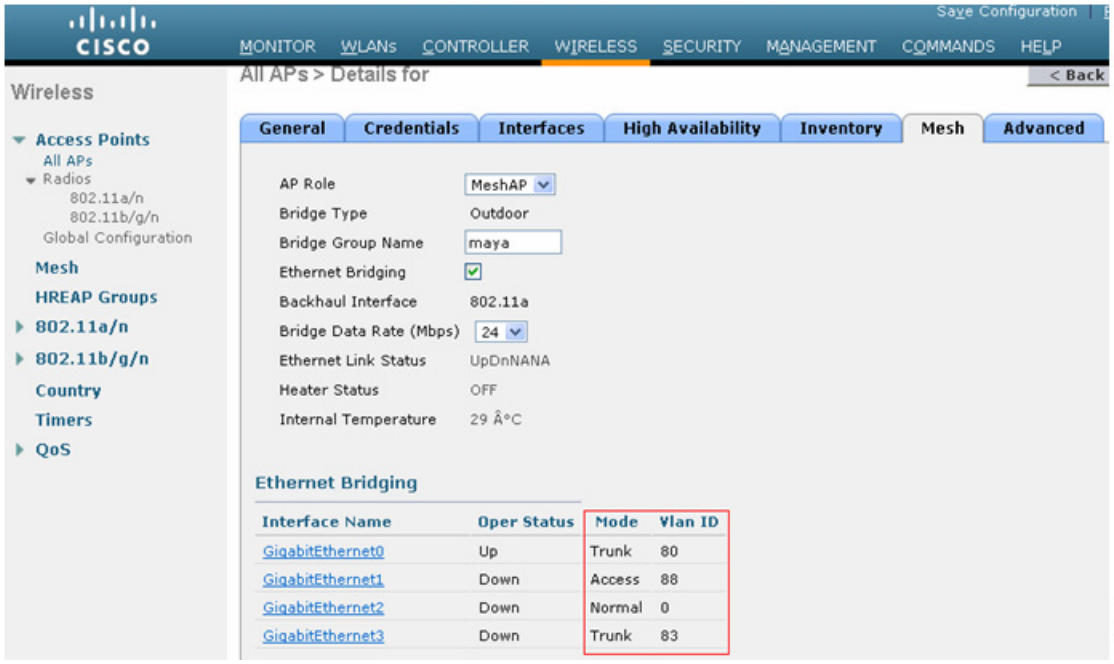
To enable VLAN tagging on a RAP or MAP using the GUI, follow these steps:

Step 1 After enabling Ethernet bridging, choose **Wireless > All APs**.

Step 2 Click the AP name link of the mesh access point on which you want to enable VLAN tagging.

Step 3 On the details page, select the **Mesh** tab. (See Figure 9-47.)

Figure 9-47 All APs > Details for (Mesh) Page



Step 4 Select the **Ethernet Bridging** check box to enable the feature and click **Apply**.

An Ethernet Bridging section appears at the bottom of the page listing each of the four Ethernet ports of the mesh access point.

- If configuring a MAP *access* port, click, for example, **gigabitEthernet1** (port 1-PoE out).
  a. Select **access** from the mode drop-down list. (See Figure 9-48.)
  b. Enter a VLAN ID. The VLAN ID can be any value between 1 and 4095.
  c. Click **Apply**.

Note VLAN ID 1 is not reserved as the default VLAN.

Note A maximum of 16 VLANs are supported across all of a RAP's subordinate MAP.

Figure 9-48 VLAN Access Mode

- If configuring a RAP or MAP *trunk* port, click **gigabitEthernet0** (port 0-PoE in).

a. Select **trunk** from the mode drop-down list. (See Figure 9-49.)

b. Specify a native VLAN ID for *incoming* traffic. The native VLAN ID can be any value between 1 and 4095. Do not assign any value assigned to a user-VLAN (access).

c. Click **Apply**.

A trunk VLAN ID field and a summary of configured VLANs appears at the bottom of the screen. The trunk VLAN ID field is for outgoing packets.

d. Specify a trunk VLAN ID for *outgoing* packets:

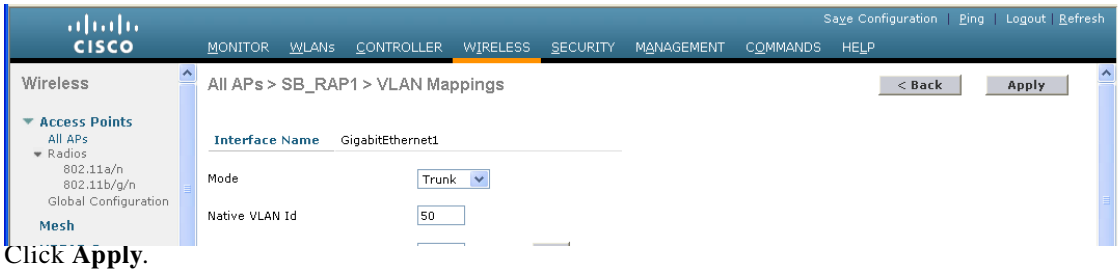
If forwarding *untagged* packets, do not change the default trunk VLAN ID value of zero. (MAP-to-MAP bridging, campus environment)

If forwarding *tagged* packets, enter a VLAN ID (1 to 4095) that is not already assigned. (RAP to switch on wired network).

e. Click **Add** to add the trunk VLAN ID to the allowed VLAN list. The newly added VLAN displays under the Configured VLANs section on the page.

Note To remove a VLAN from the list, select the Remove option from the arrow drop-down list to the right of the desired VLAN.

Figure 9-49 All APs > AP > VLAN Mappings Page



Step 5 Click **Apply**.

Step 6 Click **Save Configuration** to save your changes.

Configuring Ethernet VLAN Tagging Using the CLI

To configure a MAP *access* port, enter this command:

config ap ethernet 1 mode access enable *AP1500-MAP 50*

where *AP1500-MAP* is the variable *AP_name* and *50* is the variable *access_vlan ID*

To configure a RAP or MAP *trunk* port, enter this command:

config ap ethernet 0 mode trunk enable *AP1500-MAP 60*

where *AP1500-MAP* is the variable *AP_name* and *60* is the variable *native_vlan ID*

To add a VLAN to the VLAN allowed list of the native VLAN, enter this command:

config ap ethernet 0 mode trunk add *AP1500-MAP3 65*

where *AP1500-MAP 3* is the variable *AP_name* and *65* is the variable *VLAN ID*

Viewing Ethernet VLAN Tagging Configuration Details Using the CLI

To view VLAN configuration details for Ethernet interfaces on a specific mesh access point (*AP Name*) or all mesh access points (*summary*), enter one of the following commands:

```
(Cisco Controller) >show ap config ethernet

summary         For all APs
<AP Name>       For specific AP
(Cisco Controller) >show ap config ethernet AP-23

Vlan Tagging Information For AP AP-23
  Ethernet 0
    Mode: TRUNK
      Native Vlan 80
      Allowed Vlans: 81 83
  Ethernet 1
    Mode: ACCESS
      Access Vlan 88
  Ethernet 2
    Mode: NORMAL
  Ethernet 3
    Mode: TRUNK
      Native Vlan 83
      Allowed Vlans: 81 87 89
```

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To see if VLAN transparent mode is enabled or disabled, enter the following command:

```
(Cisco Controller) >show mesh config

Mesh Range..................................... 12000
Backhaul with client access status.............. disabled
Background Scanning State...................... enabled

Mesh Security
   Security Mode............................... EAP
   External-Auth............................... disabled
   Use MAC Filter in External AAA server....... disabled
   Force External Authentication............... disabled

Mesh Alarm Criteria
   Max Hop Count............................... 4
   Recommended Max Children for MAP............ 10
   Recommended Max Children for RAP............ 20
   Low Link SNR................................ 12
   High Link SNR............................... 60
   Max Association Number...................... 10
   Association Interval........................ 60 minutes
   Parent Change Numbers....................... 3
   Parent Change Interval...................... 60 minutes

--More-- or (q)uit

Mesh Multicast Mode............................ In-Out
Mesh Full Sector DFS........................... enabled

Mesh Ethernet Bridging VLAN Transparent Mode..... disabled
```

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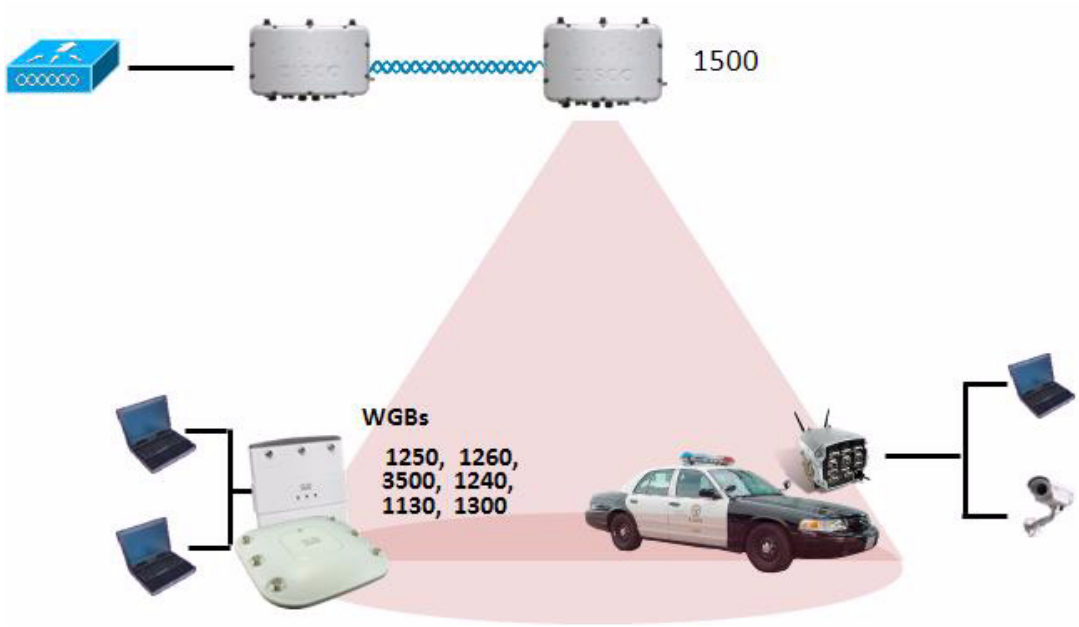
Workgroup Bridge Interoperability with Mesh Infrastructure

A workgroup bridge (WGB) is a small standalone unit that can provide a wireless infrastructure connection for Ethernet-enabled devices. Devices that do not have a wireless client adapter to connect to the wireless network can be connected to the WGB through the Ethernet port. The WGB is associated with the root AP through the wireless interface, which means that wired clients get access to the wireless network.

A WGB is used to connect wired networks over a single wireless segment by informing the mesh access point of all the clients that the WGB has on its wired segment via IAPP messages. The data packets for WGB clients contain an additional MAC address in the 802.11 header (4 MAC headers, versus the normal 3 MAC data headers). The additional MAC in the header is the address of the WGB itself. This additional MAC address is used to route the packet to and from the clients.

WGB association is supported on all radios of every mesh access point (see Figure 9-50).

Figure 9-50 WGB Example



In the current architecture, while an autonomous AP functions as a workgroup bridge, only one radio interface is used for controller connectivity, Ethernet interface for wired client connectivity, and other radio interface for wireless client connectivity. dot11radio 1 (5 GHz) can be used to connect to a controller (using the mesh infrastructure) and Ethernet interface for wired clients. dot11radio 0 (2.4 GHz) can be used for wireless client connectivity. Depending on the requirement, dot11radio 1 or dot11radio 0 can be used for client association or controller connectivity.

With the 7.0 release, a wireless client on the second radio of the WGB is not dissociated by the WGB upon losing its uplink to a wireless infrastructure or in a roaming scenario.

With two radios, one radio can be used for client access and the other radio can be used for accessing the access points. Having two independent radios performing two independent functions provides you better control and lowers the latency. Also, wireless clients on the second radio for the WGB do not get disassociated by the WGB when an uplink is lost or in a roaming scenario. One radio has to be configured as a Root AP (radio role) and the second radio has to be configured as a WGB (radio role).

Note If one radio is configured as a WGB, then the second radio cannot be a WGB or a repeater.

The following features are not supported for use with a WGB:

- Hybrid REAP
- Idle timeout
- Web authentication—If a WGB associates to a web-authentication WLAN, the WGB is added to the exclusion list, and all of the WGB-wired clients are deleted (web-authentication WLAN is another name for a guest WLAN).
- For wired clients behind the WGB, MAC filtering, link tests, and idle timeout

Configuring Workgroup Bridges

A workgroup bridge (WGB) is used to connect wired networks over a single wireless segment by informing the mesh access point of all the clients that the WGB has on its wired segment via IAPP messages. In addition to the IAPP control messages, the data packets for WGB clients contain an extra MAC address in the 802.11 header (4 MAC headers, versus the normal 3 MAC data headers). The extra MAC in the header is the address of the workgroup bridge itself. This extra MAC address is used to route the packet to and from the clients.

WGB association is supported on both the 2.4-GHz (802.11b/g) and 5-GHz (802.11a) radios on the AP1522, and the 2.4-GHz (802.11b) and 4.9-GHz (public safety) radios on the AP1524PS;

Supported platforms are autonomous WGBs AP1130, AP1240, AP1310, and the Cisco 3200 Mobile Router (*hereafter* referred to as Cisco 3200) which are configured as WGBs can associate with a mesh access point. See the "Cisco Workgroup Bridges" section in Chapter 7 of the *Cisco Wireless LAN Controller Configuration Guide, Release 7.0.116.0* for configuration steps at http://www.cisco.com/en/US/products/ps6366/products_installation_and_configuration_guides_list.html

Supported Workgroup Bridge Modes and Capacities

The supported WGB modes and capacities are as follows:

- The autonomous access points configured as WGBs must be running Cisco IOS release 12.4.25d-JA or later.

  Note If your mesh access point has two radios, you can only configure workgroup bridge mode on one of the radios. We recommend that you disable the second radio. Workgroup bridge mode is not supported on access points with three radios such as the AP1524SB.

- Client mode WGB (BSS) is supported; however, infrastructure WGB is not supported. The client mode WGB is not able to trunk VLAN as in an infrastructure WGB.
- Multicast traffic is not reliably transmitted to WGB because no ACKs are returned by the client. Multicast traffic is unicast to infrastructure WGB, and ACKs are received back.
- If one radio is configured as a WGB in a Cisco IOS access point, then the second radio cannot be a WGB or a repeater.
- Mesh access points can support up to 200 clients including wireless clients, WGB, and wired clients behind the associated WGB.
- A WGB cannot associate with mesh access points if the WLAN is configured with WPA1 (TKIP) +WPA2 (AES), and the corresponding WGB interface is configured with only one of these encryptions (either WPA1 or WPA2):
  - Figure 9-51 displays WPA security settings for WGB (controller GUI).
  - Figure 9-52 displays WPA-2 security settings for WGB (controller GUI).

Figure 9-51 WPA Security Settings for a WGB

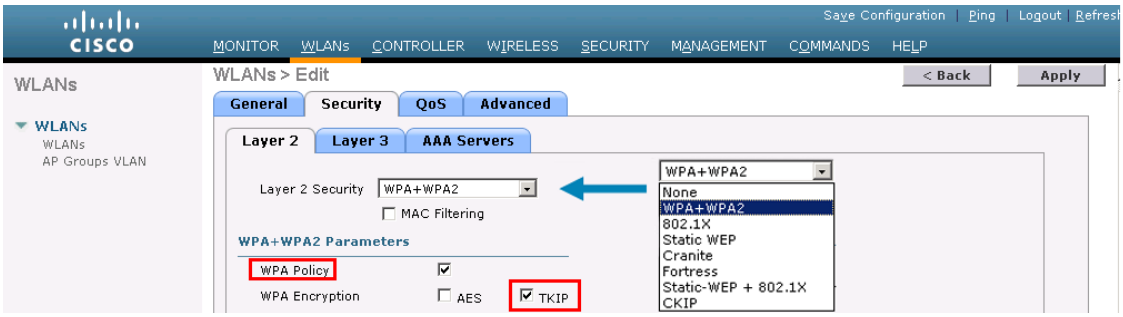
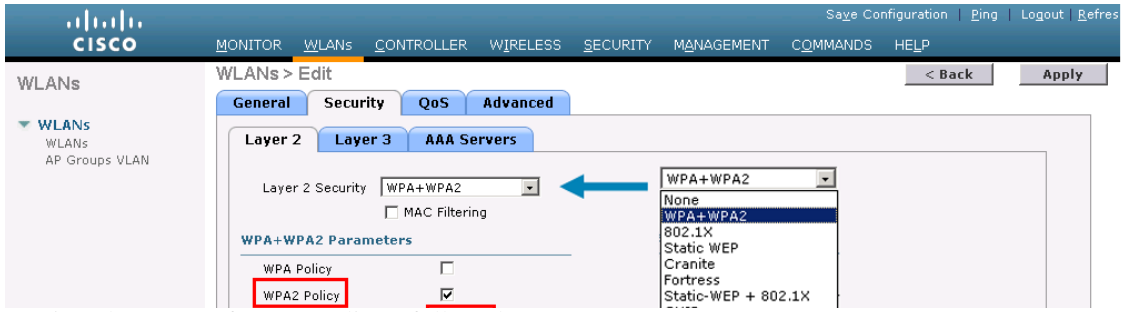


Figure 9-52 WPA-2 Security Settings for a WGB



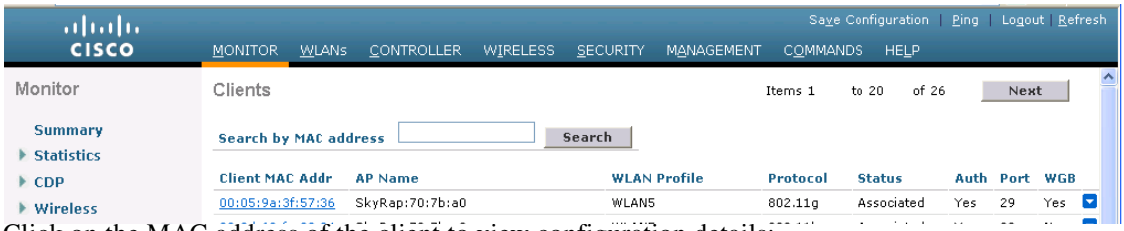
To view the status of a WGB client, follow these steps:

Step 1 Choose **Monitor > Clients**.

Step 2 On the client summary page, click on the MAC address of the client or search for the client using its MAC address.

Step 3 In the page that appears, note that the client type is identified as a WGB (far right). (See Figure 9-53.)

Figure 9-53 Clients are Identified as a WGB



Step 4 Click on the MAC address of the client to view configuration details:

- For a wireless client, the page seen in Figure 9-54 appears.
- For a wired client, the page seen in Figure 9-55 appears.

Figure 9-54 Monitor > Clients > Detail Page (Wireless WGB Client)

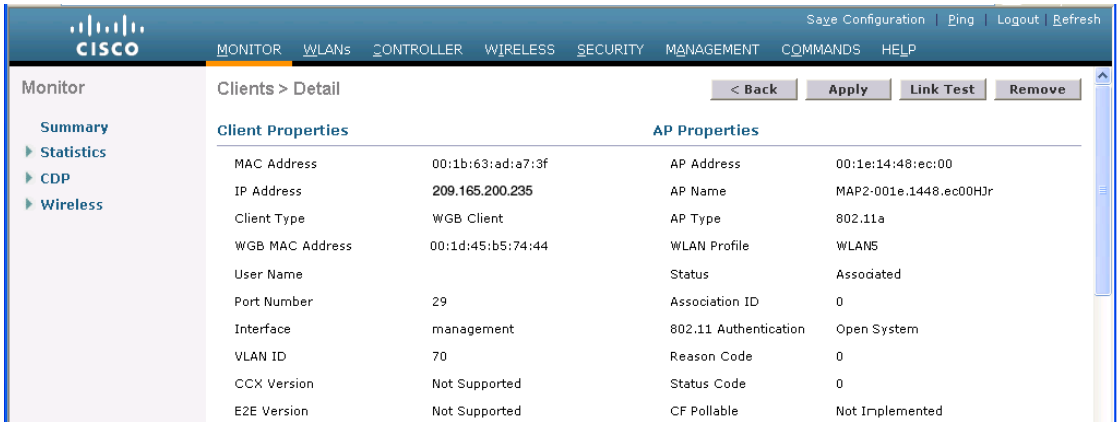
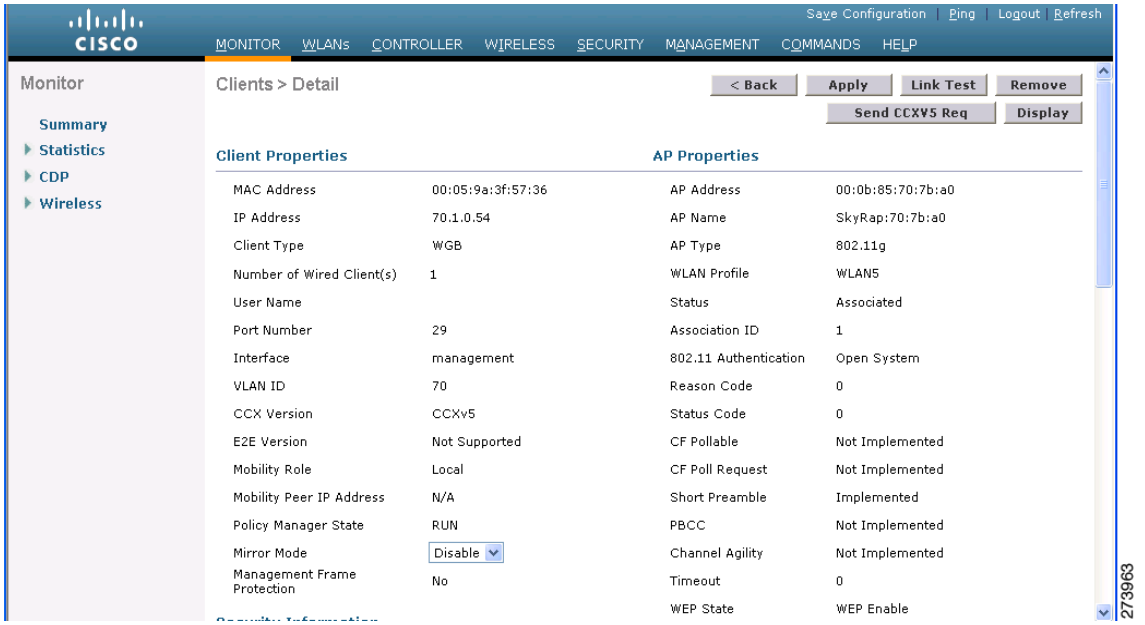


Figure 9-55 Monitor > Clients > Detail Page (Wired WGB Client)



Guidelines for Configuration

Follow these guidelines when you configure:

- We recommend using a 5-GHz radio for the uplink to Mesh AP infrastructure so you can take advantage of a strong client access on two 5-GHz radios available on mesh access points. A 5-GHz band allows more Effective Isotropic Radiated Power (EIRP) and is less polluted. In a two-radio WGB, configure 5-GHz radio (radio 1) mode as WGB. This radio will be used to access the mesh infrastructure. Configure the second radio 2.4-GHz (radio 0) mode as Root for client access.

- On the Autonomous access points, only one SSID can be assigned to the native VLAN. You cannot have multiple VLANs in one SSID on the autonomous side. SSID to VLAN mapping should be unique because this is the way to segregate traffic on different VLANs. In a unified architecture, multiple VLANs can be assigned to one WLAN (SSID).
- Only one WLAN (SSID) for wireless association of the WGB to the access point infrastructure is supported. This SSID should be configured as an infrastructure SSID and should be mapped to the native VLAN.
- A dynamic interface should be created in the controller for each VLAN configured in the WGB.
- A second radio (2.4-GHz) on the access point should be configured for client access. You have to use the same SSID on both radios and map to the native VLAN. If you create a separate SSID, then it is not possible to map it to a native VLAN, due to the unique VLAN/SSID mapping requirements. If you try to map the SSID to another VLAN, then you do not have multiple VLAN support for wireless clients.
- All Layer 2 security types are supported for the WLANs (SSIDs) for wireless client association in WGB.
- This feature does not depend on the AP platform. On the controller side, both mesh and nonmesh APs are supported.
- There is a limitation of 20 clients in the WGB. The 20-client limitation includes both wired and wireless clients. If the WGB is talking to autonomous access points, then the client limit is very high.
- The controller treats the wireless and wired clients behind a WGB in the same manner. Features such as MAC filtering and link test are not supported for wireless WGB clients from the controller.
- If required, you can run link tests for a WGB wireless client from an autonomous AP.
- Multiple VLANs for wireless clients associated to a WGB are not supported.
- Up to 16 multiple VLANs are supported for wired clients behind a WGB from the 7.0 release and later releases.
- Roaming is supported for wireless and wired clients behind a WGB. The wireless clients on the other radio will not be dissociated by the WGB when an uplink is lost or in a roaming scenario.

We recommend that you configure radio 0 (2.4 GHz) as a Root (one of the mode of operations for Autonomous AP) and radio 1 (5 GHz) as a WGB.

Configuration Example

When you configure from the CLI, the following are mandatory:

- dot11 SSID (security for a WLAN can be decided based on the requirement).
- Map the subinterfaces in both the radios to a single bridge group.

Note A native VLAN is always mapped to bridge group 1 by default. For other VLANs, the bridge group number matches the VLAN number; for example, for VLAN 46, the bridge group is 46.

- Map the SSID to the radio interfaces and define the role of the radio interfaces.

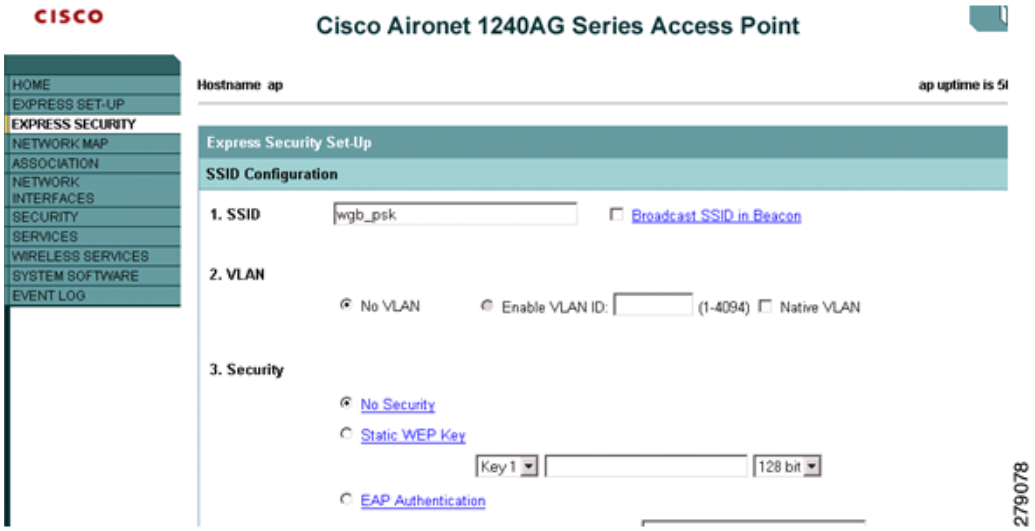
In the following example, one SSID (WGBTEST) is used in both radios, and the SSID is the infrastructure SSID mapped to NATIVE VLAN 51. All radio interfaces are mapped to bridge group -1.

```
WGB1#config t
WGB1(config)#interface Dot11Radio1.51
WGB1(config-subif)#encapsulation dot1q 51 native
```

```
WGB1(config-subif)#bridge-group 1
WGB1(config-subif)#exit
WGB1(config)#interface Dot11Radio0.51
WGB1(config-subif)#encapsulation dot1q 51 native
WGB1(config-subif)#bridge-group 1
WGB1(config-subif)#exit
WGB1(config)#dot11 ssid WGBTEST
WGB1(config-ssid)#VLAN 51
WGB1(config-ssid)#authentication open
WGB1(config-ssid)#infrastructiure-ssid
WGB1(config-ssid)#exit
WGB1(config)#interface Dot11Radio1
WGB1(config-if)#ssid WGBTEST
WGB1(config-if)#station-role workgroup-bridge
WGB1(config-if)#exit
WGB1(config)#interface Dot11Radio0
WGB1(config-if)#ssid WGBTEST
WGB1(config-if)#station-role root
WGB1(config-if)#exit
```

You can also use the GUI of an autonomous AP for configuration (see Figure 9-56). From the GUI, subinterfaces are automatically created after the VLAN is defined.

Figure 9-56 SSID Configuration Page



WGB Association Check

Both the WGB association to the controller and the wireless client association to WGB can be verified by entering the **show dot11 associations client** command in autonomous AP.

```
WGB#show dot11 associations client

802.11 Client Stations on Dot11Radio1:

SSID [WGBTEST] :

MAC Address          IP Address      Device          Name          Parent        State
0024.130f.920e       209.165.200     LWAPP-Paren     RAPSB         -             Assoc
                     .225            t
```

From the controller, choose **Monitor > Clients**. The WGB and the wireless/wired client behind the WGB are updated and the wireless/wired client are shown as the WGB client, as shown in Figure 9-57, Figure 9-58, and Figure 9-59.

Figure 9-57 Updated WGB Clients

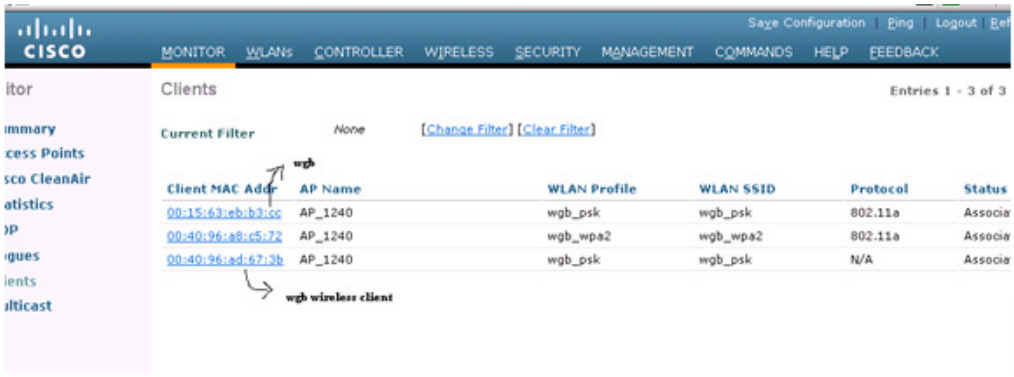
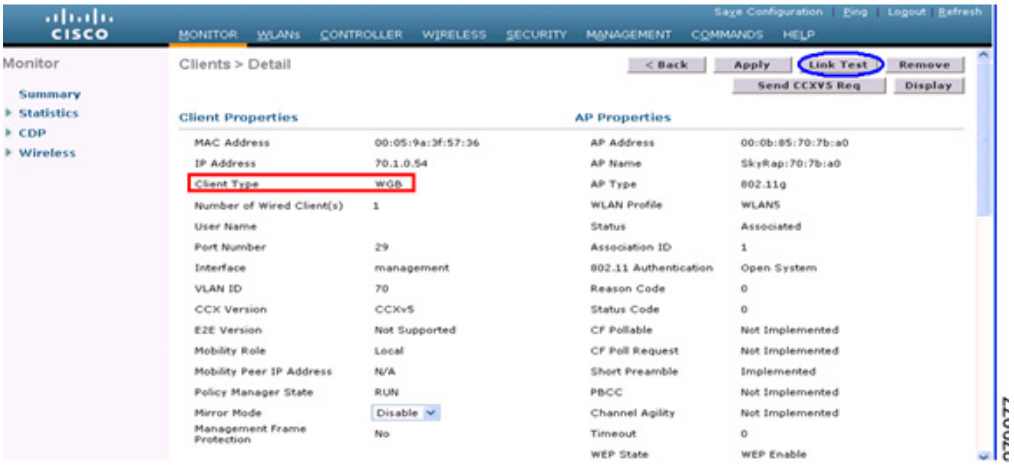


Figure 9-58 Updated WGB Clients

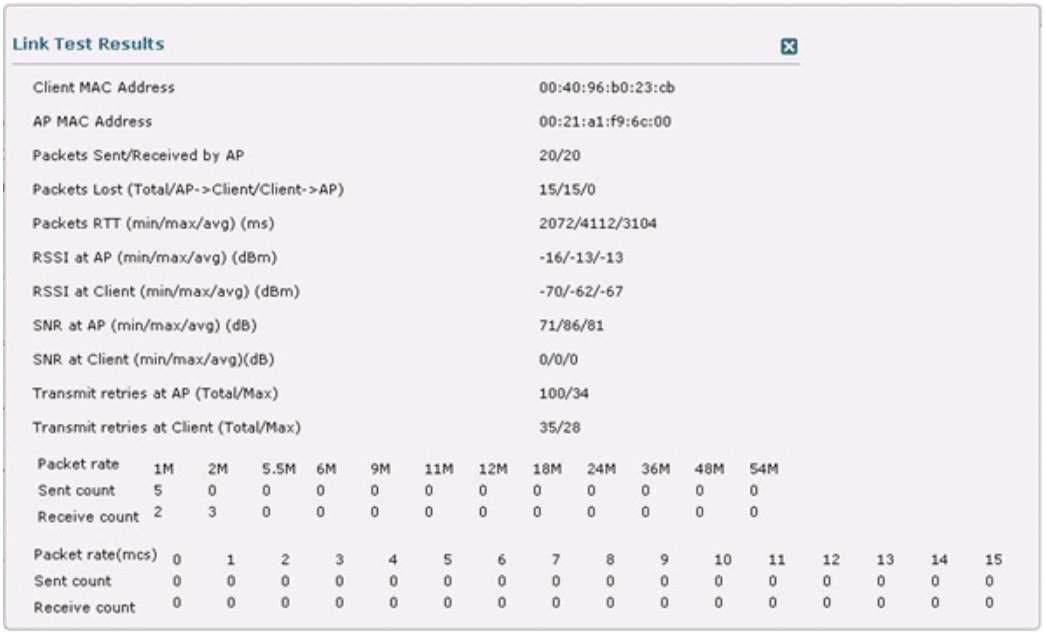
Figure 9-59 Updated WGB Clients



Link Test Result

Figure 9-60 shows the link test results.

Figure 9-60 Link Test Results



A link test can also be run from the controller CLI using the following command:

```
(Cisco Controller) > linktest client mac address
```

Link tests from the controller are only limited to the WGB, and they cannot be run beyond the WGB from the controller to a wired or wireless client connected to the WGB. You can run link tests for the wireless client connected to the WGB from the WGB itself using the following command:

```
ap#dot11 dot11Radio 0 linktest target client mac
Start linktest to 0040.96b8.d462, 100 512 byte packets
ap#

   POOR (4% lost)     Time (msec)   Strength (dBm)     SNR Quality        Retries

                                  In       Out      In       Out      In       Out

Sent: 100            Avg. 22       -37      -83      48       3        Tot. 34  35

Lost to Tgt: 4       Max. 112      -34      -78      61       10       Max. 10  5

Lost to Src: 4       Min. 0        -40      -87      15       3


Rates (Src/Tgt)      24Mb 0/5  36Mb 25/0  48Mb 73/0  54Mb 2/91
Linktest Done in 24.464 msec
```

WGB Wired/Wireless Client

You can also use the following commands to know the summary of WGBs and clients associated associated with a Cisco lightweight access point:

```
(Cisco Controller) > show wgb summary
Number of WGBs..................................... 2

MAC Address        IP Address       AP Name   Status   WLAN   Auth  Protocol  Clients

00:1d:70:97:bd:e8  209.165.200.225  c1240     Assoc    2      Yes   802.11a   2

00:1e:be:27:5f:e2  209.165.200.226  c1240     Assoc    2      Yes   802.11a   5


(Cisco Controller) > show client summary

Number of Clients.............................. 7

MAC Address        AP Name   Status      WLAN/Guest-Lan  Auth  Protocol  Port     Wired

00:00:24:ca:a9:b4  R14       Associated  1               Yes   N/A       29       No

00:24:c4:a0:61:3a  R14       Associated  1               Yes   802.11a   29       No

00:24:c4:a0:61:f4  R14       Associated  1               Yes   802.11a   29       No

00:24:c4:a0:61:f8  R14       Associated  1               Yes   802.11a   29       No

00:24:c4:a0:62:0a  R14       Associated  1               Yes   802.11a   29       No

00:24:c4:a0:62:42  R14       Associated  1               Yes   802.11a   29       No

00:24:c4:a0:71:d2  R14       Associated  1               Yes   802.11a   29       No


(Cisco Controller) > show wgb detail 00:1e:be:27:5f:e2

Number of wired client(s): 5

MAC Address        IP Address        AP Name     Mobility   WLAN  Auth

00:16:c7:5d:b4:8f  Unknown           c1240       Local      2     No

00:21:91:f8:e9:ae  209.165.200.232   c1240       Local      2     Yes

00:21:55:04:07:b5  209.165.200.234   c1240       Local      2     Yes

00:1e:58:31:c7:4a  209.165.200.236   c1240       Local      2     Yes

00:23:04:9a:0b:12  Unknown           c1240       Local      2     No
```

Client Roaming

High-speed roaming of Cisco Compatible Extension (CX), version 4 (v4) clients is supported at speeds up to 70 miles per hour in outdoor mesh deployments of AP1522s and AP1524s. An example application might be maintaining communication with a terminal in an emergency vehicle as it moves within a mesh public network.

Three Cisco CX v4 Layer 2 client roaming enhancements are supported:

- Access point assisted roaming—Helps clients save scanning time. When a Cisco CX v4 client associates to an access point, it sends an information packet to the new access point listing the characteristics of its previous access point. Roaming time decreases when the client recognizes and uses an access point list built by compiling all previous access points to which each client was associated and sent (unicast) to the client immediately after association. The access point list contains the channels, BSSIDs of neighbor access points that support the client's current SSID(s), and time elapsed since disassociation.
- Enhanced neighbor list—Focuses on improving a Cisco CX v4 client's roam experience and network edge performance, especially when servicing voice applications. The access point provides its associated client information about its neighbors using a neighbor-list update unicast message.
- Roam reason report—Enables Cisco CX v4 clients to report the reason why they roamed to a new access point. It also allows network administrators to build and monitor a roam history.

Note Client roaming is enabled by default.

For more information, see the Enterprise Mobility Design Guide at http://www.cisco.com/en/US/docs/solutions/Enterprise/Mobility/emob41dg/eMob4.1.pdf

WGB Roaming Guidelines

Follow these guidelines for WGB roaming:

- Configuring a WGB for roaming—If a WGB is mobile, you can configure it to scan for a better radio connection to a parent access point or bridge. Use the ap(config-if)#**mobile station period 3 threshold 50** command to configure the workgroup bridge as a mobile station.

  When you enable this setting, the WGB scans for a new parent association when it encounters a poor Received Signal Strength Indicator (RSSI), excessive radio interference, or a high frame-loss percentage. Using these criteria, a WGB configured as a mobile station searches for a new parent association and roams to a new parent before it loses its current association. When the mobile station setting is disabled (the default setting), a WGB does not search for a new association until it loses its current association.
- Configuring a WGB for Limited Channel Scanning—In mobile environments such as railroads, a WGB instead of scanning all the channels is restricted to scan only a set of limited channels to reduce the hand-off delay when the WGB roams from one access point to another. By limiting the number of channels, the WGB scans only those required channels; the mobile WGB achieves and maintains a continuous wireless LAN connection with fast and smooth roaming. This limited channel set is configured using the ap(config-if)#**mobile station scan** *set of channels*.

  This command invokes scanning to all or specified channels. There is no limitation on the maximum number of channels that can be configured. The maximum number of channels that can be configured is restricted only by the number of channels that a radio can support. When executed, the

WGB scans only this limited channel set. This limited channel feature also affects the known channel list that the WGB receives from the access point to which it is currently associated. Channels are added to the known channel list only if they are also part of the limited channel set.

Configuration Example

The following example shows how to configure a roaming configuration:

```
ap(config)#interface dot11radio 1
ap(config-if)#ssid outside
ap(config-if)#packet retries 16
ap(config-if)#station role workgroup-bridge
ap(config-if)#mobile station
ap(config-if)#mobile station period 3 threshold 50
ap(config-if)#mobile station scan 5745 5765
```

Use the **no mobile station scan** command to restore scanning to all the channels.

Table 9-10 identifies mesh access points and their respective frequency bands that support WGB.

Table 9-10 WGB Interoperability Chart

RAP/MAP	WGB								
	MAR3200			802.11n Indoor APs		1130/1240		1310	
Backhaul	4.9 GHz (5, 10, 20 MHz)	5 GHz	2.4 GHz	5 GHz	2.4 GHz	5 GHz	2.4 GHz	5 GHz	2.4 GHz
1552/1552	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
1524SB/1524SB	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
1524PS/1524PS	Yes	No	Yes	No	Yes	No	Yes	No	Yes
1522/1522	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
1524SB/1522	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
1524PS/1522	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
1522/1524SB	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
1522/1524PS	Yes	No	Yes	No	Yes	No	Yes	No	Yes
1240/1130	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes

Troubleshooting Tips

If a wireless client is not associated with a WGB, use the following steps to troubleshoot the problem:

1. Verify the client configuration and ensure that the client configuration is correct.
2. Check the **show bridge** command output in autonomous AP, and confirm that the AP is reading the client MAC address from the right interface.
3. Confirm that the subinterfaces corresponding to specific VLANs in different interfaces are mapped to the same bridge group.
4. If required, clear the bridge entry using the **clear bridge** command (remember that this command will remove all wired and wireless clients associated in a WGB and make them associate again).

5. Check the **show dot11 association** command output and confirm that the WGB is associated with the controller.
6. Ensure that the WGB has not exceeded its 20-client limitation.

In a normal scenario, if the **show bridge** and **show dot11 association** command outputs are as expected, wireless client association should be successful.

Configuring Voice Parameters in Indoor Mesh Networks

You can configure call admission control (CAC) and QoS on the controller to manage voice and video quality on the mesh network.

The indoor mesh access points are 802.11e capable, and QoS is supported on the local 2.4-GHz access radio and the 5-GHz backhaul radio. CAC is supported on the backhaul and the CCXv4 clients (which provides CAC between the mesh access point and the client).

Note Voice is supported only on indoor mesh networks. Voice is supported on a best-effort basis in the outdoors in a mesh network.

CAC

CAC enables a mesh access point to maintain controlled quality of service (QoS) when the wireless LAN is experiencing congestion. The Wi-Fi Multimedia (WMM) protocol deployed in CCXv3 ensures sufficient QoS as long as the wireless LAN is not congested. However, to maintain QoS under differing network loads, CAC in CCXv4 or later is required.

Note CAC is supported in Cisco Compatible Extensions (CCX) v4 or later. See Chapter 6 of the *Cisco Wireless LAN Controller Configuration Guide, Release 7.0* at http://www.cisco.com/en/US/docs/wireless/controller/7.0/configuration/guide/c70sol.html

Two types of CAC are available for access points: bandwidth-based CAC and load-based CAC. All calls on a mesh network are bandwidth-based, so mesh access points use only bandwidth-based CAC.

Bandwidth-based, or static CAC enables the client to specify how much bandwidth or shared medium time is required to accept a new call. Each access point determines whether it is capable of accommodating a particular call by looking at the bandwidth available and compares it against the bandwidth required for the call. If there is not enough bandwidth available to maintain the maximum allowed number of calls with acceptable quality, the mesh access point rejects the call.

QoS and DSCP Marking

Cisco supports 802.11e on the local access and on the backhaul. Mesh access points prioritize user traffic based on classification, and therefore all user traffic is treated on a best-effort basis.

Resources available to users of the mesh vary, according to the location within the mesh, and a configuration that provides a bandwidth limitation in one point of the network can result in an oversubscription in other parts of the network.

Similarly, limiting clients on their percentage of RF is not suitable for mesh clients. The limiting resource is not the client WLAN, but the resources available on the mesh backhaul.

Similar to wired Ethernet networks, 802.11 WLANs employ Carrier Sense Multiple Access (CSMA), but instead of using collision detection (CD), WLANs use collision avoidance (CA), which means that instead of each station trying to transmit as soon as the medium is free, WLAN devices will use a collision avoidance mechanism to prevent multiple stations from transmitting at the same time.

The collision avoidance mechanism uses two values called CWmin and CWmax. CW stands for *contention window*. The CW determines what additional amount of time an endpoint should wait, after the interframe space (IFS), to attend to transmit a packet. Enhanced distributed coordination function (EDCF) is a model that allows end devices that have delay-sensitive multimedia traffic to modify their CWmin and CWmax values to allow for statically greater (and more frequent) access to the medium.

Cisco access points support EDCF-like QoS. This provides up to eight queues for QoS.

These queues can be allocated in several different ways, as follows:

- Based on TOS / DiffServ settings of packets
- Based on Layer 2 or Layer 3 access lists
- Based on VLAN
- Based on dynamic registration of devices (IP phones)

AP1500s, with Cisco controllers, provide a minimal integrated services capability at the controller, in which client streams have maximum bandwidth limits, and a more robust differentiated services (diffServ) capability based on the IP DSCP values and QoS WLAN overrides.

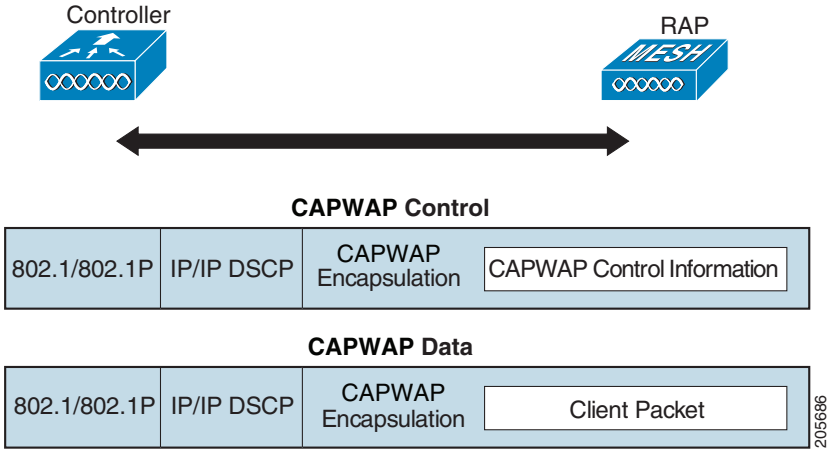
When the queue capacity has been reached, additional frames are dropped (tail drop).

Encapsulations

Several encapsulations are used by the mesh system. These encapsulations include CAPWAP control and data between the controller and RAP, over the mesh backhaul, and between the mesh access point and its client(s). The encapsulation of bridging traffic (noncontroller traffic from a LAN) over the backhaul is the same as the encapsulation of CAPWAP data.

There are two encapsulations between the controller and the RAP. The first is for CAPWAP control, and the second is for CAPWAP data. In the control instance, CAPWAP is used as a container for control information and directives. In the instance of CAPWAP data, the entire packet, including the Ethernet and IP headers, is sent in the CAPWAP container (see Figure 9-61).

Figure 9-61 Encapsulations

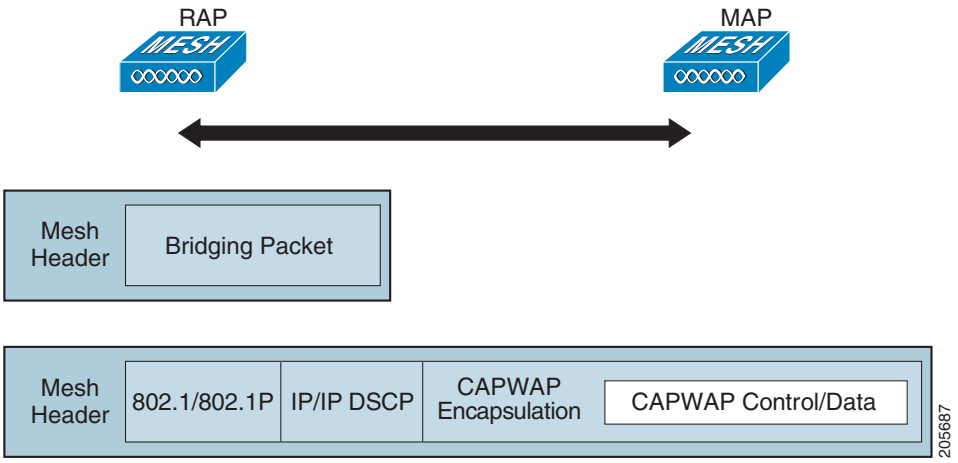


For the backhaul, there is only one type of encapsulation, encapsulating MESH traffic. However, two types of traffic are encapsulated: bridging traffic and CAPWAP control and data traffic. Both types of traffic are encapsulated in a proprietary mesh header.

In the case of bridging traffic, the entire packet Ethernet frame is encapsulated in the mesh header (see Figure 9-62).

All backhaul frames are treated identically, regardless of whether they are MAP to MAP, RAP to MAP, or MAP to RAP.

Figure 9-62 Encapsulating Mesh Traffic



Queuing on the Mesh Access Point

The mesh access point uses a high speed CPU to process ingress frames, Ethernet, and wireless on a first-come, first-serve basis. These frames are queued for transmission to the appropriate output device, either Ethernet or wireless. Egress frames can be destined for either the 802.11 client network, the 802.11 backhaul network, or Ethernet.

AP1500s support four FIFOs for wireless client transmissions. These FIFOs correspond to the 802.11e platinum, gold, silver, and bronze queues, and obey the 802.11e transmission rules for those queues. The FIFOs have a user configurable queue depth.

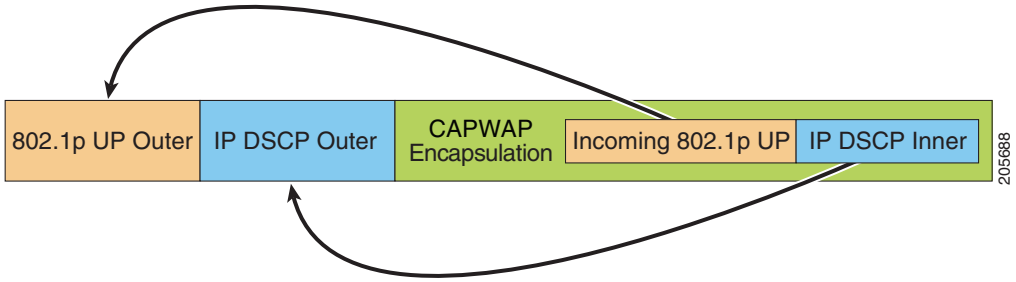
The backhaul (frames destined for another outdoor mesh access point) uses four FIFOs, although user traffic is limited to gold, silver, and bronze. The platinum queue is used exclusively for CAPWAP control traffic and voice, and has been reworked from the standard 802.11e parameters for CWmin, CWmax, and so on, to provide more robust transmission but higher latencies.

The 802.11e parameters for CWmin, CWmax, and so on, for the gold queue have been reworked to provide lower latency at the expense of slightly higher error rate and aggressiveness. The purpose of these changes is to provide a channel that is more conducive to video applications.

Frames that are destined for Ethernet are queued as FIFO, up to the maximum available transmit buffer pool (256 frames). There is support for a Layer 3 IP Differentiated Services Code Point (DSCP), so marking of the packets is there as well.

In the controller to RAP path for the data traffic, the outer DSCP value is set to the DSCP value of the incoming IP frame. If the interface is in tagged mode, the controller sets the 802.1Q VLAN ID and derives the 802.1p UP (outer) from 802.1p UP incoming and the WLAN default priority ceiling. Frames with VLAN ID 0 are not tagged (see Figure 9-63).

Figure 9-63 Controller to RAP Path



For CAPWAP control traffic the IP DSCP value is set to 46, and the 802.1p user priority is set to 7. Prior to transmission of a wireless frame over the backhaul, regardless of node pairing (RAP/MAP) or direction, the DSCP value in the outer header is used to determine a backhaul priority. The following sections describe the mapping between the four backhaul queues the mesh access point uses and the DSCP values shown in Backhaul Path QoS (see Table 9-11).

Table 9-11 Backhaul Path QoS

DSCP Value	Backhaul Queue
2, 4, 6, 8 to 23	Bronze
26, 32 to 63	Gold
46 to 56	Platinum
All others including 0	Silver

Note The platinum backhaul queue is reserved for CAPWAP control traffic, IP control traffic, and voice packets. DHCP, DNS, and ARP requests are also transmitted at the platinum QoS level. The mesh software inspects each frame to determine whether it is a CAPWAP control or IP control frame in order to protect the platinum queue from use by non-CAPWAP applications.

For a MAP to the client path, there are two different procedures, depending on whether the client is a WMM client or a normal client. If the client is a WMM client, the DSCP value in the outer frame is examined, and the 802.11e priority queue is used (see Table 9-12).

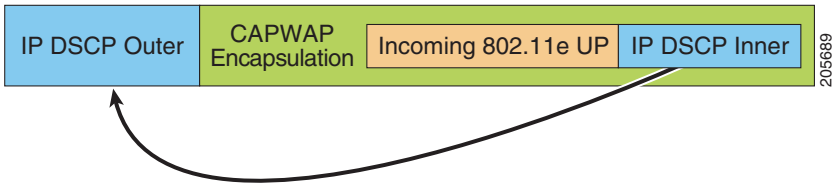
Table 9-12 MAP to Client Path QoS

DSCP Value	Backhaul Queue
2, 4, 6, 8 to 23	Bronze
26, 32 to 45, 47	Gold
46, 48 to 63	Platinum
All others including 0	Silver

If the client is not a WMM client, the WLAN override (as configured at the controller) determines the 802.11e queue (bronze, gold, platinum, or silver), on which the packet is transmitted.

For a client of a mesh access point, there are modifications made to incoming client frames in preparation for transmission on the mesh backhaul or Ethernet. For WMM clients, a MAP illustrates the way in which the outer DSCP value is set from an incoming WMM client frame (see Figure 9-64).

Figure 9-64 MAP to RAP Path



The minimum value of the incoming 802.11e user priority and the WLAN override priority is translated using the information listed in Table 9-13 to determine the DSCP value of the IP frame. For example, if the incoming frame has as its value a priority indicating the gold priority, but the WLAN is configured for the silver priority, the minimum priority of silver is used to determine the DSCP value.

Table 9-13 DSCP to Backhaul Queue Mapping

DSCP Value	802.11e UP	Backhaul Queue	Packet Types
2, 4, 6, 8 to 23	1, 2	Bronze	Lowest priority packets, if any
26, 32 to 34	4, 5	Gold	Video packets
46 to 56	6, 7	Platinum	CAPWAP control, AWPP, DHCP/DNS, ARP packets, voice packets
All others including 0	0, 3	Silver	Best effort, CAPWAP data packets

If there is no incoming WMM priority, the default WLAN priority is used to generate the DSCP value in the outer header. If the frame is an originated CAPWAP control frame, the DSCP value of 46 is placed in the outer header.

With the 5.2 code enhancements, DSCP information is preserved in an AWPP header.

All wired client traffic is restricted to a maximum 802.1p UP value of 5, except DHCP/DNS and ARP packets, which go through the platinum queue.

The non-WMM wireless client traffic gets the default QoS priority of its WLAN. The WMM wireless client traffic may have a maximum 802.11e value of 6, but it must be below the QoS profile configured for its WLAN. If admission control is configured, WMM clients must use TSPEC signaling and get admitted by CAC.

The CAPWAPP data traffic carries wireless client traffic and has the same priority and treatment as wireless client traffic.

Now that the DSCP value is determined, the rules described earlier for the backhaul path from the RAP to the MAP are used to further determine the backhaul queue on which the frame is transmitted. Frames transmitted from the RAP to the controller are not tagged. The outer DSCP values are left intact, as they were first constructed.

Bridging Backhaul Packets

Bridging services are treated a little differently from regular controller-based services. There is no outer DSCP value in bridging packets because they are not CAPWAP encapsulated. Therefore, the DSCP value in the IP header as it was received by the mesh access point is used to index into the table as described in the path from the mesh access point to the mesh access point (backhaul).

Bridging Packets from and to a LAN

Packets received from a station on a LAN are not modified in any way. There is no override value for the LAN priority. Therefore, the LAN must be properly secured in bridging mode. The only protection offered to the mesh backhaul is that non-CAPWAP control frames that map to the platinum queue are demoted to the gold queue.

Packets are transmitted to the LAN precisely as they are received on the Ethernet ingress at entry to the mesh.

The only way to integrate QoS between Ethernet ports on AP1500 and 802.11a is by tagging Ethernet packets with DSCP. AP1500s take the Ethernet packet with DSCP and places it in the appropriate 802.11e queue.

AP1500s do not tag DSCP itself:

- On the ingress port, the AP1500 sees a DSCP tag, encapsulates the Ethernet frame, and applies the corresponding 802.11e priority.
- On the egress port, the AP1500 decapsulates the Ethernet frame, and places it on the wire with an untouched DSCP field.

Ethernet devices, such as video cameras, should have the capability to mark the bits with DSCP value to take advantage of QoS.

Note QoS only is relevant when there is congestion on the network.

Guidelines For Using Voice on the Mesh Network

Follow these guidelines when you use voice on the mesh network:

- Voice is supported only on indoor mesh networks in release 5.2, 6.0, 7.0, and 7.0.116.0. For outdoors, voice is supported on a best-effort basis on a mesh infrastructure.
- When voice is operating on a mesh network, calls must not traverse more than two hops. Each sector must be configured to require no more than two hops for voice.
- RF considerations for voice networks are as follows:
  - Coverage hole of 2 to 10 percent
  - Cell coverage overlap of 15 to 20 percent
  - Voice needs RSSI and SNR values that are at least 15 dB higher than data requirements
  - RSSI of -67 dBm for all data rates should be the goal for 11b/g/n and 11a/n
  - SNR should be 25 dB for the data rate used by client to connect to the AP
  - Packet error rate (PER) should be configured for a value of one percent or less
  - Channel with the lowest utilization (CU) must be used
- On the 802.11a/n or 802.11b/g/n > *Global* parameters page, you should do the following:
  - Enable dynamic target power control (DTPC).
  - Disable all data rates less than 11 Mbps.
- On the 802.11a/n or 802.11b/g/n > *Voice* parameters page, you should do the following:
  - Load-based CAC must be disabled.

  - Enable admission control (ACM) for CCXv4 or v5 clients that have WMM enabled. Otherwise, bandwidth-based CAC does not operate properly.
  - Set the maximum RF bandwidth to 50 percent.
  - Set the reserved roaming bandwidth to 6 percent.
  - Enable traffic stream metrics.
- On the 802.11a/n or 802.11b/g/n > *EDCA* parameters page, you should do the following:
  - Set the EDCA profile for the interface as voice optimized.
  - Disable low latency MAC.
- On the QoS > *Profile* page, you should do the following:
  - Create a voice profile and select 802.1Q as the wired QoS protocol type.
- On the WLANs > *Edit* > *QoS* page, you should do the following:
  - Select a QoS of platinum for voice and gold for video on the backhaul.
  - Select allowed as the WMM policy.
- On the WLANs > *Edit* > *QoS* page, you should do the following:
  - Select CCKM for authorization (*auth*) key management (*mgmt*) if you want to support fast roaming. See the "Client Roaming" section on page 9-92.
- On the **x** > ***y*** page, you should do the following:
  - Disable voice active detection (VAD).

Voice Call Support in a Mesh Network

Table 9-14 shows the actual calls in a clean, ideal environment.

Table 9-14 Calls Possible with 1520 Series in 802.11a and 802.11b/g Radios[1]

No. of Calls	802.11a Radio	802.11b/g Radio
RAP	12	12
MAP1	7	10
MAP2	4	8

1. Traffic was bidirectional 64K voice flows. VoCoder type: G.711, PER <= 1%. Network setup was daisy-chained with no calls traversing more than 2 hops. No external interference.

Table 9-15 shows the actual calls in a clean, ideal environment.

Table 9-15 Calls Possible with 1550 Series in 802.11a/n 802.11b/g/n Radios[1]

No. of Calls	802.11a/n Radio 20 MHz	802.11a/n Radio 40 MHz	802.11b/g/n Backhaul Radio 20 MHz	802.11b/g/n Backhaul Radio 40 MHz
RAP	20	35	20	20
MAP1 (First Hop)	10	20	15	20
MAP2 (Second Hop)	8	15	10	15

1. Traffic was bidirectional 64K voice flows. VoCoder type: G.711, PER <= 1%. Network setup was daisy-chained with no calls traversing more than 2 hops. No external interference.

While making a call, observe the MOS score of the call on the 7921 phone (see Table 9-16). A MOS score between 3.5 and 4 is acceptable.

Table 9-16 MOS Ratings

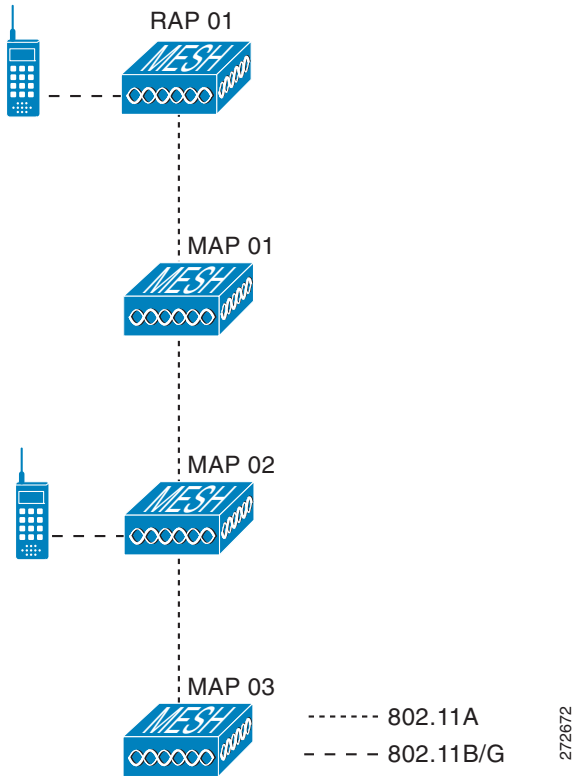
MOS rating	User satisfaction
> 4.3	Very satisfied
4.0	Satisfied
3.6	Some users dissatisfied
3.1	Many users dissatisfied
< 2.58	—

Viewing the Voice Details for Mesh Networks Using the CLI

Use the commands in this section to view details on voice and video calls on the mesh network:

Note See Figure 9-65 when using the CLI commands and viewing their output.

Figure 9-65 Mesh Network Example



- To view the total number of voice calls and the bandwidth used for voice calls on each RAP, enter this command:

  show mesh cac summary

  Information similar to the following appears:

```
AP Name          Slot#   Radio  BW Used/Max  Calls
------------    -------  -----  -----------  -----
SB_RAP1              0   11b/g     0/23437    0
                     1   11a       0/23437    2
SB_MAP1              0   11b/g     0/23437    0
                     1   11a       0/23437    0
SB_MAP2              0   11b/g     0/23437    0
                     1   11a       0/23437    0
SB_MAP3              0   11b/g     0/23437    0
                     1   11a      0/23437    0
```

- To view the mesh tree topology for the network and the bandwidth utilization (used/maximum available) of voice calls and video links for each mesh access point and radio, enter this command:

  show mesh cac bwused {**voice** | **video**} *AP_name*

  Information similar to the following appears:

```
AP Name       Slot#    Radio      BW Used/Max
------------- -------  -----      -----------
SB_RAP1         0      11b/g       1016/23437
                1      11a         3048/23437
|SB_MAP1        0      11b/g       0/23437
                1      11a         3048/23437
||  SB_MAP2     0      11b/g       2032/23437
                1      11a         3048/23437
||| SB_MAP3     0      11b/g       0/23437
                1      11a         0/23437
```

Note The bars (|) to the left of the AP Name field indicate the number of hops that the MAP is from its RAP.

Note When the radio type is the same, the backhaul bandwidth utilization (bw used/max) at each hop is identical. For example, mesh access points *map1*, *map2*, *map3*, and *rap1* are all on the same radio backhaul (802.11a) and are using the same bandwidth (3048). All of the calls are in the same interference domain. A call placed anywhere in that domain affects the others.

- To view the mesh tree topology for the network and display the number of voice calls that are in progress by mesh access point radio, enter this command:

  show mesh cac access *AP_name*

  Information similar to the following appears:

```
AP Name             Slot#   Radio     Calls
-------------      -------  -----    -----
SB_RAP1              0      11b/g      0
                     1      11a        0
|   SB_MAP1          0      11b/g      0
                     1      11a        0
||  SB_MAP2          0      11b/g      1
```

```
                        1       11a         0
|||  SB_MAP3            0       11b/g       0
                        1       11a         0
```

Note Each call received by a mesh access point radio causes the appropriate calls summary column to increment by one. For example, if a call is received on the 802.11b/g radio on *map2*, then a value of one is added to the existing value in that radio's *calls* column. In this case, the new call is the only active call on the 802.11b/g radio of *map2*. If one call is active when a new call is received, the resulting value is two.

- To view the mesh tree topology for the network and display the voice calls that are in progress, enter this command:

  show mesh cac callpath *AP_name*

  Information similar to the following appears:

```
AP Name              Slot#   Radio     Calls
-------------       -------  -----    -----
SB_RAP1               0      11b/g      0
                      1      11a        1
|    SB_MAP1          0      11b/g      0
                      1      11a        1
||   SB_MAP2          0      11b/g      1
                      1      11a        1
|||  SB_MAP3          0      11b/g      0
                      1      11a        0
```

Note The *calls* column for each mesh access point radio in a call path increments by one. For example, for a call that initiates at *map2* (**show mesh cac call path** *SB_MAP2*) and terminates at *rap1* by way of *map1,* one call is added to the *map2* 802.11b/g and 802.11a radio *calls* column*,* one call to the *map1* 802.11a backhaul radio *calls* column, and one call to the *rap1* 802.11a backhaul radio *calls* column.

- To view the mesh tree topology of the network, the voice calls that are rejected at the mesh access point radio due to insufficient bandwidth, and the corresponding mesh access point radio where the rejection occurred, enter this command:

  show mesh cac rejected *AP_name*

  Information similar to the following appears:

```
AP Name              Slot#   Radio     Calls
-------------       -------  -----    -----
SB_RAP1               0      11b/g      0
                      1      11a        0
|    SB_MAP1          0      11b/g      0
                      1      11a        0
||   SB_MAP2          0      11b/g      1
                      1      11a        0
|||  SB_MAP3          0      11b/g      0
                      1      11a        0
```

Note If a call is rejected at the *map2* 802.11b/g radio, its *calls* column increments by one.

- To view the number of bronze, silver, gold, platinum, and management queues active on the specified access point, enter this command. The peak and average length of each queue are shown as well as the overflow count.

  show mesh queue-stats *AP_name*

  Information similar to the following appears:

```
Queue Type  Overflows  Peak length  Average length
 ----------  ---------  -----------  --------------
 Silver      0          1            0.000
 Gold        0          4            0.004
 Platinum    0          4            0.001
 Bronze      0          0            0.000
 Management  0          0            0.000
```

  Overflows—The total number of packets dropped due to queue overflow.

  Peak Length—The peak number of packets waiting in the queue during the defined statistics time interval.

  Average Length—The average number of packets waiting in the queue during the defined statistics time interval.

Enabling Mesh Multicast Containment for Video

You can use the controller CLI to configure three mesh multicast modes to manage video camera broadcasts on all mesh access points. When enabled, these modes reduce unnecessary multicast transmissions within the mesh network and conserve backhaul bandwidth.

Mesh multicast modes determine how bridging-enabled access points MAP and RAP send multicasts among Ethernet LANs within a mesh network. Mesh multicast modes manage non-CAPWAP multicast traffic only. CAPWAP multicast traffic is governed by a different mechanism.

The three mesh multicast modes are as follows:

- Regular mode—Data is multicast across the entire mesh network and all its segments by bridging-enabled RAP and MAP.
- In-only mode—Multicast packets received from the Ethernet by a MAP are forwarded to the RAP's Ethernet network. No additional forwarding occurs, which ensures that non-CAPWAP multicasts received by the RAP are not sent back to the MAP Ethernet networks within the mesh network (their point of origin), and MAP to MAP multicasts do not occur because they are filtered out.

  Note When an HSRP configuration is in operation on a mesh network, we recommend the In-Out multicast mode be configured.

- In-out mode—The RAP and MAP both multicast but in a different manner:
  - In-out mode is the default mode.
  - If multicast packets are received at a MAP over Ethernet, they are sent to the RAP; however, they are not sent to other MAP over Ethernet, and the MAP to MAP packets are filtered out of the multicast.
  - If multicast packets are received at a RAP over Ethernet, they are sent to all the MAPs and their respective Ethernet networks. When the in-out mode is in operation, it is important to properly partition your network to ensure that a multicast sent by one RAP is not received by another RAP on the same Ethernet segment and then sent back into the network.

Note If 802.11b clients need to receive CAPWAP multicasts, then multicast must be enabled globally on the controller as well as on the mesh network (using the **config network multicast global enable** CLI command). If multicast does not need to extend to 802.11b clients beyond the mesh network, the global multicast parameter should be disabled (using the **config network multicast global disable** CLI command).

Enabling Multicast on the Mesh Network Using the CLI

To enable multicast mode on the mesh network to receive multicasts from beyond the mesh networks, enter these commands:

config network multicast global enable

config mesh multicast {**regular** | **in** | **in-out**}

To enable multicast mode only the mesh network (multicasts do not need to extend to 802.11b clients beyond the mesh network), enter these commands:

config network multicast global disable

config mesh multicast {**regular** | **in** | **in-out**}

Note Multicast for mesh networks cannot be enabled using the controller GUI.

IGMP Snooping

IGMP snooping delivers improved RF usage through selective multicast forwarding and optimizes packet forwarding in voice and video applications.

A mesh access point transmits multicast packets only if a client is associated with the mesh access point that is subscribed to the multicast group. So, when IGMP snooping is enabled, only that multicast traffic relevant to given hosts is forwarded.

To enable IGMP snooping on the controller, enter the following command:

configure network multicast igmp snooping enable

A client sends an IGMP *join* that travels through the mesh access point to the controller. The controller intercepts the *join* and creates a table entry for the client in the multicast group. The controller then proxies the IGMP *join* through the upstream switch or router.

You can query the status of the IGMP groups on a router by entering the following command:

```
router# show ip gmp groups
IGMP Connected Group Membership

Group Address    Interface   Uptime  Expires    Last Reporter
233.0.0.1        Vlan119     3w1d    00:01:52   10.1.1.130
```

For Layer 3 roaming, an IGMP query is sent to the client's WLAN. The controller modifies the client's response before forwarding and changes the source IP address to the controller's dynamic interface IP address.

The network hears the controller's request for the multicast group and forwards the multicast to the new controller.

For more information about video, see the following:

- Video Surveillance over Mesh Deployment Guide: http://www.cisco.com/en/US/tech/tk722/tk809/technologies_tech_note09186a0080b02511.shtml
- Cisco Unified Wireless Network Solution: VideoStream Deployment Guide: http://www.cisco.com/en/US/products/ps10315/products_tech_note09186a0080b6e11e.shtml

Locally Significant Certificates for Mesh APs

Until the 7.0 release, mesh APs supported only the Manufactured Installed Certificate (MIC) to authenticate and get authenticated by controllers to join the controller. You might have had to have your own public key infrastructure (PKI) to control CAs, to define policies, to define validity periods, to define restrictions and usages on the certificates that are generated, and get these certificates installed on the APs and controllers. After these customer-generated or locally significant certificates (LSCs) are present on the APs and controllers, the devices start using these LSCs, to join, authenticate, and derive a session key. Cisco supported normal APs from the 5.2 release and later releases and extended the support for mesh APs as well from the 7.0 release.

With the 7.0.116.0 release, the following functionality has been added:

- Graceful fallback to MIC if APs are unable to join the controller with LSC certificates—Local APs try to join a controller with an LSC for the number of times that are configured on the controller (the default value is 3). After these trials, the AP deletes the LSC and tries to join a controller with an MIC.

  Mesh APs try to join a controller with an LSC until its lonely timer expires and the AP reboots. The lonely timer is set for 40 minutes. After the reboot, the AP tries to join a controller with an MIC. If the AP is again not able to join a controller with an MIC in 40 minutes, the AP reboots and then tries to join a controller with an LSC.

Note An LSC in mesh APs is not deleted. An LSC is deleted in mesh APs only when the LSC is disabled on the controller, which causes the APs to reboot.

- Over the air provisioning of MAPs.

Guidelines for Configuration

Follow these guidelines when using LSCs for mesh APs:

- This feature does not remove any preexisting certificates from an AP. It is possible for an AP to have both LSC and MIC certificates.
- After an AP is provisioned with an LSC, it does not read in its MIC certificate on boot-up. A change from an LSC to an MIC will require the AP to reboot. APs do it for a fallback if they cannot be joined with an LSC.
- Provisioning an LSC on an AP does not require an AP to turn off its radios, which is vital for mesh APs, which may get provisioned over-the-air.
- Because mesh APs need a dot1x authentication, a CA and ID certificate is required on the server (in the controller or third-party server depending on the configuration).
- LSC provisioning will be supported only over Ethernet. You have to connect the mesh AP to the controller through Ethernet and get the LSC certificate provisioned. After the LSC becomes the default, an AP can be connected over-the-air to the controller using the LSC certificate.

Differences Between LSCs for Mesh APs and Normal APs

CAPWAP APs use LSC for DTLS setup during a JOIN irrespective of the AP mode. Mesh APs also use the certificate for mesh security, which involves a dot1x authentication with the controller (or an external AAA server), through the parent AP. After the mesh APs are provisioned with an LSC, they need to use the LSC for this purpose because MIC will not be read in.

Mesh APs use a statically configured dot1x profile to authenticate.

This profile is hardcoded to use "cisco" as the certificate issuer. This profile needs to be made configurable so that vendor certificates can be used for mesh authentication (enter the **config local-auth eap-profile cert-issuer vendor "prfMaP1500LlEAuth93"** command).

You must enter the **config mesh lsc enable/disable** command to enable or disable an LSC for mesh APs. This command will cause all the mesh APs to reboot.

Note An LSC on mesh is open for very specific Oil and Gas customers with the 7.0 release. Initially, it is a hidden feature. The **config mesh lsc enable/disable** is a hidden command. Also, the **config local-auth eap-profile cert-issuer vendor "prfMaP1500LlEAuth93"** command is a normal command, but the "prfMaP1500LlEAuth93" profile is a hidden profile, and is not stored on the controller and is lost after the controller reboot.

Certificate Verification Process in LSC AP

LSC-provisioned APs have both LSC and MIC certificates, but the LSC certificate will be the default one. The verification process consists of the following two steps:

1. The controller sends the AP the MIC device certificate, which the AP verifies with the MIC CA.
2. The AP sends the LSC device certificate to the controller, which the controller verifies with the LSC CA.

Configuring an LSC Using the CLI

To configure LSC, follow these steps:

Step 1 Enable LSC and provision the LSC CA certificate in the controller.

Step 2 Enter the following command:

config local-auth eap-profile cert-issuer vendor "prfMaP1500LlEAuth93"

Step 3 Turn on the feature by entering the following command:

config mesh lsc enable/disable

Step 4 Install the CA and ID cert on the controller (or any other authentication server) from the same certificate server.

Step 5 Connect the mesh AP through Ethernet and provision for an LSC certificate.

Step 6 Let the mesh AP get a certificate and join the controller using the LSC certificate. See Figure 9-66 and Figure 9-67.

Figure 9-66 Local Significant Certificate

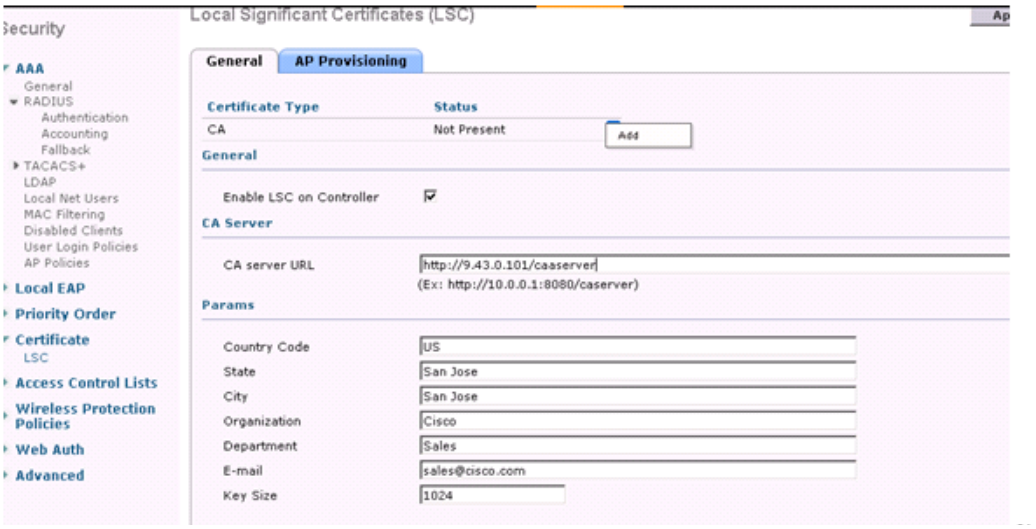
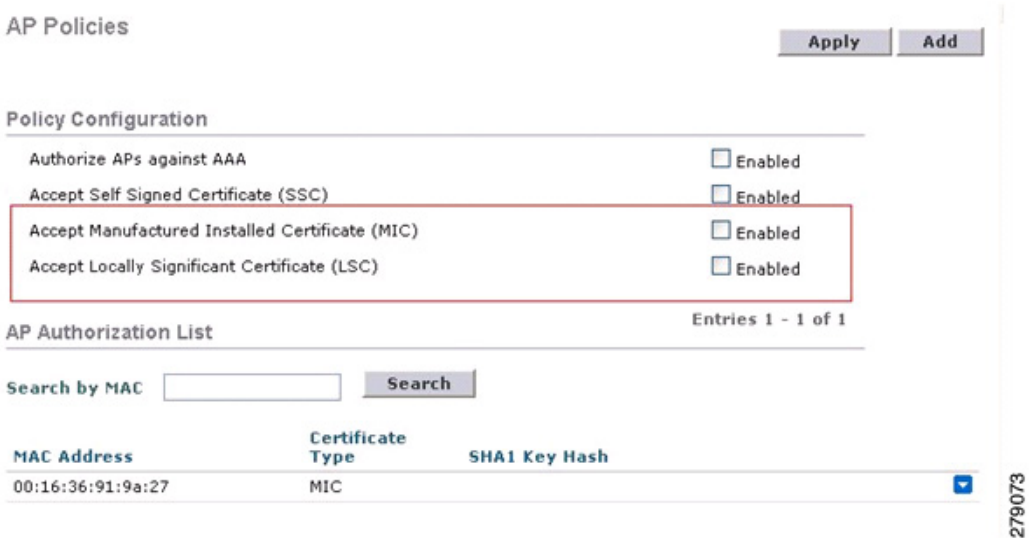


Figure 9-67 AP Policy Configuration



LSC-Related Commands

The following commands are related to LSCs:

- **config certificate lsc enable|disable**
  - **enable**—To enable an LSC on the system.
  - **disable**—To disable an LSC on the system. Use this keyword to remove the LSC device certificate and send a message to an AP, to do the same and disable an LSC, so that subsequent joins could be made using the MIC/SSC. The removal of the LSC CA cert on the WLC should be done explicitly by using the CLI to accommodate any AP that has not transitioned back to the MIC/SSC.
- **config certificate lsc ca-server "URL-Path"**

This command configures the URL to the CA server for getting the certificates. The URL contains either the domain name or the IP address, port number (typically=80), and the CGI-PATH. The following format is an example:

http://ipaddr:port/cgi-path

Only one CA server is allowed to be configured. The CA server has to be configured to provision an LSC.

- **config certificate lsc ca-server delete**

  This command deletes the CA server configured on the WLC.

- **config certificate lsc ca-cert** {**add** | **delete**}

  This command adds or deletes the LSC CA certificate into/from the WLC's CA certificate database as follows:

  - **add**—Queries the configured CA server for a CA certificate using the SSCEP getca operation, and gets into the WLC and installs it permanently into the WLC database. If installed, this CA certificate is used to validate the incoming LSC device certificate from the AP.
  - **delete**—Deletes the LSC CA certificate from the WLC database.

- **config certificate lsc subject-params** *Country State City Orgn Dept Email*

  This command configures the parameters for the device certificate that will be created and installed on the controller and the AP.

  All of these strings have 64 bytes, except for the Country that has a maximum of 3 bytes. The Common Name will be autogenerated using its Ethernet MAC address. This should be given prior to the creation of the controller device certificate request.

  The above parameters are sent as an LWAPP payload to the AP, so that the AP can use these parameters to generate the certReq. The CN is autogenerated on the AP using the current MIC/SSC "Cxxxx-MacAddr" format, where xxxx is the product number.

- **config certificate lsc other-params** *keysize validity*

  The keysize and validity configurations have defaults. Therefore, it is not mandatory to configure them.

  1. The keysize can be from 360 to 2048 (the default is 2048 bits).
  2. The validity period can be configured from 1 to 20 years (the default is 10 years).

- **config certificate lsc ap-provision enable|disable**

  This command enables or disables the provisioning of the LSCs on the APs if the APs just joined using the SSC/MIC. If enabled, all APs that join and do not have the LSC will get provisioned.

  If disabled, no more automatic provisioning will be done. This command does not affect the APs, which already have LSCs in them.

- **config certificate lsc ra-cert add|delete**

  This command is recommended when the CA server is a Cisco IOS CA server. The WLC can use the RA to encrypt the certificate requests and make communication more secure. RA certificates are not currently supported by other external CA servers, such as MSFT.

  - **add**—Queries the configured CA server for an RA certificate using the SCEP operation and installs it into the WLC Database. This keyword is used to get the certReq signed by the CA.
  - **delete**—Deletes the LSC RA certificate from the WLC database.

- **config auth-list ap-policy lsc enable/disable**

After getting the LSC, an AP tries to join the WLC. Before the AP tries to join the WLC, this command must be executed on the WLC console. Execution of this command is mandatory. By default, the **config auth-list ap-policy lsc** command is in the disabled state, and in the disabled state, the APs are not allowed to join the WLC using the LSC.

- **config auth-list ap-policy mic enable|disable**

  After getting the MIC, an AP tries to join the WLC. Before the AP tries to join the WLC, this command must be executed on the WLC console. Execution of this command is mandatory. By default, the **config auth-list ap-policy mic** command is in the enabled state. If an AP cannot join because of the enabled state, this log message in the WLC side is displayed: LSC/MIC AP is not allowed to join by config.

Controller CLI show Commands

The following are the WLC **show** commands:

- **show certificate lsc summary**

  This command displays the LSC certificates installed on the WLC. It would be the CA certificate, device certificate, and optionally, an RA certificate if the RA certificate has also been installed. It also indicates if an LSC is enabled or not.

- **show certificate lsc ap-provision**

  This command displays the status of the provisioning of the AP, whether it is enabled or disabled, and whether a provision list is present or not.

- **show certificate lsc ap-provision details**

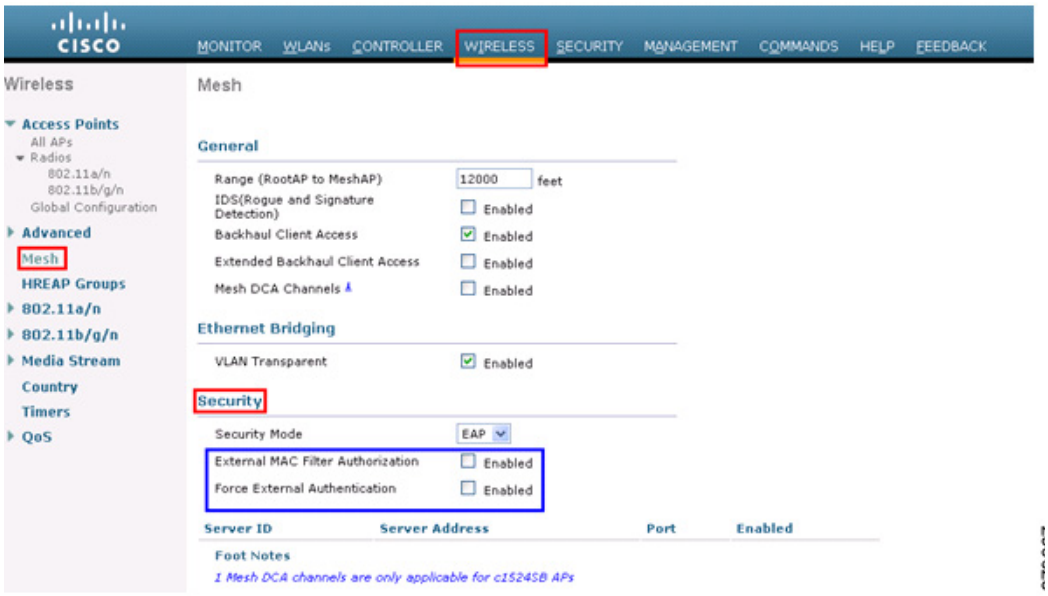
  This command displays the list of MAC addresses present in the AP provisioning lists.

Controller GUI Security Settings

Although the settings are not directly related to the feature, it may help you in achieving the desired behavior with respect to APs provisioned with an LSC.

Figure 9-68 shows three possible cases for mesh AP MAC authorization and EAP.

Figure 9-68 Possible Cases for Mesh AP MAC Authorization and EAP



- Case 1—Local MAC Authorization and Local EAP Authentication

  Add the MAC address of RAP/MAP to the controller MAC filter list.

  Example:

```
(Cisco Controller) > config macfilter mac-delimiter colon
(Cisco Controller) > config macfilter add 00:0b:85:60:92:30 0 management
```

- Case 2—External MAC Authorization and Local EAP authentication

  Enter the following command on the WLC:

```
(Cisco Controller) > config mesh security rad-mac-filter enable
```

  or

  Check only the external MAC filter authorization on the GUI page and follow these guidelines:

  - Do not add the MAC address of the RAP/MAP to the controller MAC filter list.
  - Configure the external radius server details on the WLC.
  - Enter the **config macfilter mac-delimiter colon** command configuration on the WLC.
  - Add the MAC address of the RAP/MAP in the external radius server in the following format:

    User name: 11:22:33:44:55:66 Password : 11:22:33:44:55:66

- Case 3—External EAP authentication

  Configure the external radius server details on the WLC and apply the following configuration on the controller:

```
(Cisco Controller) > config mesh radius-server index enable
(Cisco Controller) > config mesh security force-ext-auth enable
```

  Add the user ID and password on the AAA server in the *(<platform name string>-<Ethernet mac address hex string>)* format for EAP Authentication.

If it is a Cisco IOS AP, it should be in the following format:

username: c1240-112233445566 and password: c1240-112233445566 for 1240 platform APs

username: c1520-112233445566 and password: c1520-112233445566 for 1520 platform APs

For 1510 VxWorks-based AP, it should be in the following format:

username: 112233445566 and password: 112233445566

Deployment Guidelines

Follow these guidelines during deployment:

- When using local authorization, the controller should be installed with the vendor's CA and device certificate.
- When using an external AAA server, the controller should be installed with the vendor's CA and device certificate.
- Mesh security should be configured to use 'vendor' as the cert-issuer.
- MAPs cannot move from an LSC to an MIC when they fall back to a backup controller.

The **config mesh lsc enable|disable** command is required to enable or disable an LSC for mesh APs. This command causes all the mesh APs to reboot. Currently, disabling this command may also reboot nonmesh APs.

Slot Bias Options

When a 1524SB AP is switched on, either slot 1 or slot 2 can be used for an uplink depending on the strength of the signal. AWPP treats both slots equally. For a MAP, slot 2 is the preferred (biased) uplink slot, that is, the slot that is used to connect to the parent AP. Slot 1 is the preferred downlink slot. When both radio slots are available for use and if slot 1 is used for an uplink backhaul, a 15-minute timer is started. At the end of 15 minutes, the AP scans for a channel in slot 2 so that slot 2 might be used for an uplink backhaul again. This process is called slot bias.

We recommend that you use directional antenna on slot 2 for a proper linear functionality. We also recommend that you ensure that slot 2 is selected for a strong uplink. However, there may be some scenarios where directional antennas are used on both the backhaul radios for mobility. When the AP is powered on, the parent can be selected in either direction. If slot 1 is selected, the AP should not go to the scanning mode after 15 minutes, that is, you should disable the slot bias.

Disabling Slot Bias

In the 7.0.116.0 release, you can use the **config mesh slot-bias disable** to disable slot bias so that the APs can be stable on slot 1.

To disable slot bias, enter the following command:

```
(Cisco Controller) > config mesh slot-bias disable
```

Note The slot bias is enabled by default.

Usage Guidelines

Follow these guidelines for the **config mesh slot-bias disable** command:

- The **config mesh slot-bias disable** command is a global command and is applicable to all 1524SB APs associated with the same controller.
- Slot bias is applicable only when both slot 1 and slot 2 are usable. If a slot radio does not have a channel that is available because of dynamic frequency selection (DFS), the other slot takes up both the uplink and downlink roles.
- If slot 2 is not available because of hardware issues, slot bias functions normally. Take corrective action by disabling the slot bias or fixing the antenna.
- A 15-minute timer is initiated (slot bias) only when slot 1 and slot 2 are usable (have channels to operate).
- The 15-minute timer is not initiated if slot 2 cannot find any channels because of DFS, which results in slot 1 taking over the uplink and the downlink.
- Slot 2 takes over slot 1 if slot 1 does not have any channels to operate because of DFS.
- If slot 2 has a hardware failure, then slot bias is initiated, and slot 1 is selected for uplinking.
- Disabling slot bias enables you to take preventive action for a smooth operation.

Commands Related to Slot Bias

The following commands related to slot bias:

- To see which slot is being used for an uplink or a downlink, enter the following command:

```
(Cisco Controller) > show mesh config

Mesh Range..................................... 12000
Mesh Statistics update period.................. 3 minutes
Backhaul with client access status............. enabled
Backhaul with extended client access status..... disabled
Background Scanning State...................... enabled
Backhaul Amsdu State........................... enabled
Mesh Security
   Security Mode............................... EAP
   External-Auth............................... disabled
   Use MAC Filter in External AAA server....... disabled
   Force External Authentication............... disabled
Mesh Alarm Criteria
   Max Hop Count............................... 4
   Recommended Max Children for MAP............ 10
   Recommended Max Children for RAP............ 20
   Low Link SNR................................ 12
   High Link SNR............................... 60
   Max Association Number...................... 10
   Association Interval........................ 60 minutes
   Parent Change Numbers....................... 3
   Parent Change Interval...................... 60 minutes
Mesh Multicast Mode............................ In-Out
Mesh Full Sector DFS........................... enabled
Mesh Ethernet Bridging VLAN Transparent Mode..... enabled
Mesh DCA channels for serial backhaul APs....... disabled
Mesh Slot Bias................................. disabled
```

- To verify that slot 1 is being used for an uplink, do the following:
  a. Enable debugging on the AP by entering the following command in the controller:

```
(Cisco Controller) > debug ap enable AP_name
```

b. Enter the following commands in the controller:

```
(Cisco Controller) > debug ap command show mesh config AP_name
(Cisco Controller) > debug ap command show mesh adjacency parent AP_name
```

Preferred Parent Selection

You can configure a preferred parent for a MAP. This feature gives more control to you and enables you to enforce a linear topology in a mesh environment. You can skip AWPP and force a parent to go to a preferred parent.

Preferred Parent Selection Criteria

The child AP selects the preferred parent based on the following criteria:

- The preferred parent is the best parent.
- The preferred parent has a link SNR of at least 20 dB (other parents, however good, are ignored).
- The preferred parent has a link SNR in the range of 12 dB and 20 dB, but no other parent is significantly better (that is, the SNR is more than 20 percent better). For an SNR lower than 12 dB, the configuration is ignored.
- The preferred parent is not blacklisted.
- The preferred parent is not in silent mode because of dynamic frequency selection (DFS).
- The preferred parent is in the same bridge group name (BGN). If the configured preferred parent is not in the same BGN and no other parent is available, the child joins the parent AP using the default BGN.

Note Slot bias and preferred parent selection features are independent of each other. However, with the preferred parent configured, the connection is made to the parent using slot 1 or slot 2, whichever the AP sees first. If slot 1 is selected for the uplink in a MAP, then slot bias occurs. We recommend that you disable slot bias if you already know that slot 1 is going to be selected.

Configuring a Preferred Parent

To configure a preferred parent, enter the following command:

```
(Cisco Controller) > config mesh parent preferred AP_name MAC
```

where:

- *AP_name* is the name of the child AP that you have to specify.
- *MAC* is the MAC address of the preferred parent that you have to specify.

The following example shows how to configure the preferred parent for the MAP1SB access point, where 00:24:13:0f:92:00 is the preferred parent's MAC address:

```
(Cisco Controller) > config mesh parent preferred MAP1SB 00:24:13:0f:92:00
```

Related Commands

The following commands are related to preferred parent selection:

- To clear a configured parent, enter the following command:

  (Cisco Controller) > **config mesh parent preferred** *AP_name* **none**

- To get information about the AP that is configured as the preferred parent of a child AP, enter the following command:

  (Cisco Controller) > **show ap config general** *AP_name*

The following example shows how to get the configuration information for the MAP1SB access point, where 00:24:13:0f:92:00 is the MAC address of the preferred parent:

```
(Cisco Controller) > show ap config general MAP1SB

Cisco AP Identifier.............................. 9
Cisco AP Name.................................... MAP1SB
Country code..................................... US - United States
Regulatory Domain allowed by Country.............. 802.11bg:-A 802.11a:-A
AP Country code.................................. US - United States
AP Regulatory Domain............................. 802.11bg:-A 802.11a:-A
Switch Port Number .............................. 1
MAC Address...................................... 12:12:12:12:12:12
IP Address Configuration......................... DHCP
IP Address....................................... 209.165.200.225
IP NetMask....................................... 255.255.255.224
CAPWAP Path MTU.................................. 1485
Domain.......................................
Name Server...................................
Telnet State..................................... Disabled
Ssh State........................................ Disabled
Cisco AP Location................................ default location
Cisco AP Group Name.............................. default-group
Primary Cisco Switch Name........................ 4404
Primary Cisco Switch IP Address.................. 209.165.200.230
Secondary Cisco Switch Name......................
Secondary Cisco Switch IP Address................ Not Configured
Tertiary Cisco Switch Name....................... 4404
Tertiary Cisco Switch IP Address................. 3.3.3.3
Administrative State ............................ ADMIN_ENABLED
Operation State ................................. REGISTERED
Mirroring Mode .................................. Disabled
AP Mode ......................................... Local
Public Safety ................................... Global: Disabled, Local: Disabled
AP subMode ...................................... WIPS
Remote AP Debug ................................. Disabled
S/W  Version .................................... 5.1.0.0
Boot  Version ................................... 12.4.10.0
Mini IOS Version ................................ 0.0.0.0
Stats Reporting Period .......................... 180
LED State........................................ Enabled
PoE Pre-Standard Switch.......................... Enabled
PoE Power Injector MAC Addr...................... Disabled
Power Type/Mode.................................. PoE/Low Power (degraded mode)
Number Of Slots.................................. 2
AP Model......................................... AIR-LAP1252AG-A-K9
IOS Version...................................... 12.4(10:0)
Reset Button..................................... Enabled
AP Serial Number................................. serial_number
AP Certificate Type.............................. Manufacture Installed
Management Frame Protection Validation........... Enabled (Global MFP Disabled)
AP User Mode..................................... CUSTOMIZED
AP username...................................... maria
AP Dot1x User Mode............................... Not Configured
AP Dot1x username................................ Not Configured
```

```
Cisco AP system logging host..................... 255.255.255.255
AP Up Time....................................... 4 days, 06 h 17 m 22 s
AP LWAPP Up Time................................. 4 days, 06 h 15 m 00 s
Join Date and Time............................... Mon Mar 3 06:19:47 2008

Ethernet Port Duplex............................. Auto
Ethernet Port Speed.............................. Auto
AP Link Latency.................................. Enabled
 Current Delay................................... 0 ms
 Maximum Delay................................... 240 ms
 Minimum Delay................................... 0 ms
 Last updated (based on AP Up Time)..............  4 days, 06 h 17 m 20 s
Rogue Detection.................................. Enabled
AP TCP MSS Adjust................................ Disabled
Mesh preferred parent............................ 00:24:13:0f:92:00
```

Co-Channel Interference

In addition to hidden node interference, co-channel interference can also impact performance. Co-channel interference occurs when adjacent radios on the same channel interfere with the performance of the local mesh network. This interference takes the form of collisions or excessive deferrals by CSMA. In both cases, performance of the mesh network is degraded. With appropriate channel management, co-channel interference on the wireless mesh network can be minimized.

Viewing Mesh Statistics for a Mesh Access Point

This section describes how to use the controller GUI or CLI to view mesh statistics for specific mesh access points.

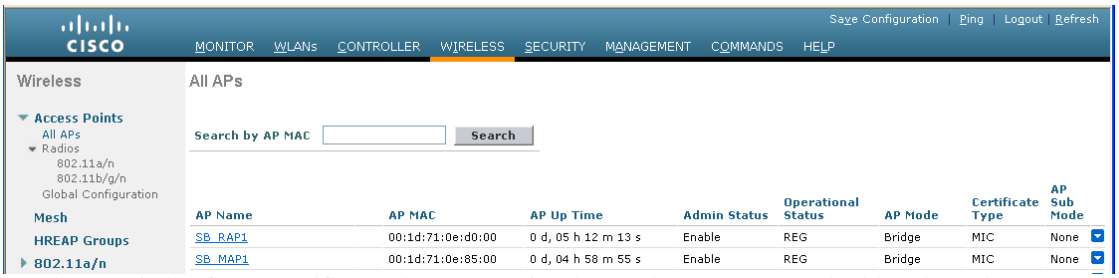
Note You can modify the Statistics Timer interval setting on the All APs > Details page of the controller GUI.

Viewing Mesh Statistics for a Mesh Access Point Using the GUI

To view mesh statistics for a specific mesh access point using the controller GUI, follow these steps:

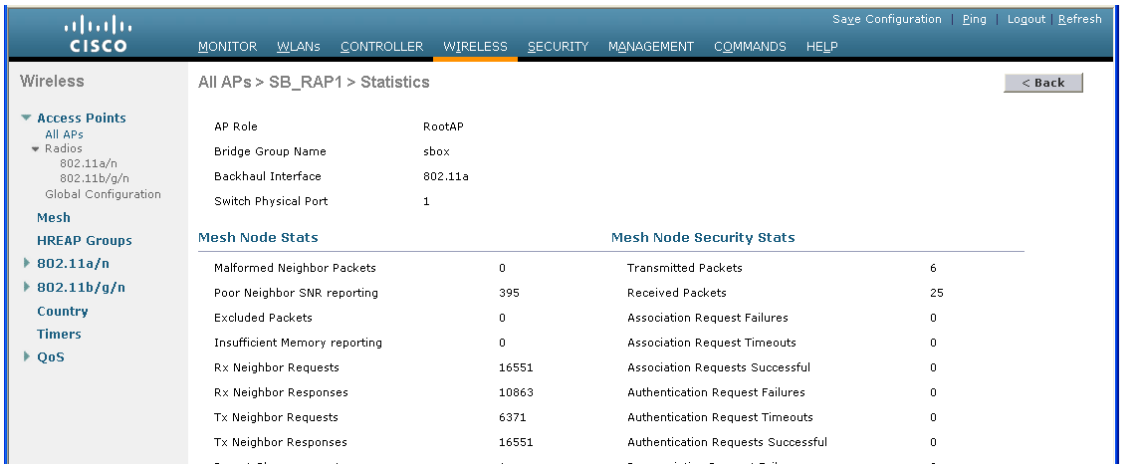
Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page. (See Figure 9-69.)

Figure 9-69 All APs Page



Step 2 To view statistics for a specific mesh access point, hover the mouse over the blue drop-down arrow for the desired mesh access point and choose **Statistics**. The **All APs >** *AP Name* **> Statistics** page for the selected mesh access point appears. (See Figure 9-70.)

Figure 9-70 All APs > Access Point Name > Statistics Page



This page shows the role of the mesh access point in the mesh network, the name of the bridge group to which the mesh access point belongs, the backhaul interface on which the access point operates, and the number of the physical switch port. It also displays a variety of mesh statistics for this mesh access point. Table 9-17 describes each of the statistics.

Table 9-17 Mesh Access Point Statistics

Statistics	Parameter	Description
Mesh Node Stats	Malformed Neighbor Packets	The number of malformed packets received from the neighbor. Examples of malformed packets include malicious floods of traffic such as malformed or short DNS packets and malformed DNS replies.
	Poor Neighbor SNR Reporting	The number of times the signal-to-noise ratio falls below 12 dB on the backhaul link.
	Excluded Packets	The number of packets received from excluded neighbor mesh access points.
	Insufficient Memory Reporting	The number of insufficient memory conditions.
	Rx Neighbor Requests	The number of broadcast and unicast requests received from the neighbor mesh access points.
	Rx Neighbor Responses	The number of responses received from the neighbor mesh access points.
	Tx Neighbor Requests	The number of unicast and broadcast requests sent to the neighbor mesh access points.
	Tx Neighbor Responses	The number of responses sent to the neighbor mesh access points.
	Parent Changes Count	The number of times a mesh access point (child) moves to another parent.
	Neighbor Timeouts Count	The number of neighbor timeouts.

Table 9-17 Mesh Access Point Statistics (continued)

Statistics	Parameter	Description
Queue Stats	Gold Queue	The average and peak number of packets waiting in the gold (video) queue during the defined statistics time interval.
	Silver Queue	The average and peak number of packets waiting in the silver (best effort) queue during the defined statistics time interval.
	Platinum Queue	The average and peak number of packets waiting in the platinum (voice) queue during the defined statistics time interval.
	Bronze Queue	The average and peak number of packets waiting in the bronze (background) queue during the defined statistics time interval.
	Management Queue	The average and peak number of packets waiting in the management queue during the defined statistics time interval.

Table 9-17 Mesh Access Point Statistics (continued)

Statistics	Parameter	Description
Mesh Node Security Stats	Transmitted Packets	The number of packets transmitted during security negotiations by the selected mesh access point.
	Received Packets	The number of packets received during security negotiations by the selected mesh access point.
	Association Request Failures	The number of association request failures that occur between the selected mesh access point and its parent.
	Association Request Timeouts	The number of association request timeouts that occur between the selected mesh access point and its parent.
	Association Requests Successful	The number of successful association requests that occur between the selected mesh access point and its parent.
	Authentication Request Failures	The number of failed authentication requests that occur between the selected mesh access point and its parent.
	Authentication Request Timeouts	The number of authentication request timeouts that occur between the selected mesh access point and its parent.
	Authentication Requests Successful	The number of successful authentication requests between the selected mesh access point and its parent.
	Reassociation Request Failures	The number of failed reassociation requests between the selected mesh access point and its parent.
	Reassociation Request Timeouts	The number of reassociation request timeouts between the selected mesh access point and its parent.
	Reassociation Requests Successful	The number of successful reassociation requests between the selected mesh access point and its parent.
	Reauthentication Request Failures	The number of failed reauthentication requests between the selected mesh access point and its parent.
	Reauthentication Request Timeouts	The number of reauthentication request timeouts that occur between the selected mesh access point and its parent.
	Reauthentication Requests Successful	The number of successful reauthentication requests that occur between the selected mesh access point and its parent.
	Unknown Association Requests	The number of unknown association requests received by the parent mesh access point from its child. The unknown association requests often occur when a child is an unknown neighbor mesh access point.
	Invalid Association Requests	The number of invalid association requests received by the parent mesh access point from the selected child mesh access point. This state may occur when the selected child is a valid neighbor but is not in a state that allows association.

Table 9-17 Mesh Access Point Statistics (continued)

Statistics	Parameter	Description
Mesh Node Security Stats (continued)	Unknown Reauthentication Requests	The number of unknown reauthentication requests received by the parent mesh access point node from its child. This state may occur when a child mesh access point is an unknown neighbor.
	Invalid Reauthentication Requests	The number of invalid reauthentication requests received by the parent mesh access point from a child. This state may occur when a child is a valid neighbor but is not in a proper state for reauthentication.
	Unknown Reassociation Requests	The number of unknown reassociation requests received by the parent mesh access point from a child. This state may occur when a child mesh access point is an unknown neighbor.
	Invalid Reassociation Requests	The number of invalid reassociation requests received by the parent mesh access point from a child. This state may occur when a child is a valid neighbor but is not in a proper state for reassociation.

Viewing Mesh Statistics for an Mesh Access Point Using the CLI

Use these commands to view mesh statistics for a specific mesh access point using the controller CLI:

- To view packet error statistics, a count of failures, timeouts, and successes with respect to associations and authentications, and reassociations and reauthentications for a specific mesh access point, enter this command:

  show mesh security-stats *AP_name*

  Information similar to the following appears:

```
AP MAC : 00:0B:85:5F:FA:F0
Packet/Error Statistics:
----------------------------
x Packets 14, Rx Packets 19, Rx Error Packets 0

Parent-Side Statistics:
-------------------------
Unknown Association Requests 0
Invalid Association Requests 0
Unknown Re-Authentication Requests 0
Invalid Re-Authentication Requests 0
Unknown Re-Association Requests 0
Invalid Re-Association Requests 0
Unknown Re-Association Requests 0
Invalid Re-Association Requests 0

Child-Side Statistics:
-------------------------
Association Failures 0
Association Timeouts 0
Association Successes 0
Authentication Failures 0
Authentication Timeouts 0
Authentication Successes 0
Re-Association Failures 0
```

```
Re-Association Timeouts 0
Re-Association Successes 0
Re-Authentication Failures 0
Re-Authentication Timeouts 0
Re-Authentication Successes 0
```

- To view the number of packets in the queue by type, enter this command:

  show mesh queue-stats *AP_name*

  Information similar to the following appears:

```
Queue Type  Overflows  Peak length  Average length
 ----------  ---------  -----------  --------------
 Silver      0          1            0.000
 Gold        0          4            0.004
 Platinum    0          4            0.001
 Bronze      0          0            0.000
 Management  0          0            0.000
```

  Overflows—The total number of packets dropped due to queue overflow.

  Peak Length—The peak number of packets waiting in the queue during the defined statistics time interval.

  Average Length—The average number of packets waiting in the queue during the defined statistics time interval.

Viewing Neighbor Statistics for a Mesh Access Point

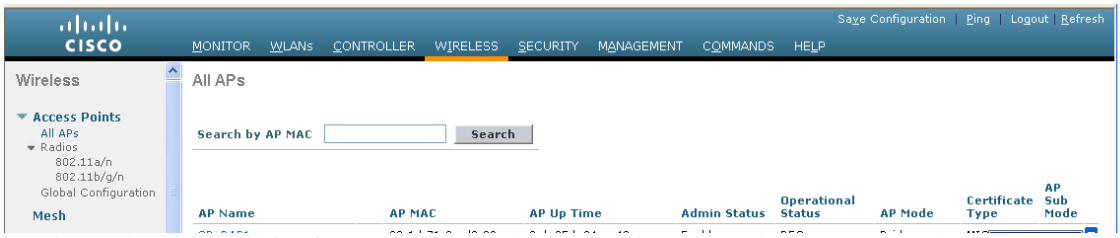
This section describes how to use the controller GUI or CLI to view neighbor statistics for a selected mesh access point. It also describes how to run a link test between the selected mesh access point and its parent.

Viewing Neighbor Statistics for a Mesh Access Point Using the GUI

To view neighbor statistics for a specific mesh access point using the controller GUI, follow these steps:

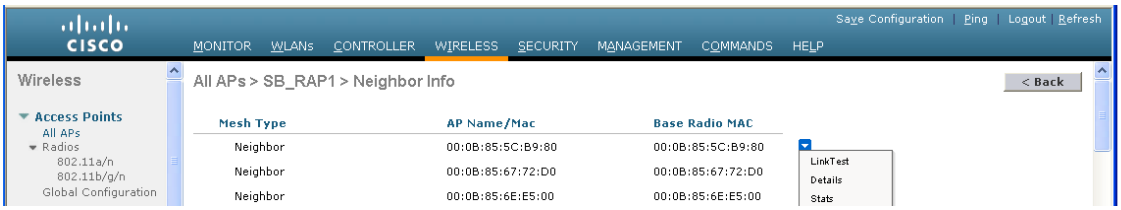
Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page. (See Figure 9-71.)

Figure 9-71 All APs Page



Step 2 To view neighbor statistics for a specific mesh access point, hover the mouse over the blue drop-down arrow for the desired mesh access point and choose **Neighbor Information**. The All APs > *Access Point Name* > Neighbor Info page for the selected mesh access point appears (see Figure 9-72).

Figure 9-72 All APs > Access Point Name > Neighbor Info Page

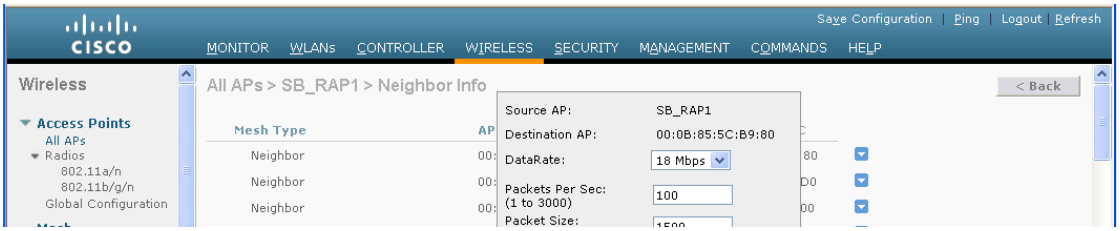


This page lists the parent, children, and neighbors of the mesh access point. It provides each mesh access point's name and radio MAC address.

Step 3 To perform a link test between the mesh access point and its parent or children, follow these steps:

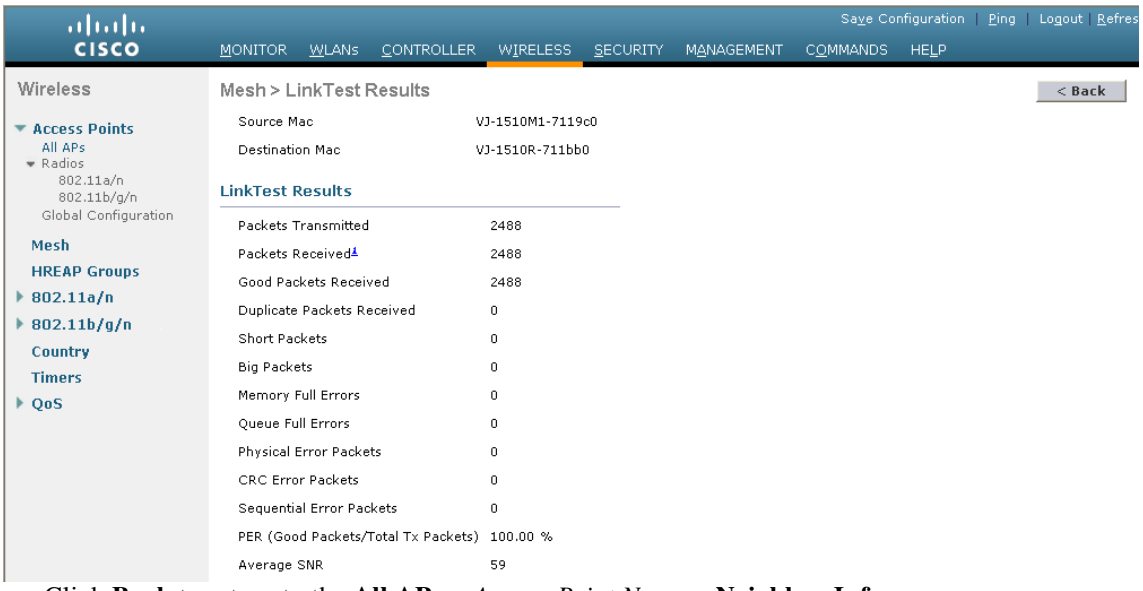
a. Hover the mouse over the blue drop-down arrow of the parent or desired child and choose **LinkTest**. A pop-up window appears (see Figure 9-73).

Figure 9-73 Link Test Page



b. Click **Submit** to start the link test. The link test results appear on the Mesh > LinkTest Results page (see Figure 9-74).

Figure 9-74 Mesh > LinkTest Results Page



c. Click **Back** to return to the **All APs >** *Access Point Name* **> Neighbor Info** page.

Step 4 To view the details for any of the mesh access points on this page, follow these steps:

a. Hover the mouse over the blue drop-down arrow for the desired mesh access point and choose **Details**. The **All APs >** *Access Point Name* **> Link Details >** *Neighbor Name* page appears (see Figure 9-75).

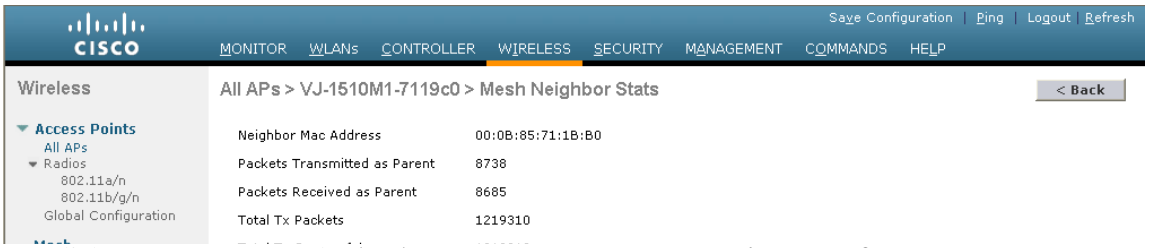
Figure 9-75 All APs > Access Point Name > Link Details > Neighbor Name page

b. Click **Back** to return to the **All APs >** *Access Point Name* **> Neighbor Info** page.

Step 5 To view statistics for any of the mesh access points on this page, follow these steps:

a. Hover the mouse over the blue drop-down arrow for the desired mesh access point and choose **Stats**. The **All APs >** *Access Point Name* **> Mesh Neighbor Stats** page appears (see Figure 9-76).

Figure 9-76 All APs > Access Point Name > Mesh Neighbor Stats Page



b. Click **Back** to return to the **All APs >** *Access Point Name* **> Neighbor Info** page.

Viewing the Neighbor Statistics for a Mesh Access Point using the CLI

Use these commands to view neighbor statistics for a specific mesh access point using the controller CLI.

- To view the mesh neighbors for a specific mesh access point, enter this command:

  show mesh neigh {**detail** | **summary**} *AP_Name*

  Information similar to the following appears when you request a summary display:

```
AP Name/Radio Mac   Channel Snr-Up Snr-Down Link-Snr Flags State
-----------------   ------- ------ -------- -------- ------ -------
mesh-45-rap1        165     15     18       16       0x86b UPDATED NEIGH PARENT BEACON
00:0B:85:80:ED:D0   149      5      6        5       0x1a60 NEED UPDATE BEACON DEFAULT
00:17:94:FE:C3:5F   149   7      0        0    0x860     BEACON
```

- To view the channel and signal-to-noise ratio (SNR) details for a link between a mesh access point and its neighbor, enter this command:

  show mesh path *AP_Name*

  Information similar to the following appears:

```
AP Name/Radio Mac  Channel Snr-Up Snr-Down Link-Snr Flags State
-----------------  ------- ------ -------- -------- ------ -------
mesh-45-rap1       165     15     18       16       0x86b UPDATED NEIGH PARENT BEACON
mesh-45-rap1 is a Root AP.
```

- To view the percentage of packet errors for packets transmitted by the neighbor mesh access point, enter this command:

  show mesh per-stats *AP_Name*

Information similar to the following appears:

```
Neighbor MAC Address 00:0B:85:5F:FA:F0
Total Packets transmitted: 104833
Total Packets transmitted successfully: 104833
Total Packets retried for transmission: 33028

Neighbor MAC Address 00:0B:85:80:ED:D0
Total Packets transmitted: 0
Total Packets transmitted successfully: 0
Total Packets retried for transmission: 0

Neighbor MAC Address 00:17:94:FE:C3:5F
Total Packets transmitted: 0
Total Packets transmitted successfully: 0
Total Packets retried for transmission: 0
```

Packet error rate percentage = 1 – (number of successfully transmitted packets/number of total packets transmitted).

Converting Indoor Access Points to Mesh Access Points

Before you can install and indoor access point into an indoor mesh deployment, follow these steps:

Step 1 Convert the autonomous access point (k9w7 image) to a lightweight access point.

For information about this process, see this URL: http://cisco-images.cisco.com/en/US/docs/wireless/access_point/conversion/lwapp/upgrade/guide/lwapnote.html.

Step 2 Convert the lightweight access point to either a mesh access point (MAP) or root access point (RAP) as follows:

Note Indoor mesh access points (1130 and 1240) can function as either a RAP or a MAP. By default, all are configured as MAPs.

- To convert the access point to a mesh access point using the controller CLI, perform one of the following:
  - To convert from a lightweight access point to a MAP, enter this command:

    config ap mode bridge *Cisco_AP*

    The mesh access point reloads.
  - To convert from a lightweight access point to a RAP, enter these CLI commands:

    config ap mode bridge *Cisco_AP*

    config ap role rootAP *Cisco_AP*

    The mesh access point reloads and is configured to operate as a RAP.
- To convert the access point to a mesh access point using the GUI, follow these steps:
  a. Choose **Wireless** and click on the AP Name link for the 1130 or 1240 indoor access point you want to convert.
  b. At the General Properties panel, choose **Bridge** from the AP Mode drop-down list.

     The access point reboots.

c. At the Mesh panel, choose either **RootAP** or **MeshAP** from the AP Role drop-down list.

d. Click **Apply** to commit your changes.

e. Click **Save Configuration** to save your changes.

Changing MAP and RAP Roles for Indoor Mesh Access Points

Cisco 1130 and 1240 series indoor mesh access points can function as either RAPs or MAPs.

Using the GUI to Change MAP and RAP Roles for Indoor Mesh Access Points

To change an indoor mesh access point from one role to another using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > All APs** to open the All APs page.

Step 2 Click the name of the 1130 or 1240 series access point that you want to change.

Step 3 Click the **Mesh** tab.

Step 4 From the AP Role drop-down list, choose **MeshAP** or **RootAP** to specify this access point as a MAP or RAP, respectively.

Step 5 Click **Apply** to commit your changes. The access point reboots.

Step 6 Click **Save Configuration** to save your changes.

Note We recommend that you use a Fast Ethernet connection between the MAP and controller when changing from a MAP to RAP.

Note After a RAP-to-MAP conversion, the MAP's connection to the controller is a wireless backhaul rather than a Fast Ethernet connection. You must ensure that the Fast Ethernet connection of the RAP being converted is disconnected before the MAP starts up so that the MAP can join over the air.

Note We recommend that your power source for MAPs is either a power supply or power injector. We do not recommend that you use PoE as a power source for MAPs.

Using the CLI to Change MAP and RAP Roles for Indoor Mesh Access Points

To change an indoor mesh access point from one role to another using the controller CLI, follow these steps:

Step 1 Change the role of an indoor access point from MAP to RAP or from RAP to MAP by entering this command:

config ap role {**rootAP** | **meshAP**} *Cisco_AP*

The access point reboots after you change the role.

Step 2 Save your changes by entering this command:

save config

Converting Indoor Mesh Access Points to Nonmesh Lightweight Access Points (1130AG, 1240AG)

The access point reboots after you enter the conversion commands in the controller CLI or perform the steps on the controller or the Cisco WCS.

Note We recommend that you use a Fast Ethernet connection to the controller for the conversion from a mesh (bridge) to nonmesh (local) access point. If the backhaul is a radio, after the conversion, you must enable Ethernet and then reload the access image.

Note When a root access point is converted back to a lightweight access point, all of its subordinate mesh access points lose connectivity to the controller. A mesh access point is unable to service its clients until the mesh access point is able to connect to a different root access point in the vicinity. Likewise, clients might connect to a different mesh access point in the vicinity to maintain connectivity to the network.

- To convert an indoor mesh access point (MAP or RAP) to a nonmesh lightweight access point using the controller CLI, enter this command.

  config ap mode local *Cisco_AP*

  The access point reloads.

- To convert an indoor mesh access point (MAP or RAP) to a nonmesh lightweight access point using the GUI, follow these steps:
  a. Choose **Wireless** and click on the AP Name link for the 1130 or 1240 indoor access point you want to convert.
  b. At the General Properties panel, choose **Local** from the AP Mode drop-down list.
  c. Click **Apply** to apply changes.
  d. Click **Save Configuration** to save your changes.
- To convert an indoor mesh access point (MAP or RAP) to a nonmesh lightweight access point using Cisco WCS, follow these steps:
  a. Choose **Configure > Access Points** and click on the AP Name link for the 1130 or 1240 indoor access point you want to convert.
  b. At the General Properties panel, choose **Local** as the AP Mode (left side).

c. Click **Save**.

Configuring Mesh Access Points to Operate with Cisco 3200 Series Mobile Access Routers

Outdoor access points (1522, 1524PS) can interoperate with the Cisco 3200 Series Mobile Access Router (MAR) on the public safety channel (4.9 GHz) as well as the 2.4-GHz access and 5-GHz backhaul.

The Cisco 3200 creates an *in-vehicle network* in which devices such as PCs, surveillance cameras, digital video recorders, printers, PDAs, and scanners can share wireless networks such as cellular or WLAN-based services back to the main infrastructure. Data that is collected from in-vehicle deployments, such as a police car can be integrated into the overall wireless infrastructure. For specific interoperability details between series 1130, 1240, and 1520 mesh access points and series 3200 mobile access routers, see Table 9-18.

Table 9-18 Mesh Access Points and MAR 3200 Interoperability

Mesh Access Point Model	MAR Model
1522[1]	c3201[2], c3202[3], c3205[4]
1524PS	c3201, c3202
1130, 1240 configured as indoor mesh access points with universal access	c3201, c3205

1. Universal access must be enabled on the 1522 if connecting to a MAR on the 802.11a radio or 4.9-GHz band.
2. Model c3201 is a MAR with a 802.11b/g radio (2.4 GHz).
3. Model c3202 is a MAR with a 4-9-GHz sub-band radio.
4. Model c3205 is a MAR with a 802.11a radio (5.8-GHz sub-band).

Configuration Guidelines

Follow these guidelines to allow the 1522 or 1524PS mesh access point and Cisco MAR 3200 to interoperate on the public safety network:

- Client access must be enabled on the backhaul (Mesh global parameter).
- Public Safety must be enabled globally on all mesh access points (MAPs) in the mesh network.
- Channel number assignments on the 1522 or 1524PS must match those on the Cisco 3200 radio interfaces:
  - Channels 20 (4950 GHz) through 26 (4980 GHz) and sub-band channels 1 through 19 (5 and 10 MHz) are used for MAR interoperability. This configuration change is made on the controller. No changes are made to the access point configuration.
  - Channel assignments are made only to the RAP. Updates to the MAP are propagated by the RAP.

The default channel width for MAR 3200s is 5 MHz. You must do one of the following:

- Change the channel width to 10 or 20 MHz to enable WGBs to associate with series 1520 mesh access points.
- Change the channel on the 1522 or 1524PS to a channel in the 5-MHz (channels 1 to 10) or 10-MHz band (channels 11 through 19) as follows:

- When using the controller CLI, you must disable the 802.11a radio prior to configuring its channels. You reenable the radio after the channels are configured.
- When using the GUI, enabling and disabling the 802.11a radio for channel configuration is not required.
- Cisco MAR 3200s can scan channels within but not across the 5-, 10-, or 20-MHz bands.

Using the GUI to Enable Mesh Access Points to Operate with Cisco 3200 Series Mobile Access Routers

To enable the 1522 and 1524PS mesh access points to associate to the Cisco 3200 series MAR using the controller GUI, follow these steps:

Step 1 Enable the backhaul for client access by choosing **Wireless > Mesh** to open the Mesh page.

Step 2 Select the **Backhaul Client Access** check box to allow wireless client association over the 802.11a radio.

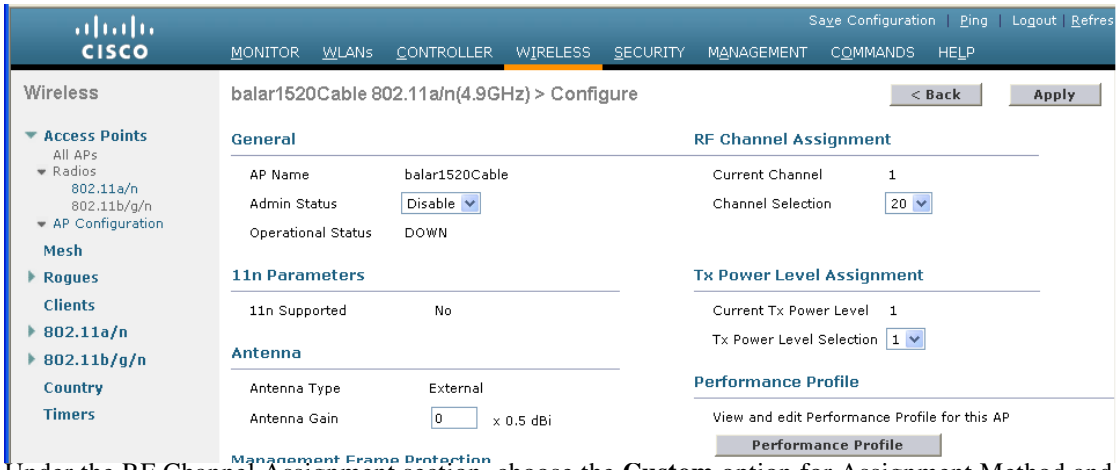
Step 3 Click **Apply** to commit your changes.

Step 4 When prompted to allow a reboot of all the mesh access points on the network, click **OK**.

Step 5 Choose **Wireless > Access Points > Radios > 802.11a/n** to open the 802.11a/n Radios page.

Step 6 Hover your cursor over the blue drop-down arrow for the appropriate RAP and choose **Configure**. The 802.11a/n (4.9 GHz) > Configure page appears (see Figure 9-77).

Figure 9-77 802.11 a/n (4.9GHz) > Configure Page



Step 7 Under the RF Channel Assignment section, choose the **Custom** option for Assignment Method and select a channel between 1 and 26.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Enable Mesh Access Points to Operate with Cisco 3200 Series Mobile Access Routers

To enable the 1522 and 1524PS mesh access points to associate to the Cisco 3200 series MAR using the controller CLI, follow these steps:

Step 1 Enable client access mode on the 1522 and 1524PS mesh access points by entering this command:

config mesh client-access enable

Step 2 Enable public safety on a global basis by entering this command:

config mesh public-safety enable *all*

Step 3 Enable the public safety channels by entering these commands:

- For the 1522 access point, enter these commands:

  config 802.11a disable *Cisco_MAP*

  config 802.11a channel ap *Cisco_MAP channel_number*

  config 802.11a enable *Cisco_MAP*

- For the 1524PS, enter these commands:

  config 802.11–a49 disable *Cisco_MAP*

  config 802.11–a49 channel ap *Cisco_MAP channel_number*

  config 802.11–a49 enable *Cisco_MAP*

Note Enter the **config 802.11–a58 enable** *Cisco_MAP* command to enable a 5-GHz radio.

Note For both the 1522 and 1524PS mesh access points, valid values for the channel number is 1 through 26.

Step 4 Save your changes by entering this command:

save config

Step 5 Verify your configuration by entering these commands:

show mesh public-safety

show mesh client-access

show ap config 802.11a summary (for 1522 access points only)

show ap config 802.11–a49 summary (for 1524PS access points only)

Note Enter the **show config 802.11-a58 summary** command to view configuration details for a 5-GHz radio.

CHAPTER 10

Managing Controller Software and Configurations

This chapter describes how to manage configurations and software versions on the controllers. It contains these sections:

Upgrading the Controller Software

When you upgrade the controller's software, the software on the controller's associated access points is also automatically upgraded. When an access point is loading software, each of its LEDs blinks in succession. Up to 10 access points can be concurrently upgraded from the controller.

Note The Cisco 5500 Series Controllers can download the 6.0 software to 100 access points simultaneously.

Caution Do not power down the controller or any access point during this process; otherwise, you might corrupt the software image. Upgrading a controller with a large number of access points can take as long as 30 minutes, depending on the size of your network. However, with the increased number of concurrent access point upgrades supported in software release 4.0.206.0 and later releases, the upgrade time should be significantly reduced. The access points must remain powered, and the controller must not be reset during this time.

Note In controller software release 5.2 or later releases, the WLAN override feature has been removed from both the controller GUI and CLI. If your controller is configured for WLAN override and you upgrade to controller software release 5.2 or later releases, the controller deletes the WLAN configuration and

broadcasts all WLANs. You can specify that only certain WLANs be transmitted by configuring access point groups. Each access point advertises only the enabled WLANs that belong to its access point group.

Guidelines for Upgrading Controller Software

Follow these guidelines before upgrading your controller to software release 7.0.116.0:

- Make sure that you have a TFTP or FTP server available for the software upgrade. Follow these guidelines when setting up a TFTP or FTP server:
  - Controller software release 6.0 is greater than 32 MB; you must make sure that your TFTP server supports files that are larger than 32 MB. Some TFTP servers that support files of this size are tftpd32 and the TFTP server is within WCS. If you attempt to download the 6.0 controller software and your TFTP server does not support files of this size, the following error message appears: "TFTP failure while storing in flash."
  - If you are upgrading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
  - If you are upgrading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
  - A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.
- You can upgrade or downgrade the controller software only between certain releases. In some instances, you must first install an intermediate release prior to upgrading to software release 6.0. shows the upgrade path that you must follow prior to downloading software release 6.0.

Note The Cisco 5500 Series Controllers can run only controller software release 6.0 or later releases.

Note When you upgrade the controller to an intermediate software release, wait until all of the access points joined to the controller are upgraded to the intermediate release before you install the 6.0 software. In large networks, it may take some time to download the software on each access point.

- In software releases 6.0.186.0 and later releases, you can download the upgrade image to the controller, and then download the image to the access points while the network is still up. New CLI and controller GUI functionality allow you to specify the boot image for both devices and to reset the access points when the controller resets. When both devices are up, the access points discover and rejoin the controller. See the "Predownloading an Image to an Access Point" section on page 10-11 for more information about predownloading images to access points.
- We recommend that you install the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file on all controller platforms. This file resolves CSCsm03461 and is necessary to view the version information for ER.aes files in the output of the **show sysinfo** command. If you

do not install this ER.aes file, your controller does not obtain the fix for this defect, and "N/A" appears in the text box Recovery Image Version or Emergency Image Version text box in the output of this command.

Note You cannot install the Cisco Unified Wireless Network Controller Boot Software 7.0.116.0ER.aes file on Cisco 5500 Controller platform.

Note The ER .aes files are independent from the controller software files. You can run any controller software file with any ER.aes file. However, installing the latest boot software file (5.2.157.0 ER.aes) ensures that the boot software modifications in all of the previous and current boot software ER.aes files are installed.

Caution If you require a downgrade from one release to another, you may lose the configuration from your current release. The workaround is to reload the previous controller configuration files saved on the backup server or to reconfigure the controller.

Note Do not upgrade a controller using a wireless client as the TFTP or FTP server if the client is associated to the same controller that is being upgraded. If you try upgrading a Wireless LAN Controller using an associated client, the upgrade will fail. The controller will not attempt to contact the TFTP server to download the image. The TFTP server can be located on a client that is not associated to the same controller to which it is associated. This is applicable on all controller platforms.

Guidelines for Upgrading to Controller Software 6.0 in Mesh Networks

Caution Before upgrading your controller to software release 6.0 in a mesh network, you must comply with the following rules.

Upgrade Compatibility Matrix

Table 10-1 outlines the upgrade compatibility of controller mesh and nonmesh releases and indicates the intermediate software releases required as part of the upgrade path.

Software Upgrade Notes

- You can upgrade from all mesh releases to controller software release 6.0 without any configuration file loss. See Table 10-1 for the available upgrade paths.

Note If you downgrade to a mesh release, you must then reconfigure the controller. We recommend that you save the configuration from the mesh release before upgrading to release 6.0 for the first time. You can reapply the configuration if you need to downgrade.

- You cannot downgrade from controller software release 6.0 to a mesh release (4.1.190.5, 4.1.191.22M, or 4.1.192.xxM) without experiencing a configuration loss.
- Configuration files are in the binary state immediately after upgrade from a mesh release to controller software release 6.0. After reset, the XML configuration file is selected.
- Do not edit XML files.

Table 10-1 Upgrade Compatibility Matrix for Controller Mesh and Non-Mesh Releases

Upgrade to / Upgrade from	6.0	5.2	4.1.192.35M	4.1.191.24M	4.1.190.5	4.1.185.0	4.1.171.0	4.0.219.0	4.0.217.204	4.0.217.0	4.0.216.0	4.0.206.0	4.0.179.11	4.0.179.8	4.0.155.5	4.0.155.0	3.2.195.10	3.2.193.5	3.2.171.6	3.2.171.5	3.2.150.10	3.2.150.6	3.2.116.21	3.2.78.0	3.1.111.0	3.1.105.0
4.1.192.35M	Y	Y																								
4.1.192.22M	Y	Y	Y																							
4.1.191.24M			Y	–																						
4.1.190.5			Y[1]	Y	–																					
4.1.185.0				Y	Y[2]	–																				
4.1.181.0					Y[2]	Y[2]																				
4.1.171.0					Y[2]	Y[2]	–																			
4.0.219.0						Y[2]	Y[2]	–																		
4.0.217.204				Y[2]		Y[2]	Y[2]	Y[2]	–																	
4.0.217.0						Y[2]	Y[2]	Y[2]	Y[3]	–																
4.0.216.0						Y[2]	Y[2]	Y[2]	Y[3]	Y	–															
4.0.206.0						Y[2]	Y[2]	Y[2]	Y[3]	Y		–														
4.0.179.11										Y		Y[4]	–													
4.0.179.8										Y		Y[4]	Y	–												
4.0.155.5										Y		Y[4]	Y	Y	–											
4.0.155.0										Y		Y[4]	Y	Y	Y	–										
3.2.195.10										Y		Y[4]	Y	Y	Y		–									
3.2.193.5										Y		Y[4]	Y	Y	Y		Y	–								

Table 10-1 Upgrade Compatibility Matrix for Controller Mesh and Non-Mesh Releases (continued)

Upgrade to	6.0	5.2	4.1.192.35M	4.1.191.24M	4.1.190.5	4.1.185.0	4.1.171.0	4.0.219.0	4.0.217.204	4.0.217.0	4.0.216.0	4.0.206.0	4.0.179.11	4.0.179.8	4.0.155.5	4.0.155.0	3.2.195.10	3.2.193.5	3.2.171.6	3.2.171.5	3.2.150.10	3.2.150.6	3.2.116.21	3.2.78.0	3.1.111.0	3.1.105.0
3.2.171.6										Y		Y [4]	Y	Y	Y		Y		–							
3.2.171.5										Y		Y [4]	Y	Y	Y		Y		Y	–						
3.2.150.10										Y		Y [4]	Y	Y	Y		Y		Y		–					
3.2.150.6										Y		Y [4]	Y	Y	Y		Y		Y		Y	–				
3.2.116.21										Y		Y [4]	Y	Y	Y		Y		Y		Y		–			
3.2.78.0										Y		Y [4]	Y	Y	Y		Y		Y		Y		Y	–		
3.1.111.0																	Y		Y		Y		Y	Y	–	
3.1.105.0																	Y		Y		Y		Y	Y	Y	–
3.1.59.24																	Y		Y		Y		Y	Y	Y	Y

1. You can upgrade directly from software release 4.1.190.5 to 4.1.192.35M; however, upgrading to 4.1.191.24M before upgrading to 4.1.192.35M is highly recommended.
2. CUSTOMERS WHO REQUIRE DYNAMIC FREQUENCY SELECTION (DFS) FUNCTIONALITY SHOULD NOT USE THIS RELEASE. This release does not provide DFS functionality fixes found in release 4.0.217.204. Additionally, this release is not supported in ETSI-compliant countries or Singapore.
3. Release 4.0.217.204 provides fixes for DFS on 1510 series access points. This functionality is needed only in countries where DFS rules apply.
4. An upgrade to 4.0.206.0 is not allowed in the following country codes when operating with the following access points: Australia (1505 and 1510), Brazil (1505 and 1510), Hong Kong (1505 and 1510), India (1505 and 1510), Japan (1510), Korea (1505 and 1510), Mexico (1505 and 1510), New Zealand (1505 and 1510), and Russia (1505 and 1510). The 1505 mesh access point is not supported in release 5.0 and later releases. The 1510 mesh access point is supported only in mesh releases 4.1.190.5, 4.1.191.22M, and 4.1.192.xxM.

Using the GUI to Upgrade Controller Software

To upgrade the controller software using the controller GUI, follow these steps:.

Note Do not install the 6.0 controller software file and the 5.2.157.0 ER.aes boot software file at the same time. Install one file and reboot the controller and then install the other file and reboot the controller.

Step 1 Upload your controller configuration files to a server to back them up.

Note Cisco highly recommends that you back up your controller's configuration files prior to upgrading the controller software. See the "Uploading and Downloading Configuration Files" section on page 10-27 for instructions.

Step 2 Obtain the 6.0 controller software and the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file from the Software Center on Cisco.com as follows:

a. Click this URL to go to the Software Center:

http://tools.cisco.com/support/downloads/go/Redirect.x?mdfid=278875243

b. Choose **Wireless Software**.

c. Choose **Wireless LAN Controllers**.

d. Choose **Standalone Controllers** or **Integrated Controllers and Controller Modules**.

e. Choose a controller series.

f. If necessary, choose a controller model.

g. If you chose Standalone Controllers in Step d., choose **Wireless LAN Controller Software**.

h. If you chose the Cisco Catalyst 6500 series / switch 7600 Series Wireless Services Module (WiSM) in Step e., choose **Wireless Services Modules (WiSM) Software**.

i. Choose a controller software release. The software releases are labeled as follows to help you determine which release to download:

- Early Deployment (ED)—These software releases provide new features, new hardware platform support, and bug fixes.
- Maintenance Deployment (MD)—These software releases provide bug fixes and ongoing software maintenance.
- Deferred (DF)—These software releases have been deferred. We recommend that you migrate to an upgraded release.

j. Choose a software release number.

k. Click the filename (*filename*.aes).

l. Click **Download**.

m. Read Cisco's End User Software License Agreement and then click **Agree**.

n. Save the file to your hard drive.

o. Repeat steps a. through n. to download the remaining file (either the 6.0 controller software or the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file).

Step 3 Copy the controller software file (*filename*.aes) and the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file to the default directory on your TFTP or FTP server.

Step 4 Disable the controller 802.11a and 802.11b/g networks.

Step 5 Disable any WLANs on the controller.

Step 6 Choose **Commands > Download File** to open the Download File to Controller page (see Figure 10-1).

Figure 10-1 Download File to Controller Page

Step 7 From the File Type drop-down list, choose **Code**.

Step 8 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 9 In the IP Address text box, enter the IP address of the TFTP or FTP server.

If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout text boxes should work correctly without any adjustment. However, you can change these values.

Step 10 Enter the maximum number of times that the TFTP server attempts to download the software in the Maximum Retries text box and the amount of time (in seconds) that the TFTP server attempts to download the software in the Timeout text box.

Step 11 In the File Path text box, enter the directory path of the software.

Step 12 In the File Name text box, enter the name of the controller software file (*filename*.aes).

Step 13 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 14 Click **Download** to download the software to the controller. A message appears indicating the status of the download.

Note You can schedule a reboot at a specified time. See Setting a Reboot Time, page 10-14.

Step 15 To install the remaining file (either the 6.0 controller software or the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file).

Step 16 Reenable the WLANs.

Step 17 For Cisco WiSMs, reenable the controller port channel on the Catalyst switch.

Step 18 Reenable your 802.11a and 802.11b/g networks.

Step 19 (Optional) Reload your latest configuration file to the controller.

Step 20 Verify that the 6.0 controller software is installed on your controller by choosing **Monitor** on the controller GUI and looking at the Software Version text box under Controller Summary.

Step 21 Verify that the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file is installed on your controller by choosing **Monitor** to open the Summary page and looking at the text box Recovery Image Version or Emergency Image Version text box.

Note If a Cisco Unified Wireless Network Controller Boot Software ER.aes file is not installed, the text box Recovery Image Version or Emergency Image Version text box shows "N/A."

Using the CLI to Upgrade Controller Software

To upgrade the controller software using the controller CLI, follow these steps:

Note Do not install the 6.0 controller software file and the 5.2.157.0 ER.aes boot software file at the same time. Install one file and reboot the controller; then install the other file and reboot the controller.

Step 1 Upload your controller configuration files to a server to back them up.

Note We highly recommend that you back up your controller's configuration files prior to upgrading the controller software. See the "Uploading and Downloading Configuration Files" section on page 10-27 for instructions.

Step 2 Obtain the 6.0 controller software and the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file from the Software Center on Cisco.com as follows:

a. Click this URL to go to the Software Center:

http://tools.cisco.com/support/downloads/go/Redirect.x?mdfid=278875243

b. Choose **Wireless Software**.

c. Choose **Wireless LAN Controllers**.

d. Choose **Standalone Controllers**, **Wireless Integrated Routers**, or **Wireless Integrated Switches**.

e. Choose the name of a controller.

f. Choose **Wireless LAN Controller Software**.

g. Choose a controller software release.

h. Click the filename (*filename*.aes).

i. Click **Download**.

j. Read Cisco's End User Software License Agreement and then click **Agree**.

k. Save the file to your hard drive.

l. Repeat steps a. to k. to download the remaining file (either the 6.0 controller software or the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file).

Step 3 Copy the controller software file (*filename*.aes) and the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file to the default directory on your TFTP or FTP server.

Step 4 Disable the controller 802.11a and 802.11b/g networks.

Step 5 For Cisco WiSMs, shut down the controller port channel on the Catalyst switch to allow the controller to reboot before the access points start downloading the software.

Step 6 Disable any WLANs on the controller (using the **config wlan disable** *wlan_id* command).

Step 7 Log into the controller CLI.

Step 8 Enter the **ping** *server-ip-address* command to verify that the controller can contact the TFTP or FTP server.

Step 9 View current download settings by entering the **transfer download start** command. Answer **n** to the prompt to view the current download settings.

Information similar to the following appears:

```
Mode..................................... TFTP
Data Type................................ Code
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Packet Timeout...................... 6
TFTP Max Retries......................... 10
TFTP Path................................ <directory path>
TFTP Filename............................ xxx.aes

This may take some time.
Are you sure you want to start? (y/N) n
Transfer Canceled
```

Step 10 Change the download settings, if necessary by entering these commands:

- **transfer download mode** {**tftp** | **ftp**}
- **transfer download datatype code**
- **transfer download serverip** *server-ip-address*
- **transfer download filename** *filename*
- **transfer download path** *server-path-to-file*

Note Pathnames on a TFTP or FTP server are relative to the server's default or root directory. For example, in the case of the Solarwinds TFTP server, the path is "/".

If you are using a TFTP server, also enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

If you are using an FTP server, also enter these commands:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 11 View the current updated settings by entering the **transfer download start** command. Answer **y** to the prompt to confirm the current download settings and start the software download.

Information similar to the following appears:

```
Mode..................................... TFTP
Data Type................................ Code
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Packet Timeout...................... 6
TFTP Max Retries......................... 10
TFTP Path................................ <directory path>
TFTP Filename............................ xxx.aes

Are you sure you want to start? (y/n) y
TFTP Code transfer starting.
TFTP receive complete... extracting components.
Writing new bootloader to flash.
Making backup copy of RTOS.
Writing new RTOS to flash.
Making backup copy of Code.
Writing new Code to flash.
TFTP File transfer operation completed successfully.
  Please restart the switch (reset system) for update to complete.
```

Step 12 Save the code update to nonvolatile NVRAM and reboot the controller by entering this command:

reset system

The controller completes the bootup process.

Note You can also schedule a reboot at a specified time. See Setting a Reboot Time, page 10-14.

Step 13 To install the remaining file (either the 6.0 controller software or the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file).

Step 14 Reenable the WLANs by entering this command:

config wlan enable *wlan_id*

Step 15 For Cisco WiSMs, re-enable the controller port channel on the Catalyst switch.

Step 16 Reenable your 802.11a and 802.11b/g networks.

Step 17 (Optional) Reload your latest configuration file to the controller.

Step 18 Verify that the 7.0 controller software is installed on your controller by entering the **show sysinfo** command and look at the Product Version text box.

Step 19 Verify that the Cisco Unified Wireless Network Controller Boot Software 5.2.157.0 ER.aes file is installed on your controller by entering the **show sysinfo** command on the controller CLI and looking at the text box Recovery Image Version or Emergency Image Version text box.

Note If a Cisco Unified Wireless Network Controller Boot Software ER.aes file is not installed, the text box Recovery Image Version or Emergency Image Version text box shows “N/A.”

Predownloading an Image to an Access Point

To minimize a network outages, you can now download an upgrade image to the access point from the controller without resetting the access point or losing network connectivity. Previously, you would download an upgrade image to the controller and reset it, which causes the access point to go into discovery mode. After the access point discovers the controller with the new image, the access point downloads the new image, resets, goes into discovery mode, and rejoins the controller.

You can now download the upgrade image to the controller and then download the image to the access point while the network is still up. You can also schedule a reboot of the controller and access points, either after a specified amount of time or at a specific date and time. When both devices are up, the access point discovers and rejoins the controller.

Note These access point models do not support predownloading of images: 1120, 1230, and 1310.

Access Point Predownload Process

The access point predownload feature works as below:

- The controller image is downloaded.
  - The downloaded image becomes the backup image on the controller. Change the current boot image as the backup image using the **config boot backup** command. This ensures that if a system failure occurs, the controller boots with the last working image of the controller.
  - User predownloads the upgraded image using the **config ap image predownload primary all** command. The upgrade image gets downloaded as the backup up image on the access points. This can be verified using the **show ap image all** command.
  - User manually changes the boot image to primary using **config boot primary** command and reboot the controller for the upgrade image to get activated.

    or
  - User issues scheduled reboot with **swap** keyword. For more information see Setting a Reboot Time, page 10-14. Here the **swap** keyword has the following importance: The swapping happens to the primary and backup images on access point, and the currently active image on controller with the backup image.
  - When the controller reboots, the access points get disassociated and eventually they come up with upgrade image. Once the controller responds to the discovery request sent by access points with its discovery response packet, the access point sends a join request.
- The actual upgrade of the images occur. The following sequence of actions occur.
  - During boot time, the access point sends a join request.
  - Controller responds with the join response along with the image version the controller is running.
  - The access point compares its running image with the running image on the controller. If the versions match, the access point joins the controller.
  - If the versions do not match, the access point compares the version of the backup image and if they match, the access point swaps the primary and backup images and reloads and subsequently joins the controller.
  - If the primary image of the access point is same as that of the controllers', the access point reloads and joins the controller.

– If none of the above conditions are true, the access point sends a image data request to the controller, downloads the latest image, reloads and joins the contoller.

Guidelines and Limitations for Predownloading Images

Follow these guidelines when you use image predownloading:

- The maximum number of concurrent predownloads is limited to half the number of concurrent normal image downloads. This limitation allows new access points to join the controller during image downloading.

  If you reach the predownload limit, then the access points that cannot get an image sleep for a time between 180 to 600 seconds and then reattempt the predownload.
- Before you enter the predownload command, you should change the active controller boot image to the backup image. This step ensures that if the controller reboots for some reason, it comes back up with the earlier running image, not the partially downloaded upgrade image.
- Access points with 16-MB total available memory (1130 and 1240 access points) may not have enough free memory to download an upgrade image and may automatically delete crash info files, radio files, and any backup images to free up space. However, this limitation does not affect the predownload process because the predownload image replaces any backup image on the access point.
- When the system time is changed by using the **config time** command, the time set for scheduled reset will not be valid and the scheduled system reset will be canceled. You are given an option either to cancel the scheduled reset before configuring the time or retain the scheduled reset and not configure the time.
- All the primary, secondary, and tertiary controllers should run the same images as the primary and backup images. That is, the primary image of all three controllers should be X and the secondary image of all three controllers should be Y or the feature will not be effective.
- At the time of the reset, if any AP is downloading the controller image, the scheduled reset is canceled. The following message appears with the reason why the scheduled reset was canceled:

  ```
  %OSAPI-3-RESETSYSTEM_FAILED: osapi_task.c:4458 System will not reset as software is
  being upgraded.
  ```

Using the GUI to Predownload an Image to an Access Point

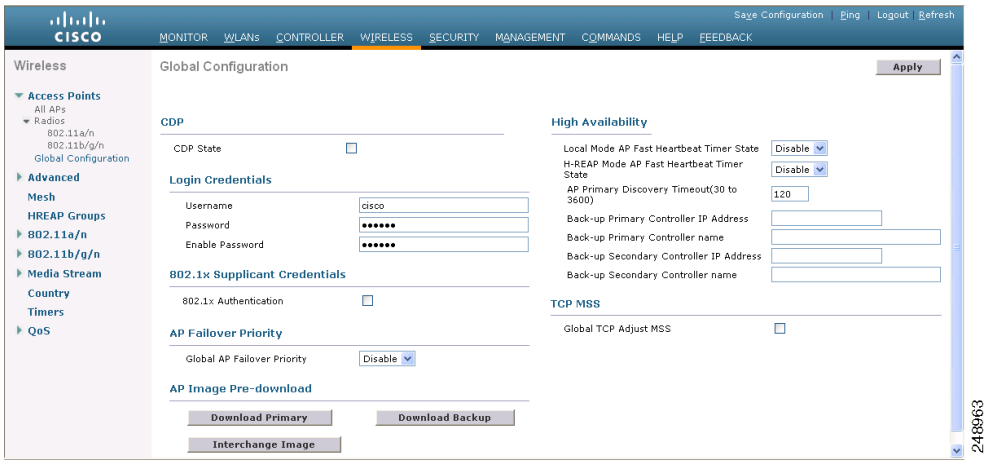
Using the GUI, you can predownload an image to a specific access point or to all access points.

To predownload an image using the controller GUI, follow these steps:

Step 1 Obtain the upgrade image and copy the image to the controller by performing Step 1 through Step 14 in the "Using the GUI to Upgrade Controller Software" section on page 10-5.

Step 2 Choose **Wireless > Access Points > Global Configuration** to open the Global Configuration page (see Figure 10-2).

Figure 10-2 Wireless > Access Points > Global Configuration Page



Step 3 Perform one of the following:

- To instruct all the access points to predownload a primary image from the controller, click **Download Primary** under the AP Image Pre-download.
- To instruct all the access points to swap their primary and backup images, click **Interchange Image**.
- To download an image from the controller and store it as a backup image, click **Download Backup**.

Step 4 Click **Apply** to commit your changes.

Using the CLI to Predownload an Image to Access Points

Using the CLI, you can predownload an image to a specific access point or to all access points. The process includes three steps:

1. Obtaining the upgrade image.
2. Specify access points that will receive the predownload image.
3. Set a reboot time for the controller and the access points.

Obtaining the Upgrade Image

To obtain the upgrade image and copy the image to the controller, follow Step 1 through Step 11 in the "Using the CLI to Upgrade Controller Software" section on page 10-8.

Specifying Access Points for Predownload

Use one of these commands to specify access points for predownload:

- Specify access points for predownload by entering this command:

  config ap image predownload {**primary** | **backup**} {*ap_name* | **all**}

  The primary image is the new image; the backup image is the existing image. Access points always boot with the primary image.

- Swap an access point's primary and backup images by entering this command:

config ap image swap {*ap_name* | **all**}

- Display detailed information on access points specified for predownload by entering this command:

  show ap image {**all** | *ap-name*}

Information similar to the following appears:

```
Total number of APs.............................. 7
Number of APs
        Initiated....................................... 4
        Predownloading.................................. 0
        Completed predownloading........................ 3
        Not Supported................................... 0
        Failed to Predownload........................... 0


AP Name Primary Image Backup Image Predownload Predownload Version Next Retry Time  Retry
                                    status     Version                            Count
------------------ -------------- -------------- --------------- --------------
---------------- ------------
AP1140-1 7.0.56.0 6.0.183.38     Complete        6.0.183.38     NA               NA
AP1140-2 7.0.56.0 6.0.183.58     Initiated       6.0.183.38     23:46:43         1
AP1130-2 7.0.56.0 6.0.183.38     Complete        6.0.183.38     NA               NA
AP1130-3 7.0.56.0 6.0.183.58     Initiated       6.0.183.38     23:43:25         1
AP1130-4 7.0.56.0 6.0.183.38     Complete        6.0.183.38     NA               NA
AP1130-5 7.0.56.0 6.0.183.58     Initiated       6.0.183.38     23:43:00         1
AP1130-6 7.0.56.0 6.0.183.58     Initiated       6.0.183.38     23:41:33         1
```

The output lists access points that are specified for predownloading and provides for each access point, primary and secondary image versions, the version of the predownload image, the predownload retry time (if necessary), and the number of predownload attempts. The output also includes the predownload status for each device. The status of the access points is as follows:

- None—The access point is not scheduled for predownload.
- Predownloading—The access point is predownloading the image.
- Not supported—The access point (1120, 1230, and 1310) does not support predownloading.
- Initiated—The access point is waiting to get the predownload image because the concurrent download limit has been reached.
- Failed—The access point has failed 64 predownload attempts.
- Complete—The access point has completed predownloading.

Setting a Reboot Time

Use one of these commands to schedule a reboot of the controller and access points:

- Specify the amount of time delay before the devices reboot by entering this command:

  reset system in *HH*:*MM*:*SS* **image** {**swap** | **no-swap**} **reset-aps** [**save-config**]

  Note The **swap** operand in the **reset** command will result in the swapping of the primary and backup images on both the controller and the access point.

  The controller sends a reset message to all joined access points, and then the controller resets.

- Specify a date and time for the devices to reboot by entering this command:

  reset system at *YYYY-MM-DD HH*:*MM*:*SS* **image** {**swap** | **no-swap**} **reset-aps** [**save-config**]

The controller sends a reset message to all joined access points, and then the controller resets.

Note The **swap** operand in the **reset** command will result in the swapping of the primary and backup images on both the controller and the access point.

- Set up an SNMP trap message that announces the upcoming reset by entering this command:

  reset system notify-time *minutes*

  The controller sends the announcement trap the configured number of minutes before the reset.
- Cancel the scheduled reboot by entering this command:

  reset system cancel

Note If you configure reset times and then use the **config time** command to change the system time on the controller, the controller notifies you that any scheduled reset times will be canceled and must be reconfigured after you set the system time.

Use the **show reset** command to display scheduled resets.

Information similar to the following appears:

```
System reset is scheduled for Apr 08 01:01:01 2010.
Current local time and date is Apr 07 02:57:44 2010.
A trap will be generated 10 minutes before each scheduled system reset.
Use 'reset system cancel' to cancel the reset.
Configuration will be saved before the system reset.
```

Transferring Files to and from a Controller

Controllers have built-in utilities for uploading and downloading various files. Follow the instructions in these sections to import files using either the controller GUI or CLI:

- Downloading a Login Banner File, page 10-15
- Downloading Device Certificates, page 10-19
- Downloading CA Certificates, page 10-22
- Uploading PACs, page 10-25
- Uploading and Downloading Configuration Files, page 10-27

Downloading a Login Banner File

In controller software release 6.0 or later releases, you can download a login banner file using either the GUI or the CLI. The login banner is the text that appears on the page before user authentication when you access the controller GUI or CLI using Telnet, SSH, or a console port connection.

You save the login banner information as a text (*.txt) file. The text file cannot be larger than 1296 characters and cannot have more than 16 lines of text.

Note The ASCII character set consists of printable and nonprintable characters. The login banner supports only printable characters.

Here is an example of a login banner:

```
Welcome to the Cisco Wireless Controller!
Unauthorized access prohibited.
Contact sysadmin@corp.com for access.
```

Follow the instructions in this section to download a login banner to the controller through the GUI or CLI. However, before you begin, make sure that you have a TFTP or FTP server available for the file download. Follow these guidelines when setting up a TFTP or FTP server:

- If you are downloading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Note Clearing the controller configuration does not remove the login banner. See the "Using the GUI to Clear the Login Banner" section on page 10-18 for information about clearing the login banner using the controller GUI or CLI.

Note The controller can have only one login banner file. If you download another login banner file to the controller, the first login banner file is overwritten.

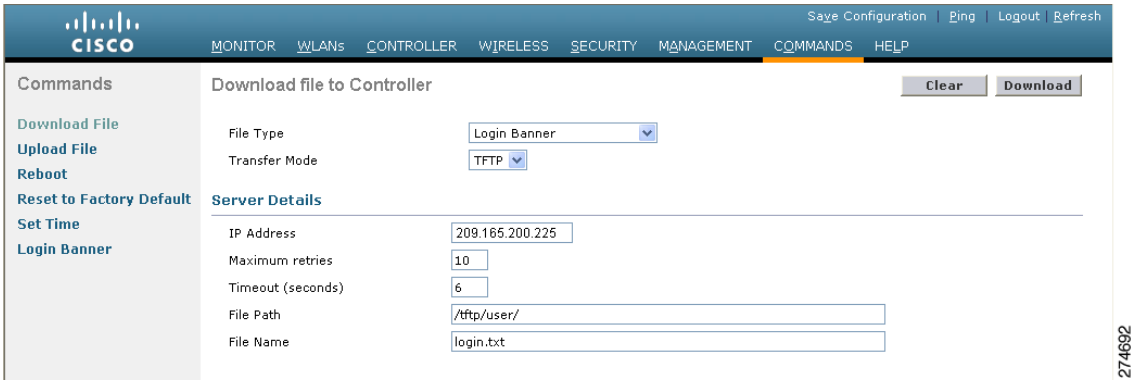
Using the GUI to Download a Login Banner File

To download a login banner file to the controller using the controller GUI, follow these steps:

Step 1 Copy the login banner file to the default directory on your TFTP or FTP server.

Step 2 Choose **Commands > Download File** to open the Download File to Controller page (see Figure 10-3).

Figure 10-3 Download File to Controller Page



Step 3 From the File Type drop-down list, choose **Login Banner**.

Step 4 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 5 In the IP Address text box, enter the IP address of the TFTP or FTP server.

If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout text boxes should work correctly without any adjustment. However, you can change these values.

Step 6 Enter the maximum number of times that the TFTP server attempts to download the certificate in the Maximum Retries text box and the amount of time (in seconds) that the TFTP server attempts to download the certificate in the Timeout text box.

Step 7 In the File Path text box, enter the directory path of the login banner file.

Step 8 In the File Name text box, enter the name of the login banner text (*.txt) file.

Step 9 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 10 Click **Download** to download the login banner file to the controller. A message appears indicating the status of the download.

Using the CLI to Download a Login Banner File

To download a login banner file to the controller using the controller CLI, follow these steps:

Step 1 Log into the controller CLI.

Step 2 Specify the transfer mode used to download the config file by entering this command:

transfer download mode {**tftp** | **ftp**}

Step 3 Download the controller login banner by entering this command:

transfer download datatype login-banner

Step 4 Specify the IP address of the TFTP or FTP server by entering this command:

transfer download serverip *server-ip-address*

Step 5 Specify the name of the config file to be downloaded by entering this command:

transfer download path *server-path-to-file*

Step 6 Specify the directory path of the config file by entering this command:

transfer download filename *filename***.txt**

Step 7 If you are using a TFTP server, enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

Step 8 If you are using an FTP server, enter these commands:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 9 View the download settings by entering the **transfer download start** command. Answer **y** when prompted to confirm the current settings and start the download process.

Information similar to the following appears:

```
Mode............................................. TFTP
Data Type........................................ Login Banner
TFTP Server IP................................... 10.10.10.10
TFTP Packet Timeout.............................. 6
TFTP Max Retries................................. 10
TFTP Path........................................ /
TFTP Filename.................................... banner.txt

This may take some time.
Are you sure you want to start? (y/N) y

TFTP Login Banner transfer starting.

TFTP receive complete... checking login banner.

Successfully installed new login banner file
```

Using the GUI to Clear the Login Banner

To clear the login banner from the controller using the controller GUI, follow these steps:

Step 1 Choose **Commands > Login Banner** to open the Login Banner page (see Figure 10-4).

Figure 10-4 Login Banner Page

Step 2 Click **Clear**.

Step 3 When prompted, click **OK** to clear the banner.

To clear the login banner from the controller using the controller CLI, enter the **clear login-banner** command.

Downloading Device Certificates

Each wireless device (controller, access point, and client) has its own device certificate. For example, the controller is shipped with a Cisco-installed device certificate. This certificate is used by EAP-FAST (when not using PACs), EAP-TLS, PEAP-GTC, and PEAP-MSCHAPv2 to authenticate wireless clients during local EAP authentication. However, if you want to use your own vendor-specific device certificate, it must be downloaded to the controller.

Note See the "Configuring Local EAP" section on page 6-42 for information on configuring local EAP.

Follow the instructions in this section to download a vendor-specific device certificate to the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the certificate download. Follow these guidelines when setting up a TFTP or FTP server:

- If you are downloading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Note All certificates downloaded to the controller must be in PEM format.

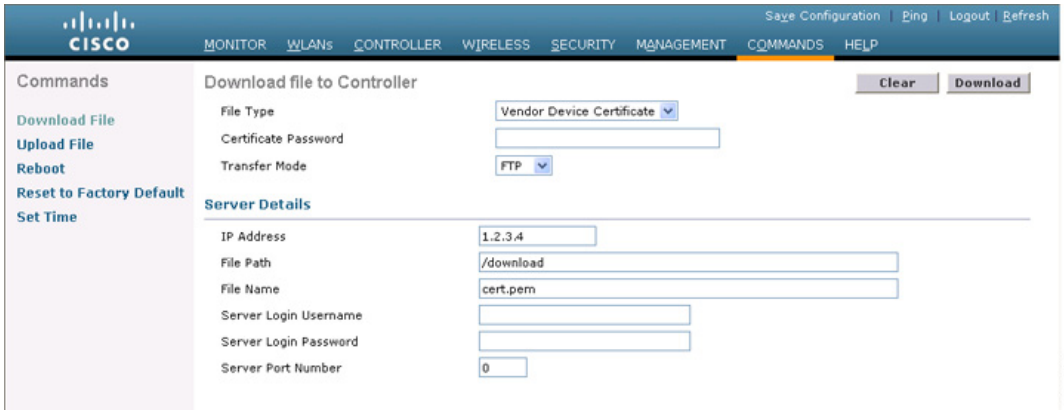
Using the GUI to Download Device Certificates

To download a device certificate to the controller using the controller GUI, follow these steps:

Step 1 Copy the device certificate to the default directory on your TFTP or FTP server.

Step 2 Choose **Commands** > **Download File** to open the Download File to Controller page (see Figure 10-5).

Figure 10-5 Download File to Controller Page



Step 3 From the File Type drop-down list, choose **Vendor Device Certificate**.

Step 4 In the Certificate Password text box, enter the password that was used to protect the certificate.

Step 5 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 6 In the IP Address text box, enter the IP address of the TFTP or FTP server.

If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout text boxes should work correctly without any adjustment. However, you can change these values.

Step 7 Enter the maximum number of times that the TFTP server attempts to download the certificate in the Maximum Retries text box and the amount of time (in seconds) that the TFTP server attempts to download the certificate in the Timeout text box.

Step 8 In the File Path text box, enter the directory path of the certificate.

Step 9 In the File Name text box, enter the name of the certificate.

Step 10 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 11 Click **Download** to download the device certificate to the controller. A message appears indicating the status of the download.

Step 12 After the download is complete, choose **Commands** > **Reboot** > **Reboot**.

Step 13 If prompted to save your changes, click **Save and Reboot**.

Step 14 Click **OK** to confirm your decision to reboot the controller.

Using the CLI to Download Device Certificates

To download a device certificate to the controller using the controller CLI, follow these steps:

Step 1 Log into the controller CLI.

Step 2 Specify the transfer mode used to download the config file by entering this command:

transfer download mode {**tftp** | **ftp**}

Step 3 Specify the type of the file to be downloaded by entering this command:

transfer download datatype eapdevcert

Step 4 Specify the certificate's private key by entering this command:

transfer download certpassword *password*

Step 5 Specify the IP address of the TFTP or FTP server by entering this command:

transfer download serverip *server-ip-address*

Step 6 Specify the name of the config file to be downloaded by entering this command:

transfer download path *server-path-to-file*

Step 7 Specify the directory path of the config file by entering this command:

transfer download filename *filename*.pem

Step 8 If you are using a TFTP server, enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

Step 9 If you are using an FTP server, enter these commands:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 10 View the updated settings by entering the **transfer download start** command. Answer **y** when prompted to confirm the current settings and start the download process.

Information similar to the following appears:

```
Mode..................................... TFTP
```

```
Data Type.................................. Vendor Dev Cert
TFTP Server IP............................. 10.10.10.4
TFTP Packet Timeout........................ 6
TFTP Max Retries........................... 10
TFTP Path.................................. /tftpboot/username/
TFTP Filename.............................. filename.pem

This may take some time.
Are you sure you want to start? (y/N) y

TFTP EAP Dev cert transfer starting.

Certificate installed.
Reboot the switch to use the new certificate.
```

Step 11 Reboot the controller by entering this command:

reset system

Downloading CA Certificates

Controllers and access points have a Certificate Authority (CA) certificate that is used to sign and validate device certificates. The controller is shipped with a Cisco-installed CA certificate. This certificate may be used by EAP-FAST (when not using PACs), EAP-TLS, PEAP-GTC, and PEAP-MSCHAPv2 to authenticate wireless clients during local EAP authentication. However, if you want to use your own vendor-specific CA certificate, it must be downloaded to the controller.

Note See the "Configuring Local EAP" section on page 6-42 for information on configuring local EAP.

Follow the instructions in this section to download CA certificates to the controller through the GUI or CLI. However, before you begin, make sure that you have a TFTP or FTP server available for the certificate download. Follow these guidelines when setting up a TFTP or FTP server:

- If you are downloading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Note All certificates downloaded to the controller must be in PEM format.

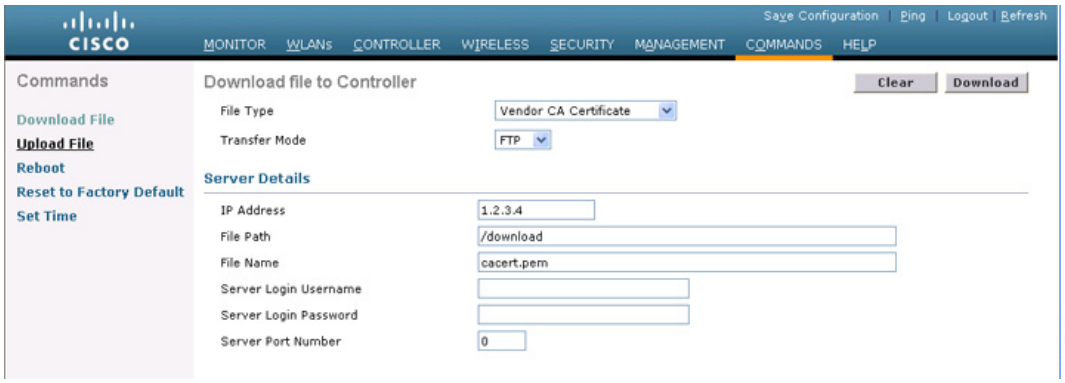
Using the GUI to Download CA Certificates

To download a CA certificate to the controller using the controller GUI, follow these steps:

Step 1 Copy the CA certificate to the default directory on your TFTP or FTP server.

Step 2 Choose **Commands** > **Download File** to open the Download File to Controller page (see Figure 10-6).

Figure 10-6 Download File to Controller Page



Step 3 From the File Type drop-down list, choose **Vendor CA Certificate**.

Step 4 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 5 In the IP Address text box, enter the IP address of the TFTP or FTP server.

If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout text boxes should work correctly without any adjustment. However, you can change these values.

Step 6 Enter the maximum number of times that the TFTP server attempts to download the certificate in the Maximum Retries text box and the amount of time (in seconds) that the TFTP server attempts to download the certificate in the Timeout text box.

Step 7 In the File Path text box, enter the directory path of the certificate.

Step 8 In the File Name text box, enter the name of the certificate.

Step 9 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 10 Click **Download** to download the CA certificate to the controller. A message appears indicating the status of the download.

Step 11 After the download is complete, choose **Commands** > **Reboot** > **Reboot**.

Step 12 If prompted to save your changes, click **Save and Reboot**.

Step 13 Click **OK** to confirm your decision to reboot the controller.

Using the CLI to Download CA Certificates

To download a CA certificate to the controller using the controller CLI, follow these steps:

Step 1 Log into the controller CLI.

Step 2 Specify the transfer mode used to download the config file by entering this command:

transfer download mode {**tftp** | **ftp**}

Step 3 Specify the type of the file to be downloaded by entering this command:

transfer download datatype eapdevcert

Step 4 Specify the IP address of the TFTP or FTP server by entering this command:

transfer download serverip *server-ip-address*

Step 5 Specify the directory path of the config file by entering this command:

transfer download path *server-path-to-file*

Step 6 Specify the name of the config file to be downloaded by entering this command:

transfer download filename *filename*.pem

Step 7 If you are using a TFTP server, enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

Step 8 If you are using an FTP server, enter these commands:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 9 View the updated settings by entering the **transfer download start** command. Answer **y** when prompted to confirm the current settings and start the download process.

Information similar to the following appears:

```
Mode..................................... TFTP
Data Type................................ Vendor CA Cert
TFTP Server IP........................... 10.10.10.4
TFTP Packet Timeout...................... 6
TFTP Max Retries......................... 10
TFTP Path................................ /tftpboot/username/
TFTP Filename............................ filename.pem

This may take some time.
Are you sure you want to start? (y/N) y

TFTP EAP CA cert transfer starting.

Certificate installed.
Reboot the switch to use the new certificate.
```

Step 10 Reboot the controller by entering the **reset system** command.

Uploading PACs

Protected access credentials (PACs) are credentials that are either automatically or manually provisioned and used to perform mutual authentication with a local EAP authentication server during EAP-FAST authentication. When manual PAC provisioning is enabled, the PAC file is manually generated on the controller.

Note See the "Configuring Local EAP" section on page 6-42 for information on configuring local EAP.

Follow the instructions in this section to generate and load PACs from the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the PAC upload. Follow these guidelines when setting up a TFTP or FTP server:

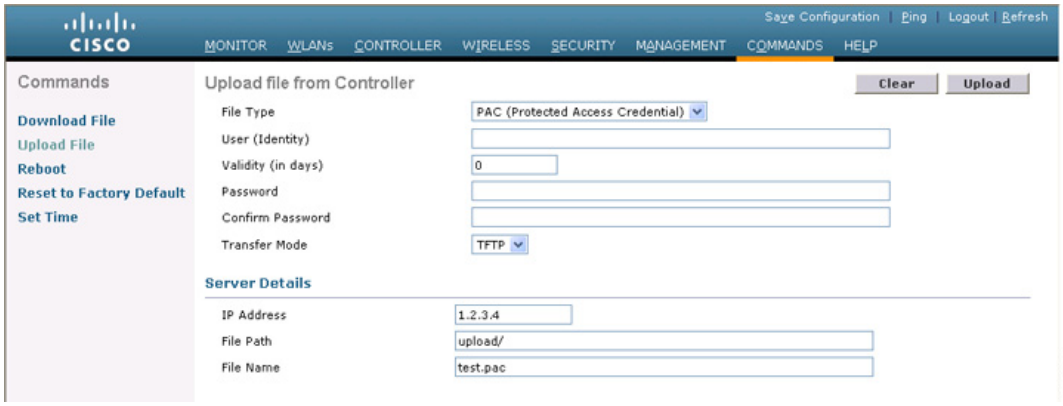
- If you are uploading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are uploading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Using the GUI to Upload PACs

To upload a PAC from the controller using the controller GUI, follow these steps:

Step 1 Choose **Commands > Upload File** to open the Upload File from Controller page (see Figure 10-7).

Figure 10-7 Upload File from Controller Page



Step 2 From the File Type drop-down list, choose **PAC (Protected Access Credential)**.

Step 3 In the User text box, enter the name of the user who will use the PAC.

Step 4 In the Validity text box, enter the number of days for the PAC to remain valid. The default setting is zero (0).

Step 5 In the Password and Confirm Password text boxes, enter a password to protect the PAC.

Step 6 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 7 In the IP Address text box, enter the IP address of the TFTP or FTP server.

Step 8 In the File Path text box, enter the directory path of the PAC.

Step 9 In the File Name text box, enter the name of the PAC file. PAC files have a .pac extension.

Step 10 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the upload occurs. The default value is 21.

Step 11 Click **Upload** to upload the PAC from the controller. A message appears indicating the status of the upload.

Step 12 Follow the instructions for your wireless client to load the PAC on your client devices. Make sure to use the password that you entered above.

Using the CLI to Upload PACs

To upload a PAC from the controller using the controller CLI, follow these steps:

Step 1 Log into the controller CLI.

Step 2 Specify the transfer mode used to upload the config file by entering this command:

transfer upload mode {**tftp** | **ftp**}

Step 3 Upload a Protected Access Credential (PAC) by entering this command:

transfer upload datatype pac

Step 4 Specify the identification of the user by entering this command:

transfer upload pac *username validity password*

Step 5 Specify the IP address of the TFTP or FTP server by entering this command:

transfer upload serverip *server-ip-address*

Step 6 Specify the directory path of the config file by entering this command:

transfer upload path *server-path-to-file*

Step 7 Specify the name of the config file to be uploaded by entering this command:

transfer upload filename *manual*.pac.

Step 8 If you are using an FTP server, enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 9 View the updated settings by entering the **transfer upload start** command. Answer **y** when prompted to confirm the current settings and start the upload process.

Information similar to the following appears:

```
Mode..................................... TFTP
TFTP Server IP........................... 10.10.10.4
TFTP Path................................ /tftpboot/username/
TFTP Filename............................ manual.pac
Data Type................................ PAC
PAC User................................. username
PAC Validity............................. 10 days
PAC Password............................. password

Are you sure you want to start? (y/N) y

PAC transfer starting.

File transfer operation completed successfully.
```

Step 10 Follow the instructions for your wireless client to load the PAC on your client devices. Make sure to use the password that you entered above.

Uploading and Downloading Configuration Files

We recommend that you upload your controller's configuration file to a server to back it up. If you lose your configuration, you can then download the saved configuration to the controller.

Note Do not download a configuration file to your controller that was uploaded from a different controller platform. For example, a Cisco 5500 Series Controller does not support the configuration file from a Cisco 4400 Series or 2100 Series Controller.

In controller software release 4.2 or later releases, the controller's bootup configuration file is stored in an Extensible Markup Language (XML) format rather than in a binary format. Therefore, you cannot download a binary configuration file onto a controller running software release 4.2 or later releases. However, when you upgrade a controller from a previous software release to 4.2 or later releases, the configuration file is migrated and converted to XML.

Follow these guidelines when working with configuration files:

- Any CLI with an invalid value is filtered out and set to default by the XML validation engine. Validation occurs during bootup. A configuration may be rejected if the validation fails. A configuration may fail if you have an invalid CLI. For example, if you have a CLI where you try to configure a WLAN without adding appropriate commands to add the WLAN.
- A configuration may be rejected if the dependencies are not addressed. For example, if you try to configure dependent parameters without using the add command. The XML validation may succeed but the configuration download infrastructure will immediately reject the configuration with no valadation errors.

- An invalid configuration can be verified by using the **show invalid-config** command. The **show invalid-config** command reports the configuration that is rejected by the conftroller either as part of download process or by XML validation infrastructure.

Note Controller software release 5.2 or later releases enable you to read and modify the configuration file. See the "Editing Configuration Files" section on page 10-33 for details. Controller software releases prior to 5.2 do not allow configuration files to be modified. If you attempt to make changes to a 4.2, 5.0, or 5.1 configuration file and then download the file to a controller, the controller displays a cyclic redundancy checksum (CRC) error while it is rebooting and returns the configuration parameters to their default values.

Uploading Configuration Files

You can upload configuration files using either the GUI or the CLI.

Using the GUI to Upload Configuration Files

To upload a configuration file to a server using the controller GUI, follow these steps:

Step 1 Choose **Commands** > **Upload File** to open the Upload File from Controller page (see Figure 10-8).

Figure 10-8 Upload File from Controller Page

Step 2 From the File Type drop-down list, choose **Configuration**.

Step 3 Encrypt the configuration file by selecting the **Configuration File Encryption** check box and entering the encryption key in the Encryption Key text box.

Step 4 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 5 In the IP Address text box, enter the IP address of the TFTP or FTP server.

Step 6 In the File Path text box, enter the directory path of the configuration file.

Step 7 In the File Name text box, enter the name of the configuration file.

Step 8 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the upload occurs. The default value is 21.

Step 9 Click **Upload** to upload the configuration file to the TFTP or FTP server. A message appears indicating the status of the upload. If the upload fails, repeat this procedure and try again.

Using the CLI to Upload Configuration Files

To upload a configuration file to a server using the controller CLI, follow these steps:

Step 1 Specify the transfer mode used to upload the configuration file by entering this command:

transfer upload mode {**tftp** | **ftp**}

Step 2 Specify the type of file to be uploaded by entering this command:

transfer upload datatype config

Step 3 Encrypt the configuration file by entering these commands:

- **transfer encrypt enable**
- **transfer encrypt set-key** *key*, where *key* is the encryption key used to encrypt the file.

Step 4 Specify the IP address of the TFTP or FTP server by entering this command:

transfer upload serverip *server-ip-address*

Step 5 Specify the directory path of the configuration file by entering this command:

transfer upload path *server-path-to-file*

Step 6 Specify the name of the configuration file to be uploaded by entering this command:

transfer upload filename *filename*

Step 7 If you are using an FTP server, enter these commands to specify the username and password used to log into the FTP server and the port number through which the upload occurs:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 8 Initiate the upload process by entering this command:

transfer upload start

Step 9 When prompted to confirm the current settings, answer **y**.

Information similar to the following appears:

```
Mode............................................. TFTP
TFTP Server IP................................... 10.10.10.4
TFTP Path........................................ Config/
TFTP Filename.................................... AS_4402_4_2_55_8_Config.xml
Data Type........................................ Config File
Encryption....................................... Disabled

*********************************************
```

```
***  WARNING: Config File Encryption Disabled  ***
************************************************

Are you sure you want to start? (y/N) y

File transfer operation completed successfully.
```

If the upload fails, repeat this procedure and try again.

Downloading Configuration Files

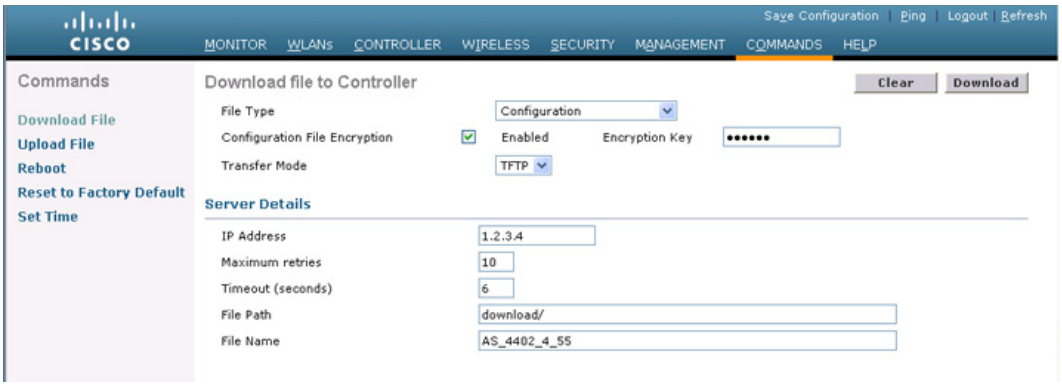
You can download configuration files using either the GUI or the CLI.

Using the GUI to Download Configuration Files

To download a configuration file to the controller using the controller GUI, follow these steps:

Step 1 Choose **Commands > Download File** to open the Download File to Controller page (see Figure 10-9).

Figure 10-9 Download File to Controller Page



Step 2 From the File Type drop-down list, choose **Configuration**.

Step 3 If the configuration file is encrypted, select the **Configuration File Encryption** check box and enter the encryption key used to decrypt the file in the Encryption Key text box.

Note The key that you enter here should match the one entered during the upload process.

Step 4 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 5 In the IP Address text box, enter the IP address of the TFTP or FTP server.

If you are using a TFTP server, the default values of 10 retries and 6 seconds for the Maximum Retries and Timeout text boxes should work correctly without any adjustment. However, you can change these values.

Step 6 Enter the maximum number of times that the TFTP server attempts to download the configuration file in the Maximum Retries text box and the amount of time (in seconds) that the TFTP server attempts to download the configuration file in the Timeout text box.

Step 7 In the File Path text box, enter the directory path of the configuration file.

Step 8 In the File Name text box, enter the name of the configuration file.

Step 9 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 10 Click **Download** to download the file to the controller. A message appears indicating the status of the download, and the controller reboots automatically. If the download fails, repeat this procedure and try again.

Using the CLI to Download Configuration Files

To download a configuration file to the controller using the controller CLI, follow these steps:

Note The controller does not support incremental configuration downloads. The configuration file contains all mandatory commands (all interface address commands, mgmtuser with read-write permission commands, and interface port or LAG enable or disable commands) required to successfully complete the download. For example, if you download only the **config time ntp server** *index server_address* command as part of the configuration file, the download fails. Only the commands present in the configuration file are applied to the controller, and any configuration in the controller prior to the download is removed.

Step 1 Specify the transfer mode used to download the configuration file by entering this command:

transfer download mode {**tftp** | **ftp**}

Step 2 Specify the type of file to be downloaded by entering this command:

transfer download datatype config

Step 3 If the configuration file is encrypted, enter these commands:

- **transfer encrypt enable**
- **transfer encrypt set-key** *key*, where *key* is the encryption key used to decrypt the file

Note The key that you enter here should match the one entered during the upload process.

Step 4 Specify the IP address of the TFTP or FTP server by entering this command:

transfer download serverip *server-ip-address*

Step 5 Specify the directory path of the configuration file by entering this command:

transfer download path *server-path-to-file*

Step 6 Specify the name of the configuration file to be downloaded by entering this command:

transfer download filename *filename*

Step 7 If you are using a TFTP server, enter these commands:

- **transfer download tftpMaxRetries** *retries*
- **transfer download tftpPktTimeout** *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that the TFTP server attempts to download the software for the *retries* parameter and the amount of time (in seconds) that the TFTP server attempts to download the software for the *timeout* parameter.

Step 8 If you are using an FTP server, enter these commands to specify the username and password used to log into the FTP server and the port number through which the download occurs:

- **transfer download username** *username*
- **transfer download password** *password*
- **transfer download port** *port*

Note The default value for the *port* parameter is 21.

Step 9 View the updated settings by entering this command:

transfer download start

Step 10 When prompted to confirm the current settings and start the download process, answer **y**.

Information similar to the following appears:

```
Mode............................................. TFTP
TFTP Server IP................................... 10.10.10.4
TFTP Path........................................ Config/
TFTP Filename.................................... AS_4402_4_2_55_8_Config.xml
Data Type........................................ Config File
Encryption....................................... Disabled

************************************************
***  WARNING: Config File Encryption Disabled  ***
************************************************

Are you sure you want to start? (y/N) y

File transfer operation completed successfully.
```

If the download fails, repeat this procedure and try again.

Saving Configurations

Controllers contain two kinds of memory: volatile RAM and NVRAM. At any time, you can save the configuration changes from active volatile RAM to nonvolatile RAM (NVRAM) using one of these commands:

- **save config**—Saves the configuration from volatile RAM to NVRAM without resetting the controller.
- **reset system**—Prompts you to confirm that you want to save configuration changes before the controller reboots.
- **logout**—Prompts you to confirm that you want to save configuration changes before you log out.

Editing Configuration Files

When you save the controller's configuration, the controller stores it in XML format in flash memory. Controller software release 5.2 or later releases enable you to easily read and modify the configuration file by converting it to CLI format. When you upload the configuration file to a TFTP or FTP server, the controller initiates the conversion from XML to CLI. You can then read or edit the configuration file in a CLI format on the server. When you are finished, you download the file back to the controller, where it is reconverted to an XML format and saved.

To edit the controller's configuration file, follow these steps:

Step 1 Upload the configuration file to a TFTP or FTP server by performing one of the following:

- Upload the file using the controller GUI. Follow the instructions in the "Using the GUI to Upload Configuration Files" section on page 10-28.
- Upload the file using the controller CLI. Follow the instructions in the "Using the CLI to Upload Configuration Files" section on page 10-29.

Step 2 Read or edit the configuration file on the server. You can modify or delete existing CLI commands and add new CLI commands to the file.

Note To edit the configuration file, you can use either Notepad or WordPad on Windows or the VI editor on Linux.

Step 3 Save your changes to the configuration file on the server.

Step 4 Download the configuration file to the controller by performing one of the following:

- Download the file using the controller GUI. Follow the instructions in the "Using the GUI to Download Configuration Files" section on page 10-30.
- Download the file using the controller CLI. Follow the instructions in the "Using the CLI to Download Configuration Files" section on page 10-31.

The controller converts the configuration file to an XML format, saves it to flash memory, and then reboots using the new configuration. CLI commands with known keywords and proper syntax are converted to XML while improper CLI commands are ignored and saved to flash memory. Any CLI commands that have invalid values are replaced with default values. To see any ignored commands or invalid configuration values, enter this command:

show invalid-config

Note You cannot execute this command after the **clear config** or **save config** command.

Step 5 If the downloaded configuration contains a large number of invalid CLI commands, you might want to upload the invalid configuration to the TFTP or FTP server for analysis. To do so, perform one of the following:

- Upload the invalid configuration using the controller GUI. Follow the instructions in the "Using the GUI to Upload Configuration Files" section on page 10-28 but choose **Invalid Config** from the File Type drop-down list in Step 2 and skip Step 3.
- Upload the invalid configuration using the controller CLI. Follow the instructions in the "Using the CLI to Upload Configuration Files" section on page 10-29 but enter the transfer **upload datatype invalid-config** command in Step 2 and skip Step 3.

Step 6 The controller does not support the uploading and downloading of port configuration CLI commands. If you want to configure the controller ports, enter these commands:

- **config port linktrap** {*port* | **all**} {**enable** | **disable**}—Enables or disables the up and down link traps for a specific controller port or for all ports.
- **config port adminmode** {*port* | **all**} {**enable** | **disable**}—Enables or disables the administrative mode for a specific controller port or for all ports.

Step 7 Save your changes by entering this command:

save config

Clearing the Controller Configuration

To clear the active configuration in NVRAM, follow these steps:

Step 1 Clear the configuration by entering this command:

clear config

Enter **y** at the confirmation prompt to confirm the action.

Step 2 Reboot the system by entering this command:

reset system

Enter **n** to reboot without saving configuration changes. When the controller reboots, the configuration wizard starts automatically.

Step 3 Follow the instructions in the "Using the Configuration Wizard" section on page 2-1 to complete the initial configuration.

Erasing the Controller Configuration

To reset the controller configuration to default, follow these steps:

Step 1 Reset the configuration by entering this command:

reset system

At the confirmation prompt, enter **y** to save configuration changes to NVRAM. The controller reboots.

Step 2 When you are prompted for a username, restore the factory-default settings by entering this command:

recover-config

The controller reboots and the configuration wizard starts automatically.

Step 3 Follow the instructions in the "Using the Configuration Wizard" section on page 2-1 to complete the initial configuration.

Resetting the Controller

You can reset the controller and view the reboot process on the CLI console using one of the following two methods:

- Turn the controller off and then turn it back on.
- On the CLI, enter **reset system**. At the confirmation prompt, enter **y** to save configuration changes to NVRAM. The controller reboots.

When the controller reboots, the CLI console displays the following reboot information:

- Initializing the system.
- Verifying the hardware configuration.
- Loading microcode into memory.
- Verifying the operating system software load.
- Initializing with its stored configurations.
- Displaying the login prompt.

CHAPTER 11

Managing User Accounts

This chapter describes how to create and manage guest user accounts, how the web authentication process works, and how to customize the web authentication login page. It contains these sections:

Creating Guest User Accounts

The controller can provide guest user access on WLANs. The first step in creating guest user accounts is to create a lobby administrator account, also known as a lobby ambassador account. Once this account has been created, a lobby ambassador can create and manage guest user accounts on the controller. The lobby ambassador has limited configuration privileges and access only to the web pages used to manage the guest accounts.

The lobby ambassador can specify the amount of time that the guest user accounts remain active. After the specified time elapses, the guest user accounts expire automatically.

The local user database is limited to a maximum of 2048 entries, which is also the default value (on the Security > AAA > General page). This database is shared by local management users (including lobby ambassadors), local network users (including guest users), MAC filter entries, exclusion list entries, and access point authorization list entries. Together they cannot exceed the configured maximum value.

Creating a Lobby Ambassador Account

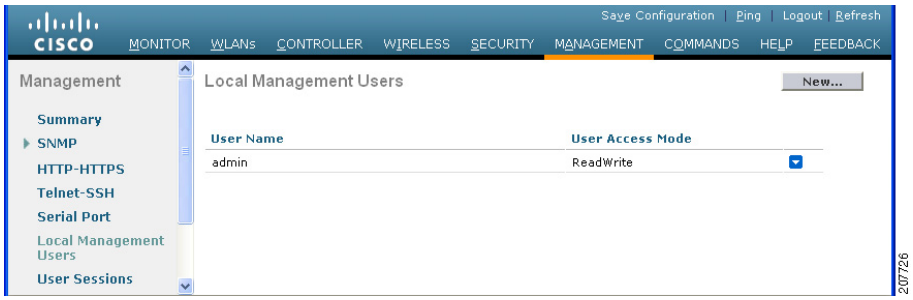
You can create a lobby ambassador account on the controller through either the GUI or the CLI.

Using the GUI to Create a Lobby Ambassador Account

To create a lobby ambassador account using the controller GUI, follow these steps:

Step 1 Choose **Management** > **Local Management Users** to open the Local Management Users page (see Figure 11-1).

Figure 11-1 Local Management Users Page

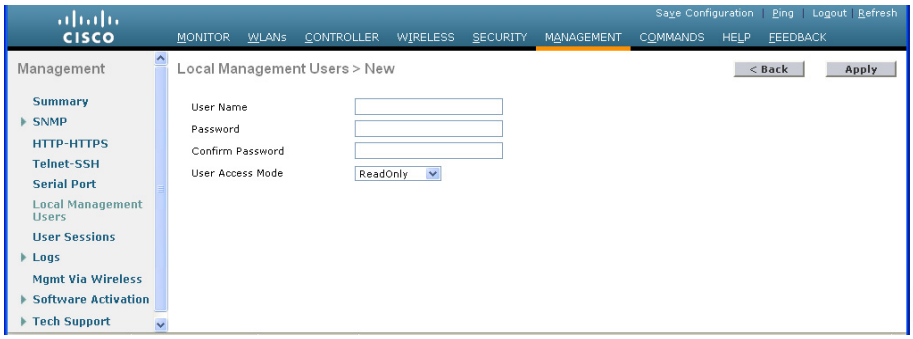


This page lists the names and access privileges of the local management users.

Note If you want to delete any of the user accounts from the controller, hover your cursor over the blue drop-down arrow and choose **Remove**. However, deleting the default administrative user prohibits both GUI and CLI access to the controller. Therefore, you must create a user with administrative privileges (ReadWrite) before you remove the default user.

Step 2 Click **New** to create a lobby ambassador account. The Local Management Users > New page appears (see Figure 11-2).

Figure 11-2 Local Management Users > New Page



Step 3 In the User Name text box, enter a username for the lobby ambassador account.

Note Management usernames must be unique because they are stored in a single database.

Step 4 In the Password and Confirm Password text boxes, enter a password for the lobby ambassador account.

Note Passwords are case sensitive. The settings for the management User Details parameters depends on the settings that you make in the Password Policy page. The following requirements are enforced on the password

- The password should contain characters from at least three of the following classes: lowercase letters, uppercase letters, digits, and special characters.
- No character in the password can be repeated more than three times consecutively.
- The password should not contain a management username or the reverse letters of a username.

- The password should not contain words like Cisco, oscic, admin, nimda, or any variant obtained by changing the capitalization of letters by substituting 1, |, or ! or substituting 0 for o or substituting $ for s.

Step 5 Choose **LobbyAdmin** from the User Access Mode drop-down list. This option enables the lobby ambassador to create guest user accounts.

Note The ReadOnly option creates an account with read-only privileges, and the ReadWrite option creates an administrative account with both read and write privileges.

Step 6 Click **Apply** to commit your changes. The new lobby ambassador account appears in the list of local management users.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Create a Lobby Ambassador Account

Use this command to create a lobby ambassador account using the controller CLI:

config mgmtuser add *lobbyadmin_username lobbyadmin_pwd* **lobby-admin**

Note Replacing **lobby-admin** with **read-only** creates an account with read-only privileges. Replacing **lobby-admin** with **read-write** creates an administrative account with both read and write privileges.

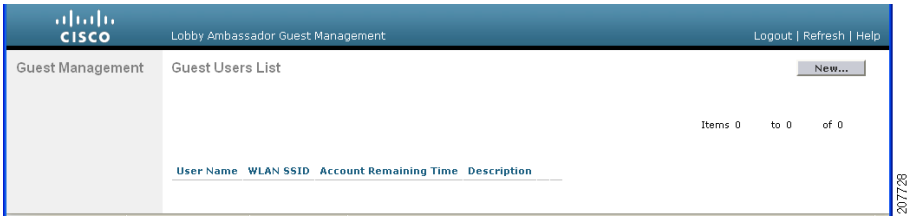
Creating Guest User Accounts as a Lobby Ambassador

A lobby ambassador would follow these steps to create guest user accounts.

Note A lobby ambassador cannot access the controller CLI interface and therefore can create guest user accounts only from the controller GUI.

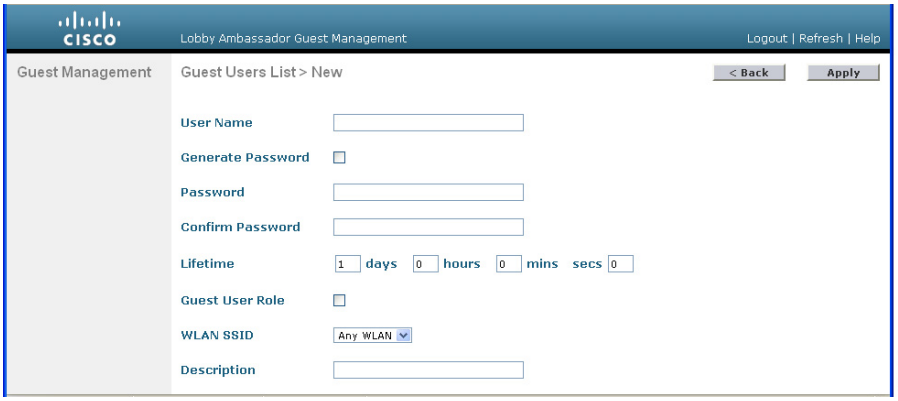
Step 1 Log into the controller as the lobby ambassador, using the username and password specified in the "Creating a Lobby Ambassador Account" section. The Lobby Ambassador Guest Management > Guest Users List page appears (see Figure 11-3).

Figure 11-3 Lobby Ambassador Guest Management > Guest Users List Page



Step 2 Click **New** to create a guest user account. The Lobby Ambassador Guest Management > Guest Users List > New page appears (see Figure 11-4).

Figure 11-4 Lobby Ambassador Guest Management > Guest Users List > New Page



Step 3 In the User Name text box, enter a name for the guest user. You can enter up to 24 characters.

Step 4 Perform one of the following:

- If you want to generate an automatic password for this guest user, select the **Generate Password** check box. The generated password is entered automatically in the Password and Confirm Password text boxes.
- If you want to create a password for this guest user, leave the **Generate Password** check box unselected and enter a password in both the Password and Confirm Password text boxes.

Note Passwords can contain up to 24 characters and are case sensitive.

Step 5 From the Lifetime drop-down lists, choose the amount of time (in days, hours, minutes, and seconds) that this guest user account is to remain active. A value of zero (0) for all four text boxes creates a permanent account.

Default: 1 day

Range: 5 minutes to 30 days

Note The smaller of this value or the session timeout for the guest WLAN, which is the WLAN on which the guest account is created, takes precedence. For example, if a WLAN session timeout is due to expire in 30 minutes but the guest account lifetime has 10 minutes remaining, the account is deleted in 10 minutes upon guest account expiry. Similarly, if the WLAN session timeout expires before the guest account lifetime, the client experiences a recurring session timeout that requires reauthentication.

Note You can change a guest user account with a nonzero lifetime to another lifetime value at any time while the account is active. However, to make a guest user account permanent using the controller GUI, you must delete the account and create it again. If desired, you can use the **config netuser lifetime** *user_name* **0** command to make a guest user account permanent without deleting and recreating it.

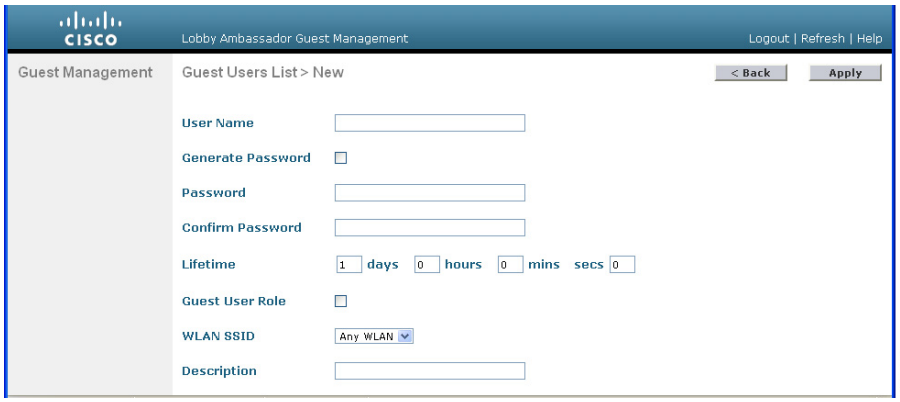
Step 6 From the WLAN SSID drop-down list, choose the SSID that will be used by the guest user. The only WLANs that are listed are those WLANs for which Layer 3 web authentication has been configured.

Note We recommend that you create a specific guest WLAN to prevent any potential conflicts. If a guest account expires and it has a name conflict with an account on the RADIUS server and both are on the same WLAN, the users associated with both accounts are disassociated before the guest account is deleted.

Step 7 In the Description text box, enter a description of the guest user account. You can enter up to 32 characters.

Step 8 Click **Apply** to commit your changes. The new guest user account appears in the list of guest users on the Guest Users List page (see Figure 11-5).

Figure 11-5 Lobby Ambassador Guest Management > Guest Users List Page



From this page, you can see all of the guest user accounts, their WLAN SSID, and their lifetime. You can also edit or remove a guest user account. When you remove a guest user account, all of the clients that are using the guest WLAN and are logged in using that account's username are deleted.

Step 9 Repeat this procedure to create any additional guest user accounts.

Viewing Guest User Accounts

After a lobby ambassador has created guest user accounts, you can view them from the controller GUI or CLI.

Using the GUI to View Guest Accounts

To view guest user accounts using the controller GUI, choose **Security > AAA > Local Net Users**. The Local Net Users page appears (see Figure 11-6).

Figure 11-6 Local Net Users Page

From this page, you can see all of the local net user accounts (including guest user accounts) and can edit or remove them as desired. When you remove a guest user account, all of the clients that are using the guest WLAN and are logged in using that account's username are deleted.

Using the CLI to View Guest Accounts

To see all of the local net user accounts (including guest user accounts) using the controller CLI, enter this command:

show netuser summary

Obtaining a Web Authentication Certificate

The controller's operating system automatically generates a fully functional web authentication certificate, so you do not need to do anything in order to use certificates with Layer 3 web authentication. However, if desired, you can prompt the operating system to generate a new web authentication certificate, or you can download an externally generated SSL certificate.

Support for Chained Certificate

In controller versions earlier than 5.1.151.0, web authentication certificates can be only device certificates and should not contain the CA roots chained to the device certificate (no chained certificates).

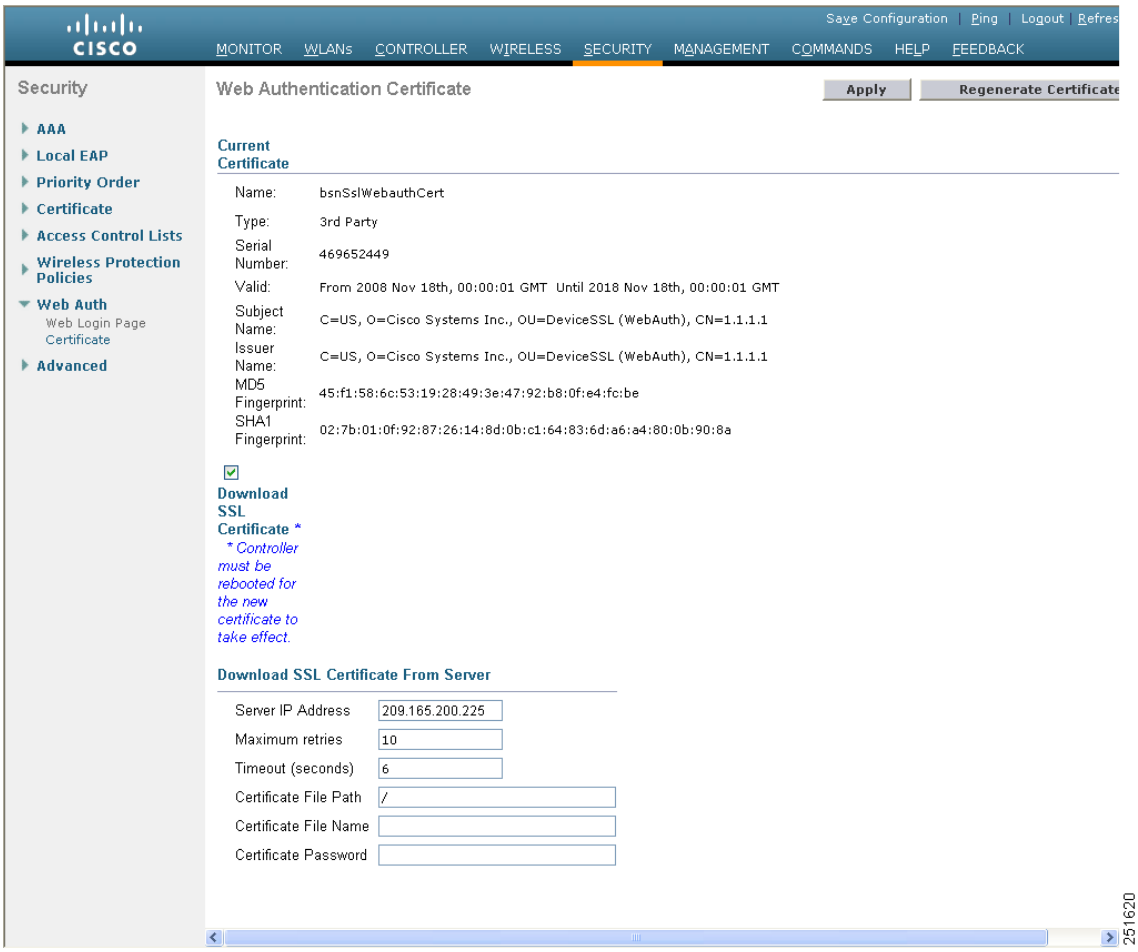
With controller version 5.1.151.0 and later, the controller allows for the device certificate to be downloaded as a chained certificate (up to a level of 2) for web authentication. For more information about chained certificates, see the *Generate CSR for Third-Party Certificates and Download Chained Certificates to the WLC* document at http://www.cisco.com/en/US/products/ps6366/products_configuration_example09186a0080a77592.shtml.

Using the GUI to Obtain a Web Authentication Certificate

To view the current web authentication certificate, generate a new certificate, or download an externally generated certificate using the controller GUI, follow these steps:

Step 1 Choose **Security** > **Web Auth** > **Certificate** to open the Web Authentication Certificate page (see Figure 11-7).

Figure 11-7 Web Authentication Certificate Page



This page shows the details of the current web authentication certificate.

Step 2 If you want to use a new operating system-generated web authentication certificate, follow these steps:

a. Click **Regenerate Certificate**. The operating system generates a new web authentication certificate, and a successfully generated web authentication certificate message appears.

b. Reboot the controller to register the new certificate.

Step 3 If you prefer to use an externally generated web authentication certificate, follow these steps:

a. Verify that the controller can ping the TFTP server.

b. Select the **Download SSL Certificate** check box.

c. In the Server IP Address text box, enter the IP address of the TFTP server.

The default values of 10 retries and 6 seconds for the Maximum Retries and Timeout text boxes should work correctly without any adjustment. However, you can change these values.

d. Enter the maximum number of times that each download can be attempted in the Maximum Retries text box and the amount of time (in seconds) allowed for each download in the Timeout text box.

e. In the Certificate File Path text box, enter the directory path of the certificate.

f. In the Certificate File Name text box, enter the name of the certificate (*certname*.pem).

g. In the Certificate Password text box, enter the password for the certificate.

h. Click **Apply** to commit your changes. The operating system downloads the new certificate from the TFTP server.

i. Reboot the controller to register the new certificate.

Using the CLI to Obtain a Web Authentication Certificate

To see the current web authentication certificate, generate a new certificate, or download an externally generated certificate using the controller CLI, follow these steps.

Step 1 See the current web authentication certificate by entering this command:

show certificate summary

Information similar to the following appears:

```
Web Administration Certificate..................... Locally Generated
Web Authentication Certificate..................... Locally Generated
Certificate compatibility mode:................ off
```

Step 2 If you want the operating system to generate a new web authentication certificate, follow these steps:

a. To generate the new certificate, enter this command:

config certificate generate webauth

b. To reboot the controller to register the new certificate, enter this command:

reset system

Step 3 If you prefer to use an externally generated web authentication certificate, follow these steps:

Note We recommend that the Common Name (CN) of the externally generated web authentication certificate be 1.1.1.1 (or the equivalent virtual interface IP address) in order for the client's browser to match the domains of the web authentication URL and the web authentication certificate.

a. Specify the name, path, and type of certificate to be downloaded by entering these commands:

transfer download mode tftp

transfer download datatype webauthcert

transfer download serverip *server_ip_address*

transfer download path *server_path_to_file*

transfer download filename *certname*.pem

transfer download certpassword *password*

transfer download tftpMaxRetries *retries*

transfer download tftpPktTimeout *timeout*

Note The default values of 10 retries and a 6-second timeout should work correctly without any adjustment. However, you can change these values. To do so, enter the maximum number of times that each download can be attempted for the *retries* parameter and the amount of time (in seconds) allowed for each download for the *timeout* parameter.

b. Start the download process by entering this command:

transfer download start

c. Reboot the controller to register the new certificate by entering this command:

reset system

Web Authentication Process

Web authentication is a Layer 3 security feature that causes the controller to not allow IP traffic (except DHCP-related packets) from a particular client until that client has correctly supplied a valid username and password. When you use web authentication to authenticate clients, you must define a username and password for each client. When the clients attempt to join the wireless LAN, their users must enter the username and password when prompted by a login page.

When web authentication is enabled (under Layer 3 Security), users might receive a web-browser security alert the first time that they attempt to access a URL. Figure 11-8 shows a typical security alert.

Figure 11-8 Typical Web-Browser Security Alert

Note When clients connect to a WebAuth SSID with preauthorization ACL configured to allow VPN users, the clients will get disconnected from the SSID every few minutes. Webauth SSIDs must not connect without authenticating on the web page.

After the user clicks **Yes** to proceed (or if the client's browser does not display a security alert), the web authentication system redirects the client to a login page (see Figure 11-9).

To prevent the security alert from appearing, follow these steps:

Step 1 Click **View Certificate** on the Security Alert page.

Step 2 Click **Install Certificate**.

Step 3 When the Certificate Import Wizard appears, click **Next**.

Step 4 Choose **Place all certificates in the following store** and click **Browse**.

Step 5 At the bottom of the Select Certificate Store page, select the **Show Physical Stores** check box.

Step 6 Expand the **Trusted Root Certification Authorities** folder and choose **Local Computer**.

Step 7 Click **OK**.

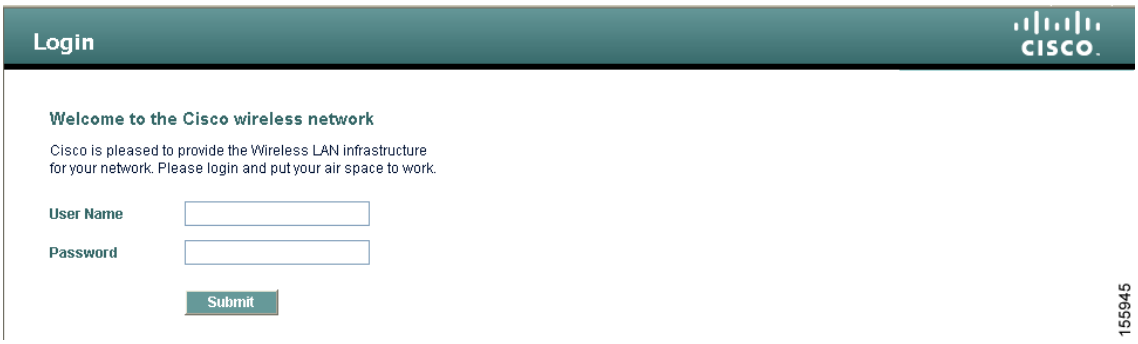
Step 8 Click **Next** > **Finish**.

Step 9 When the "The import was successful" message appears, click **OK**.

d. Because the issuer text box is blank on the controller self-signed certificate, open Internet Explorer, choose **Tools** > **Internet Options** > **Advanced**, unselect the **Warn about Invalid Site Certificates** check box under Security, and click **OK**.

Step 10 Reboot the PC. On the next web authentication attempt, the login page appears. Figure 11-9 shows the default web authentication login window.

Figure 11-9 Default Web Authentication Login Page



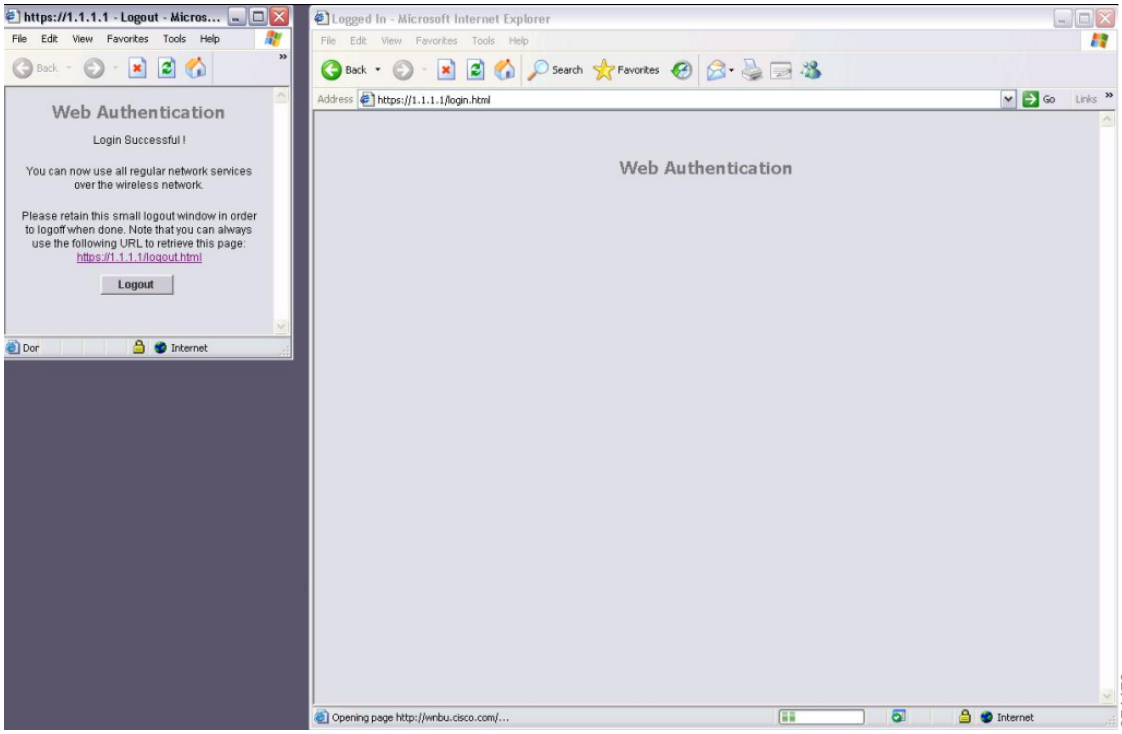
The default login page contains a Cisco logo and Cisco-specific text. You can choose to have the web authentication system display one of the following:

- The default login page
- A modified version of the default login page
- A customized login page that you configure on an external web server
- A customized login page that you download to the controller

The "Choosing the Web Authentication Login Page" section on page 11-11 provides instructions for choosing how the web authentication login page appears.

When the user enters a valid username and password on the web authentication login page and clicks **Submit**, the web authentication system displays a successful login page and redirects the authenticated client to the requested URL. Figure 11-10 shows a typical successful login page.

Figure 11-10 Successful Login Page



The default successful login page contains a pointer to a virtual gateway address URL: https://1.1.1.1/logout.html. The IP address that you set for the controller virtual interface serves as the redirect address for the login page (see Chapter 3, "Configuring Ports and Interfaces," for more information on the virtual interface).

Choosing the Web Authentication Login Page

This section provides instructions for specifying the content and appearance of the web authentication login page. Follow the instructions in one of these sections to choose the web authentication login page using the controller GUI or CLI:

- Choosing the Default Web Authentication Login Page, page 11-12
- Creating a Customized Web Authentication Login Page, page 11-16
- Using a Customized Web Authentication Login Page from an External Web Server, page 11-19
- Downloading a Customized Web Authentication Login Page, page 11-20
- Assigning Login, Login Failure, and Logout Pages per WLAN, page 11-24

Note If you do not want users to connect to a web page using a browser that is configured with SSLv2 only, you can disable SSLv2 for web authentication by entering the **config network secureweb cipher-option sslv2 disable** command. If you enter this command, users must use a browser that is configured to use a more secure protocol such as SSLv3 or later releases. The default value is enabled.

Choosing the Default Web Authentication Login Page

To use the default web authentication login page as is (see Figure 11-9) or with a few modifications, follow the instructions in the GUI or CLI procedure in this section.

If you are using a custom web-auth bundle that is served by the internal controller web server, the page should not contain more than 5 elements (including HTML, CSS, and Images). This is because the internal controller web server implements a DoS protection mechanism that limits each client to open a maximum of 5 (five) concurrent TCP connections depending on the load. Some browsers may try to open more than 5 TCP sessions at the same time (For example Firefox 4) if the page contains more elements and this may result in the page loading slowly depending on how the browser handles the DoS protection.

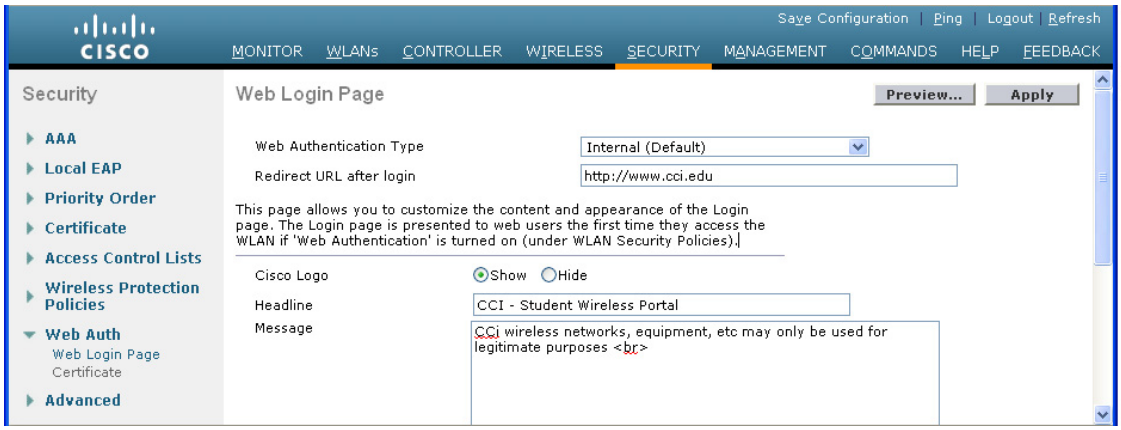
If you have a complex custom web authentication module, it is recommended that you use an external web-auth config on the controller, where the full login page is hosted at an external web server.

Using the GUI to Choose the Default Web Authentication Login Page

To choose the default web authentication login page using the controller GUI, follow these steps:

Step 1 Choose **Security** > **Web Auth** > **Web Login Page** to open the Web Login page (see Figure 11-11).

Figure 11-11 Web Login Page



Step 2 From the Web Authentication Type drop-down list, choose **Internal (Default)**.

Step 3 If you want to use the default web authentication login page as is, go to Step 8. If you want to modify the default login page, go to Step 4.

Step 4 If you want to hide the Cisco logo that appears in the top right corner of the default page, choose the Cisco Logo **Hide** option. Otherwise, click the **Show** option.

Step 5 If you want the user to be directed to a particular URL (such as the URL for your company) after login, enter the desired URL in the Redirect URL After Login text box. You can enter up to 254 characters.

Note The controller supports web authentication redirects only to HTTP (HTTP over TCP) servers. It does not support web authentication redirects to HTTPS (HTTP over SSL) servers.

Step 6 If you want to create your own headline on the login page, enter the desired text in the Headline text box. You can enter up to 127 characters. The default headline is "Welcome to the Cisco wireless network."

Step 7 If you want to create your own message on the login page, enter the desired text in the Message text box. You can enter up to 2047 characters. The default message is "Cisco is pleased to provide the Wireless LAN infrastructure for your network. Please login and put your air space to work."

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Preview** to view the web authentication login page.

Step 10 If you are satisfied with the content and appearance of the login page, click **Save Configuration** to save your changes. Otherwise, repeat any of the previous steps as necessary to achieve your desired results.

Using the CLI to Choose the Default Web Authentication Login Page

To choose the default web authentication login page using the controller CLI, follow these steps:

Step 1 Specify the default web authentication type by entering this command:

config custom-web webauth_type internal

Step 2 If you want to use the default web authentication login page as is, go to Step 7. If you want to modify the default login page, go to Step 3.

Step 3 To show or hide the Cisco logo that appears in the top right corner of the default login page, enter this command:

config custom-web weblogo {**enable** | **disable**}

Step 4 If you want the user to be directed to a particular URL (such as the URL for your company) after login, enter this command:

config custom-web redirecturl *url*

You can enter up to 130 characters for the URL. To change the redirect back to the default setting, enter the **clear redirecturl** command.

Note The controller supports web authentication redirects only to HTTP (HTTP over TCP) servers. It does not support web authentication redirects to HTTPS (HTTP over SSL) servers.

Step 5 If you want to create your own headline on the login page, enter this command:

config custom-web webtitle *title*

You can enter up to 130 characters. The default headline is "Welcome to the Cisco wireless network." To reset the headline to the default setting, enter the **clear webtitle** command.

Step 6 If you want to create your own message on the login page, enter this command:

config custom-web webmessage *message*

You can enter up to 130 characters. The default message is "Cisco is pleased to provide the Wireless LAN infrastructure for your network. Please login and put your air space to work." To reset the message to the default setting, enter the **clear webmessage** command.

Step 7 Enter the **save config** command to save your settings.

Step 8 Import your own logo into the web authentication login page as follows:

a. Make sure that you have a Trivial File Transfer Protocol (TFTP) server available for the file download. Follow these guidelines when setting up a TFTP server:

- If you are downloading through the service port, the TFTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are downloading through the distribution system network port, the TFTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP server cannot run on the same computer as the Cisco WCS because the WCS built-in TFTP server and the third-party TFTP server require the same communication port.

b. Ensure that the controller can contact the TFTP server by entering this command:

ping ip-address

c. Copy the logo file (in .jpg, .gif, or .png format) to the default directory on your TFTP server. The maximum file size is 30 kilobits. For an optimal fit, the logo should be approximately 180 pixels wide and 360 pixels high.

d. Specify the download mode by entering this command:

transfer download mode tftp

e. Specify the type of file to be downloaded by entering this command:

transfer download datatype image

f. Specify the IP address of the TFTP server by entering this command:

transfer download serverip *tftp-server-ip-address*

Note Some TFTP servers require only a forward slash (/) as the TFTP server IP address, and the TFTP server automatically determines the path to the correct directory.

g. Specify the download path by entering this command:

transfer download path *absolute-tftp-server-path-to-file*

h. Specify the file to be downloaded by entering this command:

transfer download filename {*filename.jpg* | *filename.gif* | *filename.png*}

i. View your updated settings and answer **y** to the prompt to confirm the current download settings and start the download by entering this command:

transfer download start

Information similar to the following appears:

```
Mode..................................... TFTP
Data Type................................ Login Image
TFTP Server IP........................... xxx.xxx.xxx.xxx
TFTP Path................................ <directory path>
TFTP Filename............................ <filename.jpg|.gif|.png>
This may take some time.
Are you sure you want to start? (y/n) y
```

```
TFTP Image transfer starting.
Image installed.
```

j. Save your settings by entering this command:

save config

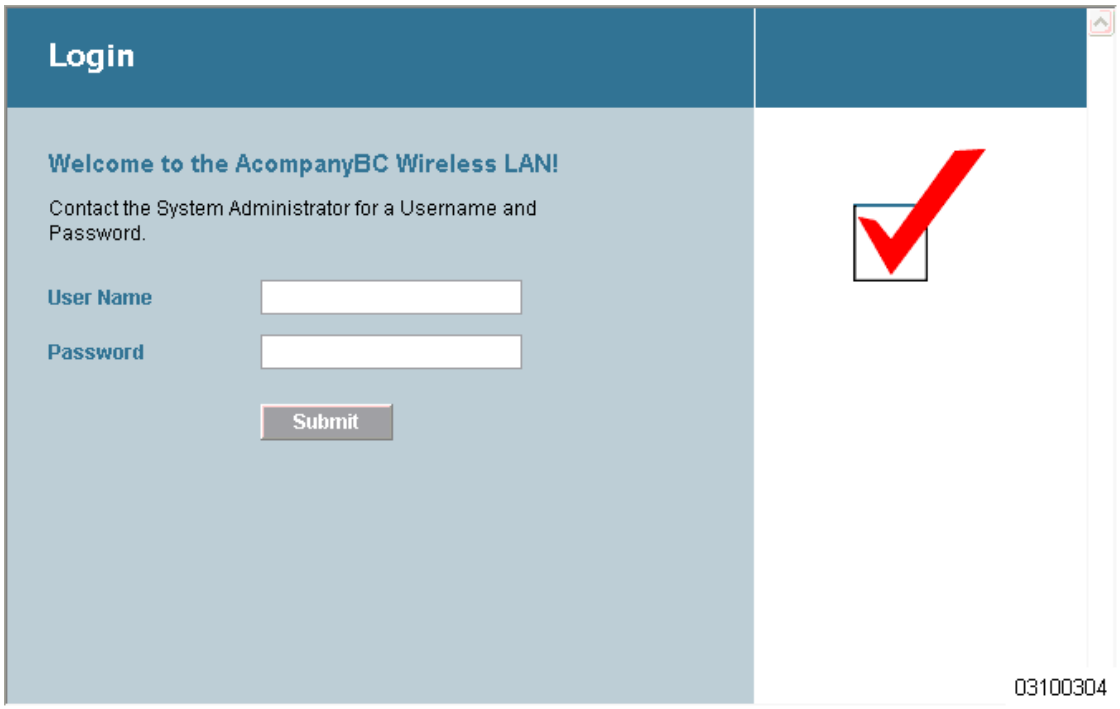
Note If you ever want to remove this logo from the web authentication login page, enter the **clear webimage** command.

Step 9 Follow the instructions in the "Using the CLI to Verify the Web Authentication Login Page Settings" section on page 11-23 to verify your settings.

Modified Default Web Authentication Login Page Example

Figure 11-12 shows an example of a modified default web authentication login page.

Figure 11-12 Modified Default Web Authentication Login Page Example



These CLI commands were used to create this login page:

- config custom-web weblogo disable
- config custom-web webtitle Welcome to the AcompanyBC Wireless LAN!
- config custom-web webmessage Contact the System Administrator for a Username and Password.
- transfer download start

Information similar to the following appears:

```
Mode.......................................... TFTP
Data Type..................................... Login Image
TFTP Server IP................................ xxx.xxx.xxx.xxx
TFTP Path..................................... /
TFTP Filename................................. Logo.gif
This may take some time.
Are you sure you want to start? (y/n) y
TFTP Image transfer starting.
Image installed.
```

config custom-web redirecturl *url*

- **show custom-web**

```
Cisco Logo.................. Disabled
CustomLogo.................. 00_logo.gif
Custom Title................ Welcome to the AcompanyBC Wireless LAN!
Custom Message ............. Contact the System Administrator for a Username and Password.
Custom Redirect URL......... http://www.AcompanyBC.com
Web Authentication Mode..... Disabled
Web Authentication URL........ Disabled
```

Creating a Customized Web Authentication Login Page

This section provides information on creating a customized web authentication login page, which can then be accessed from an external web server.

Here is a web authentication login page template. It can be used as a model when creating your own customized page:

```
<html>
<head>
<meta http-equiv="Pragma" content="no-cache">
<meta HTTP-EQUIV="Content-Type" CONTENT="text/html; charset=iso-8859-1">
<title>Web Authentication</title>
<script>

function submitAction(){
    var link = document.location.href;
    var searchString = "redirect=";
    var equalIndex = link.indexOf(searchString);
    var redirectUrl = "";

    if (document.forms[0].action == "") {
        var url = window.location.href;
        var args = new Object();
        var query = location.search.substring(1);
        var pairs = query.split("&");
        for(var i=0;i<pairs.length;i++){
        var pos = pairs[i].indexOf('=');
            if(pos == -1) continue;
                var argname = pairs[i].substring(0,pos);
                var value = pairs[i].substring(pos+1);
                args[argname] = unescape(value);
        }
            document.forms[0].action = args.switch_url;
        }

       if(equalIndex >= 0) {
         equalIndex += searchString.length;
         redirectUrl = "";
         redirectUrl += link.substring(equalIndex);
```

```
        }
        if(redirectUrl.length > 255)
        redirectUrl = redirectUrl.substring(0,255);
        document.forms[0].redirect_url.value = redirectUrl;
        document.forms[0].buttonClicked.value = 4;
        document.forms[0].submit();
}

    function loadAction(){
      var url = window.location.href;
      var args = new Object();
      var query = location.search.substring(1);
      var pairs = query.split("&");
      for(var i=0;i<pairs.length;i++){
          var pos = pairs[i].indexOf('=');
          if(pos == -1) continue;
          var argname = pairs[i].substring(0,pos);
          var value = pairs[i].substring(pos+1);
          args[argname] = unescape(value);
      }
//alert( "AP MAC Address is " + args.ap_mac);
      //alert( "The Switch URL to post user credentials is " + args.switch_url);
      //document.forms[0].action = args.switch_url;

      // This is the status code returned from webauth login action
      // Any value of status code from 1 to 5 is error condition and user
      // should be shown error as below or modify the message as it suits
      // the customer
      if(args.statusCode == 1){
        alert("You are already logged in. No further action is required on your part.");
      }
      else if(args.statusCode == 2){
        alert("You are not configured to authenticate against web portal. No further
action is required on your part.");
      }
      else if(args.statusCode == 3){
       alert("The username specified cannot be used at this time. Perhaps the username is
already logged into the system?");
      }
      else if(args.statusCode == 4){
        alert("The User has been excluded. Please contact the administrator.");
      }
      else if(args.statusCode == 5){
        alert("Invalid username and password. Please try again.");
      }

}

</script>
</head>
<body topmargin="50" marginheight="50" onload="loadAction();">
<form method="post" action="https://209.165.200.225/login.html">
<input TYPE="hidden" NAME="buttonClicked" SIZE="16" MAXLENGTH="15" value="0">
<input TYPE="hidden" NAME="redirect_url" SIZE="255" MAXLENGTH="255" VALUE="">
<input TYPE="hidden" NAME="err_flag" SIZE="16" MAXLENGTH="15" value="0">

<div align="center">
<table border="0" cellspacing="0" cellpadding="0">
<tr> <td> </td></tr>

<tr align="center"> <td colspan="2"><font size="10" color="#336699">Web
Authentication</font></td></tr>

<tr align="center">
```

```
<td colspan="2"> User Name    <input type="TEXT" name="username" SIZE="25"
MAXLENGTH="63" VALUE="">
</td>
</tr>
<tr align="center" >
<td colspan="2"> Password      <input type="Password"
name="password" SIZE="25" MAXLENGTH="24">
</td>
</tr>

<tr align="center">
<td colspan="2"><input type="button" name="Submit" value="Submit" class="button"
onclick="submitAction();">
</td>
</tr>
</table>
</div>

</form>
</body>
</html>
```

These parameters are added to the URL when the user's Internet browser is redirected to the customized login page:

- **ap_mac**—The MAC address of the access point to which the wireless user is associated.
- **switch_url**—The URL of the controller to which the user credentials should be posted.
- **redirect**—The URL to which the user is redirected after authentication is successful.
- **statusCode**—The status code returned from the controller's web authentication server.
- **wlan**—The WLAN SSID to which the wireless user is associated.

The available status codes are as follows:

- Status Code 1: "You are already logged in. No further action is required on your part."
- Status Code 2: "You are not configured to authenticate against web portal. No further action is required on your part."
- Status Code 3: "The username specified cannot be used at this time. Perhaps the username is already logged into the system?"
- Status Code 4: "You have been excluded."
- Status Code 5: "The User Name and Password combination you have entered is invalid. Please try again."

Note For additional information, see the *External Web Authentication with Wireless LAN Controllers Configuration Example* at this URL: http://www.cisco.com/en/US/tech/tk722/tk809/technologies_configuration_example09186a008076f974.shtml

Using a Customized Web Authentication Login Page from an External Web Server

If you want to use a customized web authentication login page that you configured on an external web server, follow the instructions in the GUI or CLI procedure below. When you enable this feature, the user is directed to your customized login page on the external web server.

Note For Cisco 5500 Series Controllers, Cisco 2100 Series Controller, and controller network modules, you must configure a preauthentication access control list (ACL) on the WLAN for the external web server and then choose this ACL as the WLAN preauthentication ACL under Security Policies > Web Policy on the WLANs > Edit page. For external web authentication, the only type of ACL required is permit incoming and outgoing traffic from the external webserver IP address. See External Web Authentication with Wireless LAN Controllers for details on how to setup the correct ACL when configuring External Web authentication.

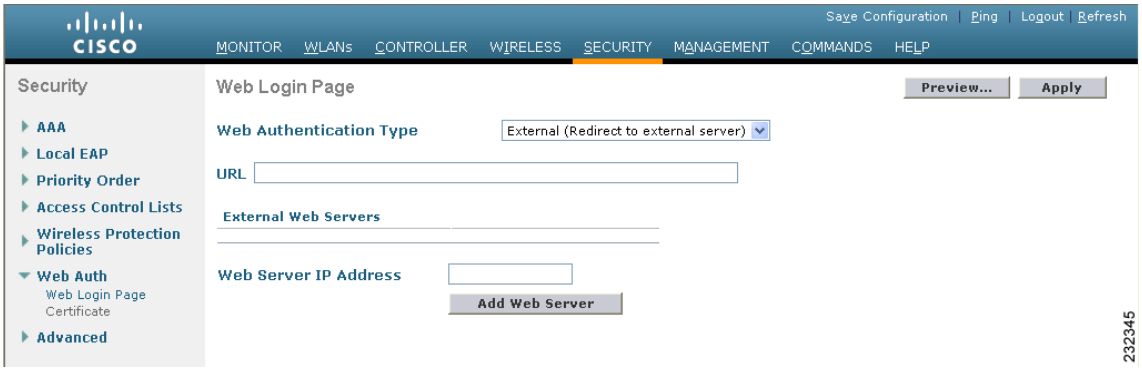
Note For 4400 series controllers and Cisco WiSM, instead of using a preauthentication ACL, the network manager must configure the external web server IP address using this command **config custom-web ext-webserver add index** *IP-address*.

Using the GUI to Choose a Customized Web Authentication Login Page from an External Web Server

To choose a customized web authentication login page from an external server using the controller GUI, follow these steps:

Step 1 Choose **Security** > **Web Auth** > **Web Login Page** to open the Web Login page (see Figure 11-13).

Figure 11-13 Web Login Page



Step 2 From the Web Authentication Type drop-down list, choose **External (Redirect to external server)**.

Step 3 In the URL text box, enter the URL of the customized web authentication login page on your web server. You can enter up to 252 characters.

Step 4 In the Web Server IP Address text box, enter the IP address of your web server. Your web server should be on a different network from the controller service port network.

Step 5 Click **Add Web Server**. This server now appears in the list of external web servers.

Step 6 Click **Apply** to commit your changes.

Step 7 If you are satisfied with the content and appearance of the login page, click **Save Configuration** to save your changes.

Using the CLI to Choose a Customized Web Authentication Login Page from an External Web Server

To choose a customized web authentication login page from an external server using the controller CLI, follow these steps:

Step 1 Specify the web authentication type by entering this command:

config custom-web webauth_type external

Step 2 Specify the URL of the customized web authentication login page on your web server by entering this command:

config custom-web ext-webauth-url *url*

You can enter up to 252 characters for the URL.

Step 3 Specify the IP address of your web server by entering this command:

config custom-web ext-webserver {**add** | **delete**} *server_IP_address*

Step 4 Enter the **save config** command to save your settings.

Step 5 Follow the instructions in the "Using the CLI to Verify the Web Authentication Login Page Settings" section on page 11-23 to verify your settings.

Downloading a Customized Web Authentication Login Page

You can compress the page and image files used for displaying a web authentication login page into a.tar file for download to a controller. These files are known as the *webauth bundle*. The maximum allowed size of the files in their uncompressed state is 1 MB. When the .tar file is downloaded from a local TFTP server, it enters the controller's file system as an untarred file.

Note If you load a webauth bundle with a .tar compression application that is not GNU compliant, the controller cannot extract the files in the bundle and the following error messages appear: "Extracting error" and "TFTP transfer failed." Therefore, we recommend that you use an application that complies with GNU standards, such as PicoZip, to compress the .tar file for the webauth bundle.

Note Configuration backups do not include extra files or components, such as the webauth bundle or external licenses, that you download and store on your controller, so you should manually save external backup copies of those files or components.

Note If the customized webauth bundle has more than 3 separated elements, we advise you to use an external server to prevent page load issues that may be caused because of TCP rate-limiting policy on the controller.

Follow these guidelines when preparing the customized login page:

- Name the login page "login.html." The controller prepares the web authentication URL based on this name. If the server does not find this file after the webauth bundle has been untarred, the bundle is discarded, and an error message appears.
- Include input text boxes for both a username and password.
- Retain the redirect URL as a hidden input item after extracting from the original URL.
- Extract and set the action URL in the page from the original URL.
- Include scripts to decode the return status code.
- Make sure that all paths used in the main page (to refer to images, for example).

You can download a login page example from Cisco WCS and use it as a starting point for your customized login page. See the "Downloading a Customized Web Auth Page" section in the Using Templates chapter of the *Cisco Wireless Control System Configuration Guide, Release 7.0,* for instructions.

Using the GUI to Download a Customized Web Authentication Login Page

To download a customized web authentication login page from the controller GUI, follow these steps:

Step 1 Make sure that you have a TFTP server available for the file download. See the guidelines for setting up a TFTP server in Step 8 of the "Using the CLI to Choose the Default Web Authentication Login Page" section on page 11-13.

Step 2 Copy the .tar file containing your login page to the default directory on your TFTP server.

Step 3 Choose **Commands** > **Download File** to open the Download File to Controller page (see Figure 11-14).

Figure 11-14 Download File to Controller Page

Step 4 From the File Type drop-down list, choose **Webauth Bundle**.

Step 5 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 6 In the IP Address text box, enter the IP address of the TFTP server.

Step 7 If you are using a TFTP server, enter the maximum number of times the controller should attempt to download the .tar file in the Maximum Retries text box.

The range is 1 to 254.

The default is 10.

Step 8 If you are using a TFTP server, enter the amount of time in seconds before the controller times out while attempting to download the *.tar file in the Timeout text box.

The range is 1 to 254 seconds.

The default is 6 seconds.

Step 9 In the File Path text box, enter the path of the .tar file to be downloaded. The default value is "/."

Step 10 In the File Name text box, enter the name of the .tar file to be downloaded.

Step 11 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the download occurs. The default value is 21.

Step 12 Click **Download** to download the .tar file to the controller.

Step 13 Choose **Security > Web Auth > Web Login Page** to open the Web Login page.

Step 14 From the Web Authentication Type drop-down list, choose **Customized (Downloaded)**.

Step 15 Click **Apply** to commit your changes.

Step 16 Click **Preview** to view your customized web authentication login page.

Step 17 If you are satisfied with the content and appearance of the login page, click **Save Configuration** to save your changes.

Using the CLI to Download a Customized Web Authentication Login Page

To download a customized web authentication login page using the controller CLI, follow these steps:

Step 1 Make sure that you have a TFTP server available for the file download. See the guidelines for setting up a TFTP server in Step 8 of the "Using the CLI to Choose the Default Web Authentication Login Page" section on page 11-13.

Step 2 Copy the .tar file containing your login page to the default directory on your TFTP server.

Step 3 Specify the download mode by entering this command:

transfer download mode tftp

Step 4 Specify the type of file to be downloaded by entering this command:

transfer download datatype webauthbundle

Step 5 Specify the IP address of the TFTP server by entering this command:

transfer download serverip *tftp-server-ip-address*.

Note Some TFTP servers require only a forward slash (/) as the TFTP server IP address, and the TFTP server automatically determines the path to the correct directory.

Step 6 Specify the download path by entering this command:

transfer download path *absolute-tftp-server-path-to-file*

Step 7 Specify the file to be downloaded by entering this command:

transfer download filename *filename.tar*

Step 8 View your updated settings and answer **y** to the prompt to confirm the current download settings and start the download by entering this command:

transfer download start

Step 9 Specify the web authentication type by entering this command:

config custom-web webauth_type customized

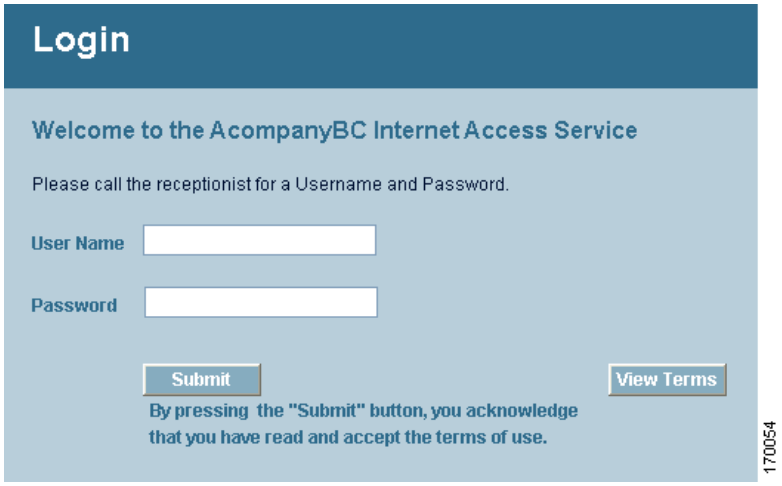
Step 10 Enter the **save config** command to save your settings.

Step 11 Follow the instructions in the "Using the CLI to Verify the Web Authentication Login Page Settings" section on page 11-23 to verify your settings.

Customized Web Authentication Login Page Example

Figure 11-15 shows an example of a customized web authentication login page.

Figure 11-15 Customized Web Authentication Login Page Example



Using the CLI to Verify the Web Authentication Login Page Settings

Enter the **show custom-web** command to verify your changes to the web authentication login page. This example shows the information that appears when the configuration settings are set to default values:

```
Cisco Logo..................................... Enabled
CustomLogo..................................... Disabled
Custom Title................................... Disabled
Custom Message................................. Disabled
Custom Redirect URL............................ Disabled
Web Authentication Mode........................ Disabled
Web Authentication URL......................... Disabled
```

This example shows the information that appears when the configuration settings have been modified:

```
Cisco Logo..................................... Disabled
CustomLogo..................................... 00_logo.gif
Custom Title................................... Welcome to the AcompanyBC Wireless LAN!
Custom Message................................. Contact the System Administrator for a
                                                Username and Password.
Custom Redirect URL.....................
Web Authentication Mode........................ Internal
Web Authentication URL........................... Disabled
```

Assigning Login, Login Failure, and Logout Pages per WLAN

You can display different web authentication login, login failure, and logout pages to users per WLAN. This feature enables user-specific web authentication pages to be displayed for a variety of network users, such as guest users or employees within different departments of an organization.

Different login pages are available for all web authentication types (internal, external, and customized). However, different login failure and logout pages can be specified only when you choose customized as the web authentication type.

Using the GUI to Assign Login, Login Failure, and Logout Pages per WLAN

To assign web login, login failure, and logout pages to a WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN to which you want to assign a web login, login failure, or logout page.

Step 3 Choose **Security > Layer 3**.

Step 4 Make sure that **Web Policy** and **Authentication** are selected.

Step 5 To override the global authentication configuration web authentication pages, select the **Override Global Config** check box.

Step 6 When the Web Auth Type drop-down list appears, choose one of the following options to define the web authentication pages for wireless guest users:

- **Internal**—Displays the default web login page for the controller. This is the default value.
- **Customized**—Displays custom web login, login failure, and logout pages. If you choose this option, three separate drop-down lists appear for login, login failure, and logout page selection. You do not need to define a customized page for all three options. Choose **None** from the appropriate drop-down list if you do not want to display a customized page for that option.

Note These optional login, login failure, and logout pages are downloaded to the controller as webauth.tar files. For details on downloading custom pages, see the "Downloading a Customized Web Authentication Login Page" section on page 11-20.

- **External**—Redirects users to an external server for authentication. If you choose this option, you must also enter the URL of the external server in the URL text box.

  You can choose specific RADIUS or LDAP servers to provide external authentication on the WLANs > Edit (Security > AAA Servers) page. Additionally, you can define the priority in which the servers provide authentication.

Step 7 If you chose External as the web authentication type in Step 6, choose **AAA Servers** and choose up to three RADIUS and LDAP servers using the drop-down lists.

Note The RADIUS and LDAP external servers must already be configured in order to be selectable options on the WLANs > Edit (Security > AAA Servers) page. You can configure these servers on the RADIUS Authentication Servers page and LDAP Servers page.

Step 8 Establish the priority in which the servers are contacted to perform web authentication as follows:

Note The default order is local, RADIUS, LDAP.

a. Highlight the server type (local, RADIUS, or LDAP) that you want to be contacted first in the box next to the Up and Down buttons.

b. Click **Up** and **Down** until the desired server type is at the top of the box.

c. Click the **<** arrow to move the server type to the priority box on the left.

d. Repeat these steps to assign priority to the other servers.

Step 9 Click **Apply** to commit your changes.

Step 10 Click **Save Configuration** to save your changes.

Using the CLI to Assign Login, Login Failure, and Logout Pages per WLAN

To assign web login, login failure, and logout pages to a WLAN using the controller CLI, follow these steps:

Step 1 Determine the ID number of the WLAN to which you want to assign a web login, login failure, or logout page by entering this command:

show wlan summary

Step 2 If you want wireless guest users to log into a customized web login, login failure, or logout page, enter these commands to specify the filename of the web authentication page and the WLAN for which it should display:

- **config wlan custom-web login-page** *page_name wlan_id*—Defines a customized login page for a given WLAN.

- **config wlan custom-web loginfailure-page** *page_name wlan_id*—Defines a customized login failure page for a given WLAN.

Note To use the controller's default login failure page, enter the **config wlan custom-web loginfailure-page none** *wlan_id* command.

- **config wlan custom-web logout-page** *page_name wlan_id*—Defines a customized logout page for a given WLAN.

Note To use the controller's default logout page, enter the **config wlan custom-web logout-page none** *wlan_id* command.

Step 3 Redirect wireless guess users to an external server before accessing the web login page by entering this command to specify the URL of the external server:

config wlan custom-web ext-webauth-url *ext_web_url wlan_id*

Step 4 Define the order in which web authentication servers are contacted by entering this command:

config wlan security web-auth server-precedence *wlan_id* {**local** | **ldap** | **radius**} {**local** | **ldap** | **radius**} {**local** | **ldap** | **radius**}

The default order of server web authentication is local, RADIUS and LDAP.

Note All external servers must be preconfigured on the controller. You can configure them on the RADIUS Authentication Servers page and the LDAP Servers page.

Step 5 Define which web authentication page displays for a wireless guest user by entering this command:

config wlan custom-web webauth-type {**internal** | **customized** | **external**} *wlan_id*

where

- **internal** displays the default web login page for the controller. This is the default value.
- **customized** displays the custom web login page that was configured in Step 2.

Note You do not need to define the web authentication type in Step 5 for the login failure and logout pages as they are always customized.

- **external** redirects users to the URL that was configured in Step 3.

Step 6 Use a WLAN-specific custom web configuration rather than a global custom web configuration by entering this command:

config wlan custom-web global disable *wlan_id*

Note If you enter the **config wlan custom-web global enable** *wlan_id* command, the custom web authentication configuration at the global level is used.

Step 7 Save your changes by entering this command:

save config

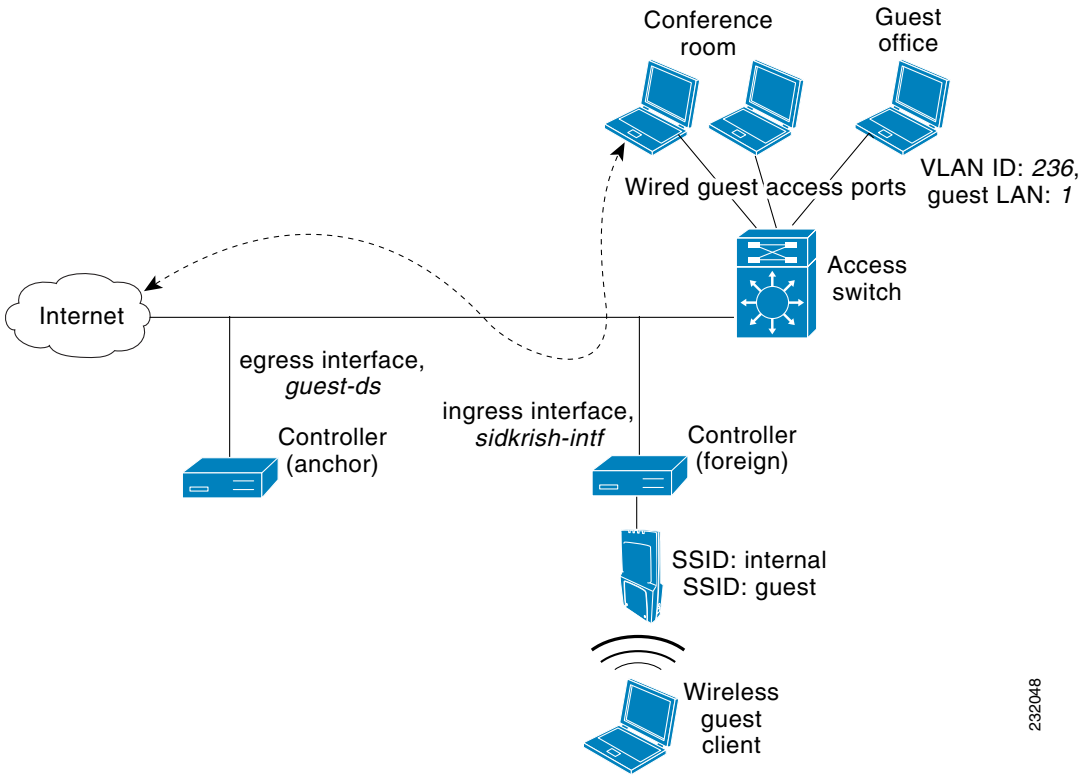
Configuring Wired Guest Access

Wired guest access enables guest users to connect to the guest access network from a wired Ethernet connection designated and configured for guest access. Wired guest access ports might be available in a guest office or through specific ports in a conference room. Like wireless guest user accounts, wired guest access ports are added to the network using the lobby ambassador feature.

Wired guest access can be configured in a standalone configuration or in a dual-controller configuration that uses both an anchor controller and a foreign controller. This latter configuration is used to further isolate wired guest access traffic but is not required for deployment of wired guest access.

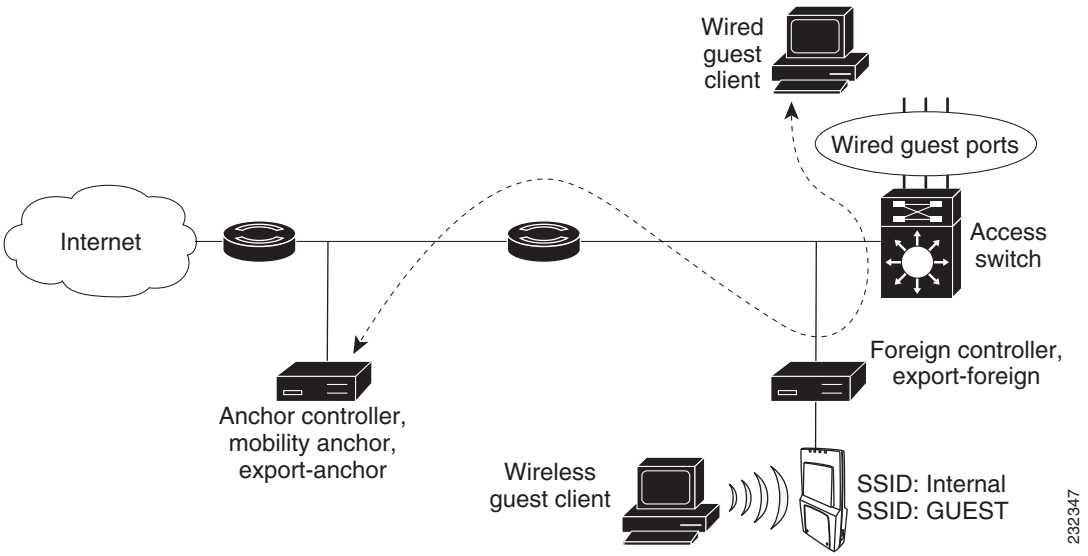
Wired guest access ports initially terminate on a Layer 2 access switch or switch port configured with VLAN interfaces for wired guest access traffic. The wired guest traffic is then trunked from the access switch to a controller. This controller is configured with an interface that is mapped to a wired guest access VLAN on the access switch. See Figure 11-16.

Figure 11-16 Wired Guest Access Example with One Controller



If two controllers are being used, the foreign controller, which receives the wired guest traffic from the access switch, forwards it to the anchor controller. A bidirectional EoIP tunnel is established between the foreign and anchor controllers to handle this traffic. See Figure 11-17.

Figure 11-17 Wired Guest Access Example with Two Controllers



Note Although wired guest access is managed by anchor and foreign anchors when two controllers are deployed, mobility is not supported for wired guest access clients. In this case, DHCP and web authentication for the client are handled by the anchor controller.

Note You can specify the amount of bandwidth allocated to a wired guest user in the network by configuring a QoS role and a bandwidth contract. For details on configuring these features. See the "Configuring Quality of Service" section on page 4-68.

Configuration Overview

To configure wired guest access on a wireless network, you will perform the following:

1. Configure a dynamic interface (VLAN) for wired guest user access
2. Create a wired LAN for guest user access
3. Configure the controller
4. Configure the anchor controller (if terminating traffic on another controller)
5. Configure security for the guest LAN
6. Verify the configuration

Wired Guest Access Guidelines

Follow these guidelines before using wired guest access on your network:

- Wired guest access is supported only on the following controllers: 5500 and 4400 series controllers, the Cisco WiSM, and the Catalyst 3750G Integrated Wireless LAN Controller Switch.
- Wired guest access interfaces must be tagged.

- Wired guest access ports must be in the same Layer 2 network as the foreign controller.
- Up to five wired guest access LANs can be configured on a controller.
- Layer 3 web authentication and web passthrough are supported for wired guest access clients. Layer 2 security is not supported.
- Do not attempt to trunk a guest VLAN on the Catalyst 3750G Integrated Wireless LAN Controller Switch to multiple controllers. Redundancy cannot be achieved by doing this action.

Using the GUI to Configure Wired Guest Access

To configure wired guest user access on your network using the controller GUI, follow these steps:

Step 1 To create a dynamic interface for wired guest user access, choose **Controller** > **Interfaces**. The Interfaces page appears.

Step 2 Click **New** to open the Interfaces > New page.

Step 3 Enter a name and VLAN ID for the new interface.

Step 4 Click **Apply** to commit your changes.

Step 5 In the Port Number text box, enter a valid port number. You can enter a number between 0 and 25 (inclusive).

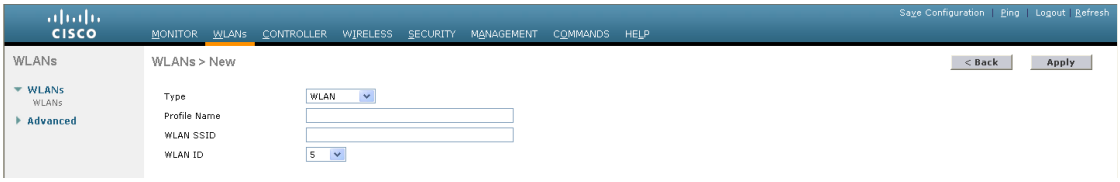
Step 6 Select the **Guest LAN** check box.

Step 7 Click **Apply** to commit your changes.

Step 8 To create a wired LAN for guest user access, choose **WLANs**.

Step 9 On the WLANs page, choose **Create New** from the drop-down list and click **Go**. The WLANs > New page appears (see Figure 11-18).

Figure 11-18 WLANs > New Page



Step 10 From the Type drop-down list, choose **Guest LAN**.

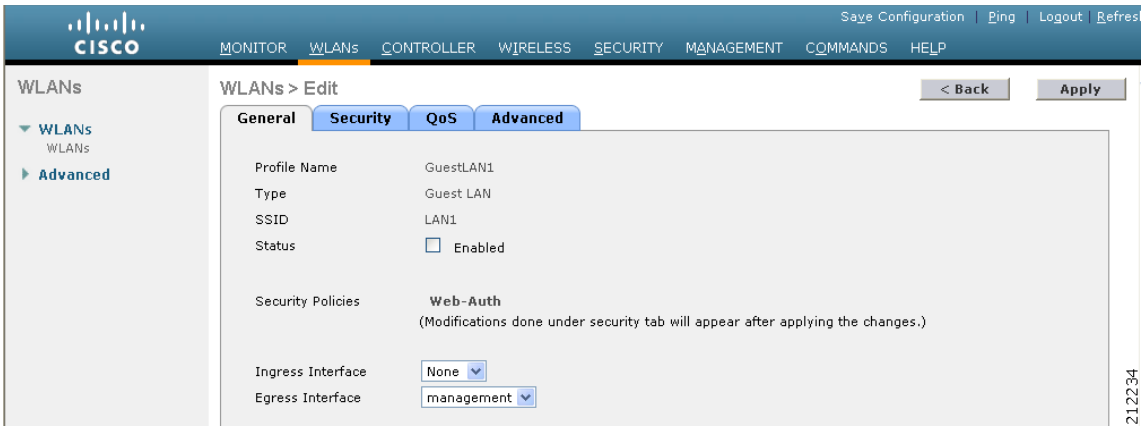
Step 11 In the Profile Name text box, enter a name that identifies the guest LAN. Do not use any spaces.

Step 12 From the WLAN ID drop-down list, choose the ID number for this guest LAN.

Note You can create up to five guest LANs, so the WLAN ID options are 1 through 5 (inclusive).

Step 13 Click **Apply** to commit your changes. The WLANs > Edit page appears (see Figure 11-19).

Figure 11-19 WLANs > Edit Page



Step 14 Select the **Enabled** check box for the Status parameter.

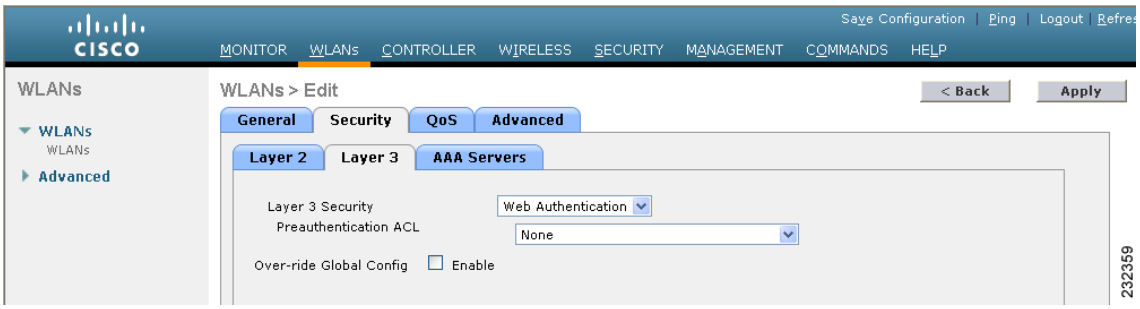
Step 15 Web authentication (Web-Auth) is the default security policy. If you want to change this to web passthrough, choose the **Security** tab after completing Step 16 and Step 17.

Step 16 From the Ingress Interface drop-down list, choose the VLAN that you created in Step 3. This VLAN provides a path between the wired guest client and the controller by way of the Layer 2 access switch.

Step 17 From the Egress Interface drop-down list, choose the name of the interface. This WLAN provides a path out of the controller for wired guest client traffic.

Step 18 If you want to change the authentication method (for example, from web authentication to web passthrough), choose **Security** > **Layer 3**. The WLANs > Edit (Security > Layer 3) page appears (see Figure 11-20).

Figure 11-20 WLANs > Edit (Security > Layer 3) Page



Step 19 From the Layer 3 Security drop-down list, choose one of the following:

- **None**—Layer 3 security is disabled.
- **Web Authentication**—Causes users to be prompted for a username and password when connecting to the wireless network. This is the default value.
- **Web Passthrough**—Allows users to access the network without entering a username and password.

Note There should not be a Layer 3 gateway on the guest wired VLAN, as this would bypass the web authentication done through the controller.

Step 20 If you choose the Web Passthrough option, an **Email Input** check box appears. Select this check box if you want users to be prompted for their e-mail address when attempting to connect to the network.

Step 21 To override the global authentication configuration set on the Web Login page, select the **Override Global Config** check box.

Step 22 When the Web Auth Type drop-down list appears, choose one of the following options to define the web authentication pages for wired guest users:

- **Internal**—Displays the default web login page for the controller. This is the default value.
- **Customized**—Displays custom web login, login failure, and logout pages. If you choose this option, three separate drop-down lists appear for login, login failure, and logout page selection. You do not need to define a customized page for all three options. Choose **None** from the appropriate drop-down list if you do not want to display a customized page for that option.

  Note These optional login, login failure, and logout pages are downloaded to the controller as webauth.tar files.

- **External**—Redirects users to an external server for authentication. If you choose this option, you must also enter the URL of the external server in the URL text box.

  You can choose specific RADIUS or LDAP servers to provide external authentication on the WLANs > Edit (Security > AAA Servers) page. Additionally, you can define the priority in which the servers provide authentication.

Step 23 If you chose External as the web authentication type in Step 22, choose **AAA Servers** and choose up to three RADIUS and LDAP servers using the drop-down lists.

Note The RADIUS and LDAP external servers must already be configured in order to be selectable options on the WLANs > Edit (Security > AAA Servers) page. You can configure these servers on the RADIUS Authentication Servers page and LDAP Servers page.

Step 24 To establish the priority in which the servers are contacted to perform web authentication as follows:

Note The default order is local, RADIUS, LDAP.

a. Highlight the server type (local, RADIUS, or LDAP) that you want to be contacted first in the box next to the Up and Down buttons.
b. Click **Up** and **Down** until the desired server type is at the top of the box.
c. Click the **<** arrow to move the server type to the priority box on the left.
d. Repeat these steps to assign priority to the other servers.

Step 25 Click **Apply** to commit your changes.

Step 26 Click **Save Configuration** to save your changes.

Step 27 Repeat this process if a second (anchor) controller is being used in the network.

Using the CLI to Configure Wired Guest Access

To configure wired guest user access on your network using the controller CLI, follow these steps:

Step 1 Create a dynamic interface (VLAN) for wired guest user access by entering this command:

config interface create *interface_name vlan_id*

Step 2 If link aggregation trunk is not configured, enter this command to map a physical port to the interface:

config interface port *interface_name primary_port* {*secondary_port*}

Step 3 Enable or disable the guest LAN VLAN by entering this command:

config interface guest-lan *interface_name* {**enable** | **disable**}

This VLAN is later associated with the ingress interface created in Step 5.

Step 4 Create a wired LAN for wired client traffic and associate it to an interface by entering this command:

config guest-lan create *guest_lan_id interface_name*

The guest LAN ID must be a value between 1 and 5 (inclusive).

Note To delete a wired guest LAN, enter the **config guest-lan delete** *guest_lan_id* command.

Step 5 Configure the wired guest VLAN's ingress interface, which provides a path between the wired guest client and the controller by way of the Layer 2 access switch by entering this command:

config guest-lan ingress-interface *guest_lan_id interface_name*

Step 6 Configure an egress interface to transmit wired guest traffic out of the controller by entering this command:

config guest-lan interface *guest_lan_id interface_name*

Note If the wired guest traffic is terminating on another controller, repeat Step 4 and Step 6 for the terminating (anchor) controller and Step 1 through Step 5 for the originating (foreign) controller. Additionally, configure the **config mobility group anchor add** {**guest-lan** *guest_lan_id* | **wlan** *wlan_id*} *IP_address* command for both controllers.

Step 7 Configure the security policy for the wired guest LAN by entering this command:

config guest-lan security {**web-auth enable** *guest_lan_id* | **web-passthrough enable** *guest_lan_id*}

Note Web authentication is the default setting.

Step 8 Enable or disable a wired guest LAN by entering this command:

config guest-lan {**enable** | **disable**} *guest_lan_id*

Step 9 If you want wired guest users to log into a customized web login, login failure, or logout page, enter these commands to specify the filename of the web authentication page and the guest LAN for which it should display:

- **config guest-lan custom-web login-page** *page_name guest_lan_id*—Defines a web login page.
- **config guest-lan custom-web loginfailure-page** *page_name guest_lan_id*—Defines a web login failure page.

Note To use the controller's default login failure page, enter the **config guest-lan custom-web loginfailure-page none** *guest_lan_id* command.

- **config guest-lan custom-web logout-page** *page_name guest_lan_id*—Defines a web logout page.

Note To use the controller's default logout page, enter the **config guest-lan custom-web logout-page none** *guest_lan_id* command.

Step 10 If you want wired guest users to be redirected to an external server before accessing the web login page, enter this command to specify the URL of the external server:

config guest-lan custom-web ext-webauth-url *ext_web_url guest_lan_id*

Step 11 If you want to define the order in which local (controller) or external (RADIUS, LDAP) web authentication servers are contacted, enter this command:

config wlan security web-auth server-precedence *wlan_id* {**local** | **ldap** | **radius**} {**local** | **ldap** | **radius**} {**local** | **ldap** | **radius**}

The default order of server web authentication is local, RADIUS, LDAP.

Note All external servers must be preconfigured on the controller. You can configure them on the RADIUS Authentication Servers page or the LDAP Servers page.

Step 12 Define the web login page for wired guest users by entering this command:

config guest-lan custom-web webauth-type {**internal** | **customized** | **external**} *guest_lan_id*

where

- **internal** displays the default web login page for the controller. This is the default value.
- **customized** displays the custom web pages (login, login failure, or logout) that were configured in Step 9.
- **external** redirects users to the URL that was configured in Step 10.

Step 13 Use a guest-LAN specific custom web configuration rather than a global custom web configuration by entering this command:

config guest-lan custom-web global disable *guest_lan_id*

Note If you enter the **config guest-lan custom-web global enable** *guest_lan_id* command, the custom web authentication configuration at the global level is used.

Step 14 Save your changes by entering this command:

save config

Note Information on the configured web authentication appears in both the **show run-config** and **show running-config** commands.

Step 15 Display the customized web authentication settings for a specific guest LAN by entering this command:

show custom-web {**all** | **guest-lan** *guest_lan_id*}

Note If internal web authentication is configured, the Web Authentication Type displays as internal rather than external (controller level) or customized (WLAN profile level).

Information similar to the following appears for the **show custom-web all** command:

```
Radius Authentication Method..................... PAP
Cisco Logo....................................... Enabled
CustomLogo....................................... None
Custom Title..................................... None
Custom Message................................... None
Custom Redirect URL.............................. None
Web Authentication Type..............            External
External Web Authentication URL............       http:\\9.43.0.100\login.html

External Web Server list
Index IP Address
----- ---------------
1       9.43.0.100
2       0.0.0.0
3       0.0.0.0
4       0.0.0.0
5       0.0.0.0
...
20      0.0.0.0

Configuration Per Profile:

WLAN ID: 1
    WLAN Status.................................. Enabled
    Web Security Policy.......................... Web Based Authentication
    Global Status................................ Disabled
    WebAuth Type................................. Customized
    Login Page................................... login1.html
    Loginfailure page name..................... loginfailure1.html
    Logout page name............................. logout1.html

WLAN ID: 2
WLAN Status.................................. Enabled
    Web Security Policy.......................... Web Based Authentication
    Global Status................................ Disabled
    WebAuth Type................................. Internal
    Loginfailure page name....................... None
    Logout page name............................. None

WLAN ID: 3
WLAN Status.................................. Enabled
    Web Security Policy.......................... Web Based Authentication
    Global Status................................ Disabled
    WebAuth Type................................. Customized
    Login Page................................... login.html
    Loginfailure page name....................... LF2.html
    Logout page name............................. LG2.html
```

Information similar to the following appears for the **show custom-web guest-lan** *guest_lan_id* command:

```
Guest LAN ID: 1
Guest LAN Status............................. Disabled
Web Security Policy.......................... Web Based Authentication
Global Status................................ Enabled
WebAuth Type................................. Internal
```

```
Loginfailure page name..................... None
Logout page name........................... None
```

Step 16 Display a summary of the local interfaces by entering this command:

show interface summary

Information similar to the following appears:

```
Interface Name                   Port Vlan Id  IP Address      Type    Ap Mgr Guest
-------------------------------- ---- -------- --------------- ------- ------ -----
ap-manager                       1    untagged 1.100.163.25    Static  Yes    No

management                       1    untagged 1.100.163.24    Static  No     No

service-port                     N/A  N/A      172.19.35.31    Static  No     No

virtual                          N/A  N/A      1.1.1.1         Static  No     No

wired                            1    20       10.20.20.8      Dynamic No     No

wired-guest                      1  236     10.20.236.50   Dynamic No    Yes
```

Note The interface name of the wired guest LAN in this example is *wired-guest* and its VLAN ID is 236.Display detailed interface information by entering this command:

show interface detailed *interface_name*

Information similar to the following appears:

```
Interface Name................................. wired-guest
MAC Address.................................... 00:1a:6d:dd:1e:40
IP Address..................................... 0.0.0.0
DHCP Option 82................................. Disabled
Virtual DNS Host Name.......................... Disabled
AP Manager..................................... No
Guest Interface................................ No
```

Step 17 Display the configuration of a specific wired guest LAN by entering this command:

show guest-lan *guest_lan_id*

Information similar to the following appears:

```
Guest LAN Identifier........................... 1
Profile Name................................... guestlan
Network Name (SSID)............................ guestlan
Status......................................... Enabled
AAA Policy Override............................ Disabled
Number of Active Clients....................... 1
Exclusionlist Timeout.......................... 60 seconds
Session Timeout................................ Infinity
Interface...................................... wired
Ingress Interface.............................. wired-guest
WLAN ACL....................................... unconfigured
DHCP Server.................................... 10.20.236.90
DHCP Address Assignment Required............... Disabled
Quality of Service............................. Silver (best effort)
Security
    Web Based Authentication..................... Enabled
    ACL.......................................... Unconfigured
    Web-Passthrough.............................. Disabled
    Conditional Web Redirect..................... Disabled
```

```
    Auto Anchor................................... Disabled
Mobility Anchor List
GLAN ID IP Address Status
------- --------------- ------
```

Note Enter the **show guest-lan summary** command to see all wired guest LANs configured on the controller.

Step 18 Display the active wired guest LAN clients by entering this command:

show client summary guest-lan

Information similar to the following appears:

```
Number of Clients............................... 1
MAC Address        AP Name Status     WLAN  Auth Protocol  Port Wired
------------------ ------- ----------- ----- ----- --------- ----- ------
00:16:36:40:ac:58   N/A   Associated   1    No    802.3     1    Yes
```

Step 19 Display detailed information for a specific client by entering this command:

show client detail *client_mac*

Information similar to the following appears:

```
Client MAC Address.............................. 00:40:96:b2:a3:44
Client Username ................................ N/A
AP MAC Address.................................. 00:18:74:c7:c0:90
Client State.................................... Associated
Wireless LAN Id................................. 1
BSSID........................................... 00:18:74:c7:c0:9f
Channel......................................... 56
IP Address...................................... 192.168.10.28
Association Id.................................. 1
Authentication Algorithm........................ Open System
Reason Code..................................... 0
Status Code..................................... 0
Session Timeout................................. 0
Client CCX version.............................. 5
Client E2E version.............................. No E2E support
Diagnostics Capability.......................... Supported
S69 Capability.................................. Supported
Mirroring....................................... Disabled
QoS Level....................................... Silver
...
```

CHAPTER 12

Configuring Cisco CleanAir

This chapter describes how to configure Cisco CleanAir functionality on the controller and lightweight access points. It contains these sections:

Overview of Cisco CleanAir

Wireless LAN systems operate in unlicensed 2.4- and 5-GHz industrial, scientific, and medical (ISM) bands. Many devices, such as microwave ovens, cordless phones, and Bluetooth devices also operate in these bands and can negatively affect Wi-Fi operations. Some of the most advanced WLAN services, such as voice over wireless and IEEE 802.11n radio communications, could be significantly impaired by the interference caused by other legal users of the ISM bands. The integration of Cisco CleanAir functionality into the Cisco Unified Wireless Network addresses this problem of radio frequency (RF) interference. The Cisco CleanAir feature, available in controller software release 7.0.98.0, enables you to identify and track non-Wi-Fi sources of interference, adjust your network configuration for optimal performance, identify threats from malicious devices, and allow your WLAN to coexist with other wireless devices.

A Cisco CleanAir system consists of CleanAir-enabled access points, controllers, and WCS. Currently, only Cisco Aironet 3500 series access points can be configured for Cisco CleanAir. These access points collect information about all devices that operate in the ISM bands, identify and evaluate the information as a potential interference source, and forward it to the controller. The controller controls the access points, collects spectrum data, and forwards information to WCS or a Cisco mobility services engine (MSE) upon request. The controller provides a local user interface to configure basic CleanAir features and display basic spectrum information. WCS provides an advanced user interface for configuring Cisco CleanAir features, displaying information, and keeping records. The MSE is optional for the basic feature set but required for advanced features such as tracking the location of non-Wi-Fi interference devices.

Role of the Controller

The controller performs these tasks in a Cisco CleanAir system:

- Configures Cisco CleanAir capabilities on the access point
- Provides interfaces (GUI, CLI, and SNMP) for configuring Cisco CleanAir features and retrieving data
- Displays spectrum data
- Collects and processes air quality reports from the access point and stores them in the air quality database
- Collects and processes interference device reports (IDRs) from the access point and stores them in the interference device database
- Forwards spectrum data to WCS and the MSE

Benefits

Cisco CleanAir is a spectrum intelligence solution designed to proactively manage the challenges of a shared wireless spectrum. It allows you to see all of the users of the shared spectrum (both native devices and foreign interferers). It also enables you or your network to act upon this information. For example, you could manually remove the interfering device, or the system could automatically change the channel away from the interference.

For every device operating in the unlicensed band, Cisco CleanAir tells you what it is, where it is, how it is impacting your wireless network, and what actions you or your network should take. It simplifies RF so that you do not have to be an RF expert.

Types of Interferences

Cisco CleanAir can detect interference, report on the location and severity of the interference, and recommend different mitigation strategies. Two such mitigation strategies are persistent device avoidance and spectrum event-driven RRM.

Wi-Fi chip-based RF management systems share these characteristics:

- Any RF energy that cannot be identified as a Wi-Fi signal is reported as noise.
- Noise measurements that are used to assign a channel plan tend to be averaged over a period of time to avoid instability or rapid changes that can be disruptive to certain client devices.
- Averaging measurements reduces the resolution of the measurement. As such, a signal that disrupts clients might not look like it needs to be mitigated after averaging.
- All RF management systems available today are reactive in nature.

Cisco CleanAir is different and can positively identify not only the source of the noise but also its location and potential impact to a WLAN. Having this information allows you to consider the noise within the context of the network and make intelligent and, where possible, proactive decisions. For CleanAir, two types of interference events are common:

- Persistent interference
- Spontaneous interference

Persistent interference events are created by devices that are stationary in nature and have intermittent but largely repeatable patterns of interference. For example, consider the case of a microwave oven located in a break room. Such a device might be active for only 1 or 2 minutes at a time. When operating, however, it can be disruptive to the performance of the wireless network and associated clients. Using Cisco CleanAir, you can positively identify the device as a microwave oven rather than indiscriminate

noise. You can also determine exactly which part of the band is affected by the device, and because you can locate it, you can understand which access points are most severely affected. You can then use this information to direct RRM in selecting a channel plan that avoids this source of interference for the access points within its range. Because this interference is not active for a large portion of the day, existing RF management applications might attempt to again change the channels of the affected access points. Persistent device avoidance is unique, however, in that it remains in effect as long as the source of interference is periodically detected to refresh the persistent status. The Cisco CleanAir system knows that the microwave oven exists and includes it in all future planning. If you move either the microwave oven or the surrounding access points, the algorithm updates RRM automatically.

Spontaneous interference is interference that appears suddenly on a network, perhaps jamming a channel or a range of channels completely. The Cisco CleanAir spectrum event-driven RRM feature allows you to set a threshold for air quality (AQ) that, if exceeded, triggers an immediate channel change for the affected access point. Most RF management systems can avoid interference, but this information takes time to propagate through the system. Cisco CleanAir relies on AQ measurements to continuously evaluate the spectrum and can trigger a move within 30 seconds. For example, if an access point detects interference from a video camera, it can recover by changing channels within 30 seconds of the camera becoming active. Cisco CleanAir also identifies and locates the source of interference so that more permanent mitigation of the device can be performed at a later time.

Note Spectrum event-driven RRM can be triggered only by Cisco CleanAir-enabled access points in local mode.

Supported Access Point Modes

Only Cisco CleanAir-enabled access points using the following access point modes can perform Cisco CleanAir spectrum monitoring:

- **Local**—In this mode, each Cisco CleanAir-enabled access point radio provides air quality and interference detection reports for the current operating channel only.
- **Hybrid-REAP**—When a hybrid-REAP access point is connected to the controller, its Cisco CleanAir functionality is identical to local mode.
- **Monitor**—When Cisco CleanAir is enabled in monitor mode, the access point provides air quality and interference detection reports for all monitored channels.

Note Suppose you have two APs, one in the H-REAP mode and the other in the Monitor mode. Also suppose that you have created a profile enabling EAP attack against 802.1x auth. The Airmagnet (AM) tool, which can generate different types of attacks, fails to generate any attack even if you have provided valid AP MAC and STA MAC addresses. But if the AP MAC and STA MAC addresses in the AM tool are swapped, that is, the AP MAC address is specified in the STA MAC field and the STA MAC address is specified in the AP MAC field, then the tool is able to generate attacks, which the AP in the Monitor mode is also able to detect.

Note The access point does not participate in AQ HeatMap in WCS.

The following options are available:

- All— All channels

  - DCA—Channel selection governed by the DCA list
  - Country—All channel legal within a regulatory domain

- **SE-Connect**—This mode enables a user to connect a Spectrum Expert application running on an external Microsoft Windows XP or Vista PC to a Cisco CleanAir-enabled access point in order to display and analyze detailed spectrum data. The Spectrum Expert application connects directly to the access point, bypassing the controller. An access point in SE-Connect mode does not provide any Wi-Fi, RF, or spectrum data to the controller. In addition to performing spectrum intellegence, an access point can provide other. See the "Configuring a Spectrum Expert Connection" section on page 12-23 for instructions on establishing a Spectrum Expert console connection.

Guidelines

Follow these guidelines when using Cisco CleanAir functionality:

- The Cisco 2100 Series Controller and Controller Network Modules support up to 75 device clusters (unique interference devices detected by a single or multiple radios) and up to 300 device records (information about an interference device detected by a single radio). The Cisco 4400 Series Controllers, Cisco WiSM, and Catalyst 3750G Wireless LAN Controller Switch support up to 750 device clusters and up to 3,000 device records. The Cisco 5500 Series Controllers support up to 2,500 device clusters and up to 10,000 device records.
- The amount of power required for processing spectrum data limits the number of monitor-mode access points that can be used for Cisco CleanAir monitoring. The Cisco CleanAir system supports up to 6 monitor-mode access points on the Cisco 2100 Series Controller and Controller Network Modules; up to 25 monitor-mode access points on the Cisco 4400 Series Controllers, the Catalyst 3750G Wireless LAN Controller Switch, and each Cisco WiSM controller; number of supported monitor mode access points is equal to the maximum number of supported access points on the Cisco 5500 and Flex 7500 Series Controllers. This limitation affects only Cisco CleanAir functionality.
- Access points in monitor mode do not transmit Wi-Fi traffic or 802.11 packets. They are excluded from radio resource management (RRM) planning and are not included in the neighbor access point list. IDR clustering depends on the controller's ability to detect neighboring in-network access points. Correlating interference device detections from multiple access points is limited between monitor-mode access points.
- Spectrum Expert (SE) Connect functionality is supported for local, hybrid REAP, bridge, and monitor modes. The access point provides spectrum information to Spectrum Expert only for the current channel(s). For local, hybrid REAP, and bridge modes, the spectrum data is available for the current active channel(s) and for the monitor mode, the common monitored channel list is available. The access point continues to send AQ (Air Quality) and IDR (Interference Device Reports) reports to the controller and perform normal activities according to the current mode. Sniffer and rogue detections access point modes are incompatible with all types of CleanAir spectrum monitoring.
- Controllers have limitations on the number of monitor mode AP's that they can support. This is because, a monitor mode AP saves data for all the channels.
- Do not connect access points in SE connect mode directly to any physical port on the Cisco 2100 or 2500 Series Controller.

Configuring Cisco CleanAir on the Controller

This section describes how to configure Cisco CleanAir functionality on the 802.11a/n or 802.11b/g/n network using either the controller GUI or CLI.

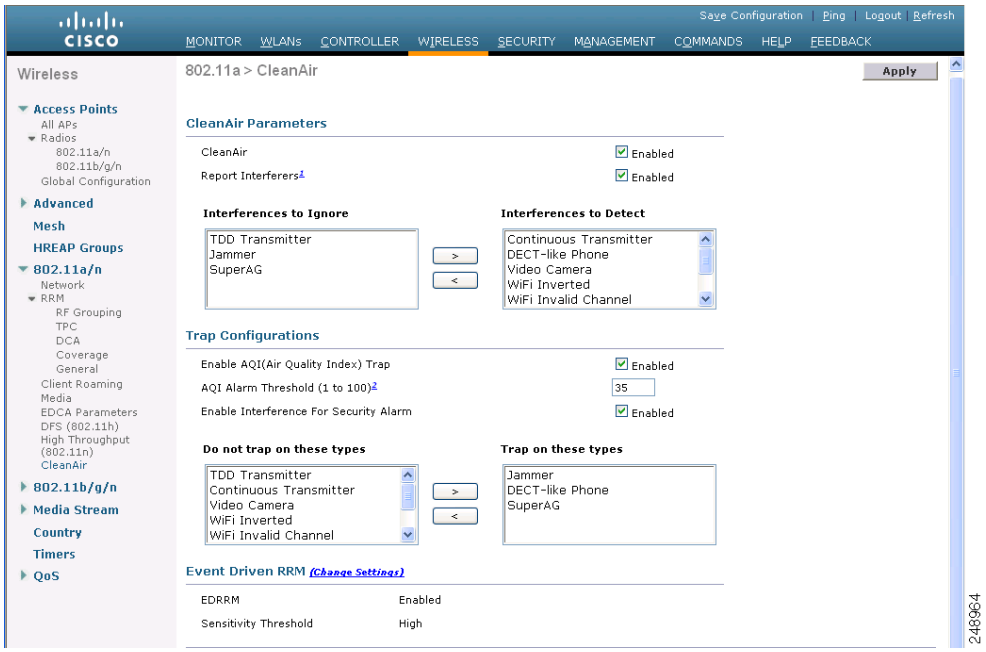
Note See the "Configuring Cisco CleanAir on an Access Point" section on page 12-11 to enable or disable Cisco CleanAir functionality for a specific access point, rather than globally across the network. For example, you may want to enable Cisco CleanAir globally on the 802.11a/n network but then disable it for a particular access point on that network.

Using the GUI to Configure Cisco CleanAir on the Controller

To configure Cisco CleanAir functionality on the controller using the controller GUI, follow these steps:

Step 1 Choose **Wireless > 802.11a/n or 802.11b/g/n > CleanAir** to open the 802.11a (or 802.11b) > CleanAir page (see Figure 12-1).

Figure 12-1 802.11a > CleanAir Page



Step 2 Select the **CleanAir** check box to enable Cisco CleanAir functionality on the 802.11a/n or 802.11b/g/n network, or unselect it to prevent the controller from detecting spectrum interference. The default value is selected.

Step 3 Select the **Report Interferers** check box to enable the Cisco CleanAir system to report any detected sources of interference, or unselect it to prevent the controller from reporting interferers. The default value is selected.

Step 4 Make sure that any sources of interference that need to be detected and reported by the Cisco CleanAir system appear in the Interferences to Detect box and any that do not need to be detected appear in the Interferences to Ignore box. Use the **>** and **<** buttons to move interference sources between these two boxes. By default, all interference sources are detected. The possible sources of interference are as follows:

- **Bluetooth Paging Inquiry**—A Bluetooth discovery (802.11b/g/n only)
- **Bluetooth Sco Acl**—A Bluetooth link (802.11b/g/n only)
- **Generic DECT**—A digital enhanced cordless communication (DECT)-compatible phone
- **Generic TDD**—A time division duplex (TDD) transmitter
- Generic Waveform—A continuous transmitter
- **Jammer**—A jamming device
- **Microwave—A microwave oven** (802.11b/g/n only)
- **Canopy**—A canopy device
- Radar—A radar device (802.11a/n only)
- **Spectrum 802.11 FH—An 802.11 frequency-hopping device** (802.11b/g/n only)
- **Spectrum 802.11 inverted**—A device using spectrally inverted Wi-Fi signals
- **Spectrum 802.11 non std channel**—A device using nonstandard Wi-Fi channels
- **Spectrum 802.11 SuperG**—An 802.11 SuperAG device
- **Spectrum 802.15.4**—An 802.15.4 device (802.11b/g/n only)
- **Video Camera**—An analog video camera
- WiMAX Fixed—A WiMAX fixed device (802.11a/n only)
- WiMAX **Mobile**—A WiMAX mobile device (802.11a/n only)
- **XBox**—A Microsoft Xbox (802.11b/g/n only)

Note Access points that are associated to the controller send interference reports only for the interferers that appear in the Interferences to Detect box. This functionality allows you to filter out interferers that you do not want as well as any that may be flooding the network and causing performance problems for the controller or WCS. Filtering allows the system to resume normal performance levels.

Step 5 Configure Cisco CleanAir alarms as follows:

a. Select the **Enable AQI (Air Quality Index) Trap** check box to enable the triggering of air quality alarms, or unselect the box to disable this feature. The default value is selected.

b. If you selected the Enable AQI Trap check box in Step a, enter a value between 1 and 100 (inclusive) in the AQI Alarm Threshold text box to specify the threshold at which you want the air quality alarm to be triggered. When the air quality falls below the threshold level, the alarm is triggered. A value of 1 represents the worst air quality, and 100 represents the best. The default value is 35.

c. Select the **Enable Interference Type Trap** check box to trigger interferer alarms when the controller detects specified device types, or unselect it to disable this feature. The default value is selected.

d. Make sure that any sources of interference that need to trigger interferer alarms appear in the Trap on These Types box and any that do not need to trigger interferer alarms appear in the Do Not Trap on These Types box. Use the **>** and **<** buttons to move interference sources between these two boxes. By default, all interference sources trigger interferer alarms.

For example, if you want the controller to send an alarm when it detects a jamming device, select the **Enable Interference Type Trap check box** and move the jamming device to the Trap on These Types box.

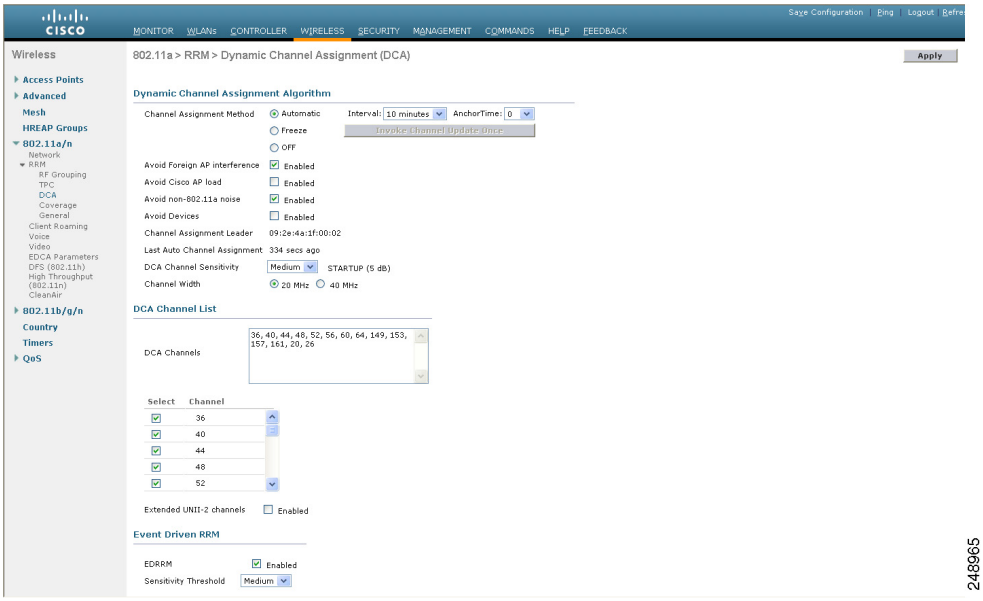
Step 6 Click **Apply** to commit your changes.

Step 7 Trigger spectrum event-driven radio resource management (RRM) to run when a Cisco CleanAir-enabled access point detects a significant level of interference as follows:

a. Look at the EDRRM field to see the current status of spectrum event-driven RRM and, if enabled, the Sensitivity Threshold field to see the threshold level at which event-driven RRM is invoked.

b. If you want to change the current status of event-driven RRM or the sensitivity level, click **Change Settings**. The **802.11a (or 802.11b) > RRM > Dynamic Channel Assignment (DCA)** page appears (see Figure 12-2).

Figure 12-2 802.11a > RRM > Dynamic Channel Assignment (DCA) Page



c. Select the **EDRRM** check box to trigger RRM to run when an access point detects a certain level of interference, or unselect it to disable this feature. The default value is selected.

d. If you selected the EDRRM check box in Step c, choose **Low**, **Medium**, or **High** from the Sensitivity Threshold drop-down list to specify the threshold at which you want RRM to be triggered. When the interference for the access point rises above the threshold level, RRM initiates a local dynamic channel assignment (DCA) run and changes the channel of the affected access point radio if possible to improve network performance. Low represents a decreased sensitivity to changes in the environment while High represents an increased sensitivity.

The EDRRM AQ threshold value for low sensitivity is 35, medium sensitivity is 50, and high sensitivity is 60.

The default value is Medium.

e. Click **Apply** to commit your changes.

Step 8 Click **Save Configuration** to save your changes.

Using the CLI to Configure Cisco CleanAir on the Controller

To configure Cisco CleanAir functionality on the controller using the controller CLI, follow these steps:

Step 1 Configure Cisco CleanAir functionality on the 802.11a/n or 802.11b/g/n network by entering this command:

config {**802.11a** | **802.11b**} CleanAir {**enable** | **disable**} **all**

If you disable this feature, the controller does not receive any spectrum data. The default value is enable.

Step 2 Configure interference detection and specify sources of interference that need to be detected by the Cisco CleanAir system by entering this command:

config {**802.11a** | **802.11b**} **CleanAir device** {**enable** | **disable**} *type*

where *type* is one of the following:

- **802.11-fh—An 802.11 frequency-hopping device** (802.11b/g/n only)
- **802.11-inv**—A device using spectrally inverted Wi-Fi signals
- **802.11-nonstd**—A device using nonstandard Wi-Fi channels
- **802.15.4**—An 802.15.4 device (802.11b/g/n only)
- **all**—All interference device types (this is the default value)
- **bt-discovery**—A bluetooth discovery (802.11b/g/n only)
- **bt-link**—A bluetooth link (802.11b/g/n only)
- **canopy**—A canopy device
- cont-tx—A continuous transmitter
- **dect-like**—A digital enhanced cordless communication (DECT)-compatible phone
- **jammer**—A jamming device
- **mw-oven—A microwave oven** (802.11b/g/n only)
- radar—A radar device (802.11a/n only)
- **superag**—An 802.11 SuperAG device
- **tdd-tx**—A time division duplex (TDD) transmitter
- **video camera**—An analog video camera
- wimax-fixed—A WiMAX fixed device
- **wimax-mobile**—A WiMAX mobile device
- **xbox**—A Microsoft Xbox (802.11b/g/n only)

Note Access points that are associated to the controller send interference reports only for the interference types specified in this command. This functionality allows you to filter out interferers that may be flooding the network and causing performance problems for the controller or WCS. Filtering allows the system to resume normal performance levels.

Step 3 Configure the triggering of air quality alarms by entering this command:

config {802.11a | 802.11b} CleanAir alarm air-quality {enable | disable}

The default value is enable.

Step 4 Specify the threshold at which you want the air quality alarm to be triggered by entering this command:

config {802.11a | 802.11b} CleanAir alarm air-quality threshold *threshold*

where *threshold* is a value between 1 and 100 (inclusive). When the air quality falls below the threshold level, the alarm is triggered. A value of 1 represents the worst air quality, and 100 represents the best. The default value is 35.

Step 5 Enable the triggering of interferer alarms by entering this command:

config {802.11a | 802.11b} CleanAir alarm device {enable | disable}

The default value is enable.

Step 6 Specify sources of interference that trigger alarms by entering this command:

config {802.11a | 802.11b} CleanAir alarm device *type* **{enable | disable}**

where *type* is one of the following:

- **802.11-fh—An 802.11 frequency-hopping device** (802.11b/g/n only)
- **802.11-inv**—A device using spectrally inverted Wi-Fi signals
- **802.11-nonstd**—A device using nonstandard Wi-Fi channels
- **802.15.4**—An 802.15.4 device (802.11b/g/n only)
- **all**—All interference device types (this is the default value)
- **bt-discovery**—A Bluetooth discovery (802.11b/g/n only)
- **bt-link**—A Bluetooth link (802.11b/g/n only)
- **canopy**—A canopy device
- cont-tx—A continuous transmitter
- **dect-like**—A digital enhanced cordless communication (DECT)-compatible phone
- **jammer**—A jamming device
- **mw-oven—A microwave oven** (802.11b/g/n only)
- radar—A radar device (802.11a/n only)
- **superag**—An 802.11 SuperAG device
- **tdd-tx**—A time division duplex (TDD) transmitter
- **video camera**—An analog video camera
- wimax-fixed—A WiMAX fixed device
- **wimax-mobile**—A WiMAX mobile device
- **xbox**—A Microsoft Xbox (802.11b/g/n only)

Step 7 Trigger spectrum event-driven radio resource management (RRM) to run when a Cisco CleanAir-enabled access point detects a significant level of interference by entering these commands:

- **config advanced {802.11a | 802.11b} channel cleanair-event {enable | disable}**—Enables or disables spectrum event-driven RRM. The default value is disabled.
- **config advanced {802.11a | 802.11b} channel cleanair-event sensitivity {low | medium | high}**—Specifies the threshold at which you want RRM to be triggered. When the interference level for the access point rises above the threshold level, RRM initiates a local dynamic channel assignment (DCA) run and changes the channel of the affected access point radio if possible to improve network performance. Low represents a decreased sensitivity to changes in the environment while high represents an increased sensitivity. The default value is medium.

Step 8 Save your changes by entering this command:

save config

Step 9 See the Cisco CleanAir configuration for the 802.11a/n or 802.11b/g/n network by entering this command:

show {802.11a | 802.11b} cleanair config

Information similar to the following appears:

```
Clean Air Solution..............................  Enabled
Air Quality Settings:
    Air Quality Reporting.......................  Enabled
    Air Quality Reporting Period (min)..........  15
    Air Quality Alarms..........................  Enabled
    Air Quality Alarm Threshold.................  35
Interference Device Settings:
    Interference Device Reporting...............  Enabled
    Interference Device Types:
        TDD Transmitter.........................  Disabled
        Jammer..................................  Disabled
        Continuous Transmitter..................  Disabled
        DECT-like Phone.........................  Disabled
        Video Camera............................  Disabled
        WiFi Inverted...........................  Disabled
        WiFi Invalid Channel....................  Disabled
        SuperAG.................................  Disabled
        Radar...................................  Disabled
        Canopy..................................  Disabled
        WiMax Mobile............................  Disabled
        WiMax Fixed.............................  Disabled
Interference Device Alarms......................  Enabled
    Interference Device Types Triggering Alarms:
        TDD Transmitter.........................  Disabled
        Jammer..................................  Enabled
        Continuous Transmitter..................  Disabled
        DECT-like Phone.........................  Disabled
        Video Camera............................  Disabled
        WiFi Inverted...........................  Enabled
        WiFi Invalid Channel....................  Enabled
        SuperAG.................................  Disabled
        Radar...................................  Disabled
        Canopy..................................  Disabled
        WiMax Mobile............................  Disabled
        WiMax Fixed.............................  Disabled
    Interference Device Merging Type............  normal
Additional Clean Air Settings:
    CleanAir Event-driven RRM State.............  Enabled
    CleanAir Driven RRM Sensitivity.............  Medium
```

```
    CleanAir Persistent Devices state........ Disabled
```

Step 10 See the spectrum event-driven RRM configuration for the 802.11a/n or 802.11b/g/n network by entering this command:

show advanced {802.11a | 802.11b} channel

Information similar to the following appears:

```
Automatic Channel Assignment
  Channel Assignment Mode....................... AUTO
  Channel Update Interval....................... 600 seconds [startup]
  Anchor time (Hour of the day).................. 0
  Channel Update Contribution................... SNI
  CleanAir Event-driven RRM option.............. Enabled
  CleanAir Event-driven RRM sensitivity...... Medium
...
```

Configuring Cisco CleanAir on an Access Point

This section describes how to configure Cisco CleanAir functionality on an individual access point using either the controller GUI or CLI.

Note See the "Configuring Cisco CleanAir on the Controller" section on page 12-5 to enable or disable Cisco CleanAir functionality globally across the 802.11a/n or 802.11b/g/n network rather than for specific access points.

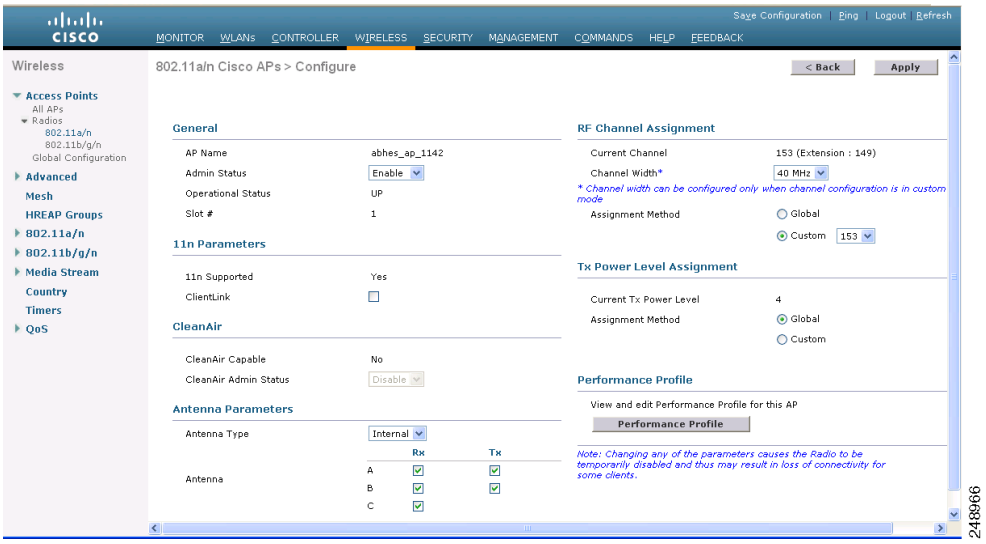
Using the GUI to Configure Cisco CleanAir on an Access Point

To configure Cisco CleanAir functionality for a specific access point using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > Radios > 802.11a/n or 802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

Step 2 Hover your cursor over the blue drop-down arrow for the desired access point and click **Configure**. The 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page appears (see Figure 12-3).

Figure 12-3 802.11a/n Cisco APs > Configure Page



The CleanAir Capable field shows whether this access point can support CleanAir functionality. If it can, go to the next step to enable or disable CleanAir for this access point. If the access point cannot support CleanAir functionality, you cannot enable CleanAir for this access point.

Note Currently, only Cisco Aironet 3500 series access points can be configured for Cisco CleanAir.

Note By default, the Cisco CleanAir functionality is enabled on the radios.

Step 3 Enable Cisco CleanAir functionality for this access point by choosing **Enable** from the CleanAir Status drop-down list. To disable CleanAir functionality for this access point, choose **Disable**. The default value is Enable. This setting overrides the global CleanAir configuration for this access point.

The Number of Spectrum Expert Connections text box shows the number of Spectrum Expert applications that are currently connected to the access point radio. Up to three active connections are possible.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Step 6 Click **Back** to return to the 802.11a/n (or 802.11b/g/n) Radios page.

Step 7 View the Cisco CleanAir status for each access point radio by looking at the CleanAir Status text box on the 802.11a/n (or 802.11b/g/n) Radios page.

The Cisco CleanAir status is one of the following:

- **UP**—The spectrum sensor for the access point radio is currently operational (error code 0).
- **DOWN**—The spectrum sensor for the access point radio is currently not operational because an error has occurred. The most likely reason for the error is that the access point radio is disabled (error code 8). To correct this error, enable the radio.
- **ERROR**—The spectrum sensor for the access point radio has crashed (error code 128), making CleanAir monitoring nonoperational for this radio. If this error occurs, reboot the access point. If the error continues to appear, you might want to disable Cisco CleanAir functionality on the radio.

- **N/A**—This access point radio is not capable of supporting Cisco CleanAir functionality. Currently, only Cisco Aironet 3500 series access point radios can be configured for Cisco CleanAir.

Note You can create a filter to make the 802.11a/n Radios page or the 802.11b/g/n Radios page show only access point radios that have a specific Cisco CleanAir status (such as UP, DOWN, ERROR, or N/A). This feature is especially useful if your list of access point radios spans multiple pages, preventing you from viewing them all at once. To create a filter, click **Change Filter** to open the Search AP dialog box, select one or more of the CleanAir Status check boxes, and click **Find**. Only the access point radios that match your search criteria appear on the 802.11a/n Radios page or the 802.11b/g/n Radios page, and the Current Filter parameter at the top of the page specifies the filter used to generate the list (for example, CleanAir Status: UP).

Using the CLI to Configure Cisco CleanAir on an Access Point

To configure CleanAir functionality for a specific access point using the controller CLI, follow these steps:

Step 1 Configure Cisco CleanAir functionality for a specific access point by entering this command:

config {**802.11a** | **802.11b**} **cleanair** {**enable** | **disable**} *Cisco_AP*

Step 2 Save your changes by entering this command:

save config

Step 3 See the Cisco CleanAir configuration for a specific access point on the 802.11a/n or 802.11b/g/n network by entering this command:

show ap config {802.11a | 802.11b} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 0
Cisco AP Name.................................... CISCO_AP3500
...
Spectrum Management Information
        Spectrum Management Capable.............. Yes
        Spectrum Management Admin State.......... Enabled
        Spectrum Management Operation State...... Up
        Rapid Update Mode........................ Disabled
        Spectrum Expert connection............... Disabled
       Spectrum Sensor State................. Configured (Error code = 0)
```

Note See Step 7 in the "Using the GUI to Configure Cisco CleanAir on an Access Point" section for descriptions of the spectrum management operation states and the possible error codes for the spectrum sensor state.

Monitoring the Interference Devices

This section describes how to monitor the interference devices of the 802.11a/n and 802.11b/g/n radio bands using the controller GUI or CLI.

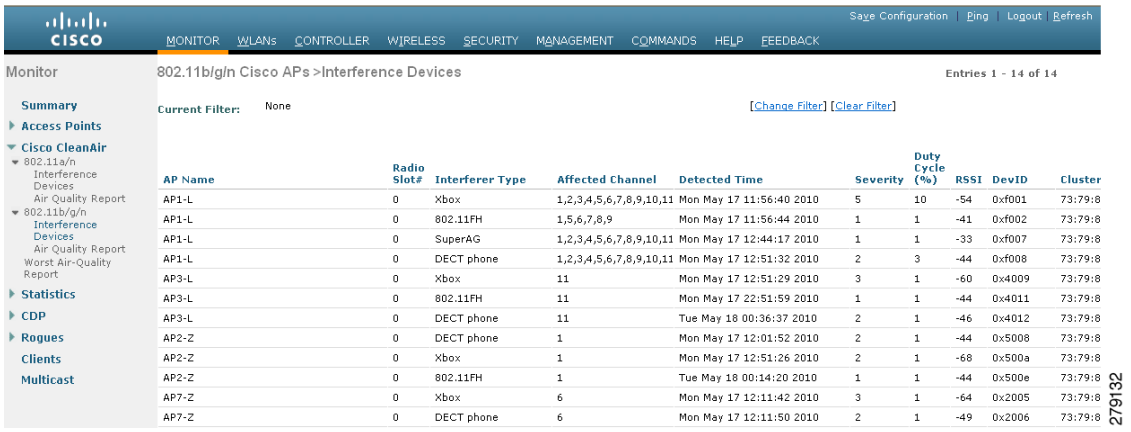
Note Only Cisco Aironet 3500 series access point radios can be configured for Cisco CleanAir.

Using GUI to Monitor the Interference Device

To monitor the interference devices using the controller GUI, follow these steps:

Step 1 Choose **Monitor > Cisco CleanAir > 802.11a/n** or **802.11b/g > Interference Devices** to open the CleanAir > Interference Devices page see (Figure 12-4).

Figure 12-4 CleanAir > Interference Device Page



This page shows the following information:

- AP Name—The name of the access point where the interference device is detected.
- Radio Slot #—Slot where the radio is installed.
- Interferer Type—Type of the interferer.
- Affected Channel—Channel that the device affects.
- Detected Time—Time at which the interference was detected.
- Severity—Severity index of the interfering device.
- Duty Cycle (%)—Proportion of time during which the interfering device was active.
- RSSI—Receive signal strength indicator (RSSI) of the access point.
- DevID—Device identification number that uniquely identified the interfering device.
- ClusterID—Cluster identification number that uniquely identifies the type of the devices.

  When a CleanAir-enabled access point detects interference devices, detections of the same device from multiple sensors are merged together to create clusters. Each cluster is given a unique ID. Some devices conserve power by limiting the transmit time until actually needed which results in the

spectrum sensor to temporarily stop detecting the device. This device is then correctly marked as down. A down device is correctly removed from the spectrum database. In cases when all the interferer detections for a specific devices are reported, the cluster ID is kept alive for an extended period of time to prevent possible device detection bouncing. If the same device is detected again, it is merged with the original cluster ID and the device detection history is preserved.

For example, some bluetooth headsets operate on battery power. These devices employ methods to reduce power consumption, such as turning off the transmitter when not actually needed. Such devices can appear to come and go from the classification. To manage these devices, CleanAir keeps the cluster IDs longer and they are remerged into a single record upon detection. This process smoothens the user records and accurately represents the device history.

Step 2 Click **Change Filter** to display the information about interference devices based on a particular criteria.

Step 3 Click **Clear Filter** to remove the filter and display the entire access point list.

You can create a filter to display the list of interference devices that are based on the following filtering parameters:

- Cluster ID—To filter based on the Cluster ID, select the check box and enter the Cluster ID in the text box next to this field.
- AP Name—To filter based on the access point name, select the check box and enter the access point name in the text box next to this field.
- Interferer Type—To filter based on the type of the interference device, select the check box and select the interferer device from the options.

  Select one of the interferer devices:

  - BT Link
  - MW Oven
  - 802.11 FH
  - BT Discovery
  - TDD Transmit
  - Jammer
  - Continuous TX
  - DECT Phone
  - Video Camera
  - 802.15.4
  - WiFi Inverted
  - WiFi Inv. Ch
  - SuperAG
  - Canopy
  - XBox
  - WiMax Mobile
  - WiMax Fixed
  - WiFi ACI
  - Unclassified
- Activity Channels

- Severity
- Duty Cycle (%)
- RSSI

Step 4 Click **Find** to commit your changes.

The current filter parameters are displayed in the Current Filter field.

Using the CLI to Monitor the Interference Device

Use these commands to monitor the interference devices for the 802.11a/n or 802.11b/g/n radio band.

- See information for all of the interferers detected by a specific access point on the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show {**802.11a** | **802.11b**} **cleanair device ap** *Cisco_AP*

  Information similar to the following appears:

```
DC = Duty Cycle (%)
ISI = Interference Severity Index (1-Low Interference, 100-High Interference)
RSSI  = Received Signal Strength Index (dBm)
DevID = Device ID

No  ClusterID          DevID  Type       AP Name      ISI  RSSI  DC   Channel
--- ------------------ ------ ---------- ---------- ---- ----- ---- -------------
1   c2:f7:40:00:00:03  0x8001 DECT phone CISCO_AP3500 1    -43   3   149,153,157,161
2   c2:f7:40:00:00:51  0x8002 Radar      CISCO_AP3500 1    -81   2   153,157,161,165
3   c2:f7:40:00:00:03  0x8005 Canopy     CISCO_AP3500 2    -62   2   153,157,161,165
```

  When a CleanAir-enabled access point detects interference devices, detections of the same device from multiple sensors are merged together to create clusters. Each cluster is given a unique ID. Some devices conserve power by limiting the transmit time until actually needed which results in the spectrum sensor to temporarily stop detecting the device. This device is then correctly marked as down. A down device is correctly removed from the spectrum database. In cases when all the interferer detections for a specific devices are reported, the cluster ID is kept alive for an extended period of time to prevent possible device detection bouncing. If the same device is detected again, it is merged with the original cluster ID and the device detection history is preserved.

  For example, some bluetooth headsets operate on battery power. These devices employ methods to reduce power consumption, such as turning off the transmitter when not actually needed. Such devices can appear to come and go from the classification. To manage these devices, CleanAir keeps the cluster IDs longer and they are remerged into a single record upon detection. This process smoothens the user records and accurately represents the device history.

- See information for all of the interferers of a specific device type on the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show {**802.11a** | **802.11b**} **cleanair device type** *type*

  Information similar to the following appears:

```
DC = Duty Cycle (%)
ISI = Interference Severity Index (1-Low Interference, 100-High Interference)
RSSI  = Received Signal Strength Index (dBm)
DevID = Device ID
  * indicates cluster center device

No  ClusterID          DevID  Type         AP Name     ISI  RSSI DC   Channel
--- ------------------ ------ ------------ ----------- ---- ----- --- -------------
1   b4:f7:40:00:00:03 0x4185 DECT-like (26) CISCO_AP35001  -58   3  153,157,161,165
```

- View a list of persistent sources of interference for a specific access point on the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show ap auto-rf {**802.11a** | **802.11b**} *Cisco_AP*

  Information similar to the following appears:

```
Number Of Slots.................................. 2
AP Name.......................................... AP1-L
MAC Address...................................... c4:7d:4f:3a:07:1e
  Slot ID........................................ 1
  Radio Type..................................... RADIO_TYPE_80211a
  Sub-band Type.................................. All
  Noise Information
    Noise Profile................................ PASSED
    Channel 34..................................  -97 dBm
    Channel 36..................................  -90 dBm
    Channel 38..................................  -97 dBm
Interference Information
    Interference Profile......................... PASSED
    Channel 34................................... -128 dBm @  0 % busy
    Channel 36................................... -128 dBm @  0 % busy
    Channel 38................................... -128 dBm @  0 % busy
    Channel 40................................... -128 dBm @  0 % busy
Load Information
    Load Profile................................. PASSED
    Receive Utilization.......................... 0 %
    Transmit Utilization......................... 0 %
    Channel Utilization.......................... 0 %
    Attached Clients............................. 0 clients
  Coverage Information
    Coverage Profile............................. PASSED
    Failed Clients............................... 0 clients
  Client Signal Strengths
    RSSI -100 dbm................................ 0 clients
    RSSI  -92 dbm................................ 0 clients
    RSSI  -84 dbm................................ 0 clients
Client Signal To Noise Ratios
    SNR    0 dB.................................. 0 clients
    SNR    5 dB.................................. 0 clients
    SNR   10 dB.................................. 0 clients
    SNR   15 dB.................................. 0 clients
Nearby APs
    AP c4:7d:4f:52:cf:a0 slot 1..................  -36 dBm on 149 (10.10.10.27)
    AP c4:7d:4f:53:1b:50 slot 1..................  -10 dBm on 149 (10.10.10.27)
Radar Information
  Channel Assignment Information
    Current Channel Average Energy............... unknown
    Previous Channel Average Energy.............. unknown
    Channel Change Count......................... 0
Last Channel Change Time..................... Mon May 17 11:56:32 2010
    Recommended Best Channel..................... 149
  RF Parameter Recommendations
    Power Level.................................. 7
    RTS/CTS Threshold............................ 2347
    Fragmentation Tnreshold...................... 2346
    Antenna Pattern.............................. 0

  Persistent Interference Devices
  Classtype Channel DC (%) RSSI (dBM) Last Update Time
---------------  -------  ------  ----------  -----------------------
  Canopy    149       4    -63           Tue May 18 03:21:16 2010
  All third party trademarks are the property of their respective owners.
```

Monitoring the Air Quality of Radio Bands

This section describes how to monitor the air quality of the 802.11a/n and 802.11b/g/n radio bands using the controller GUI or CLI.

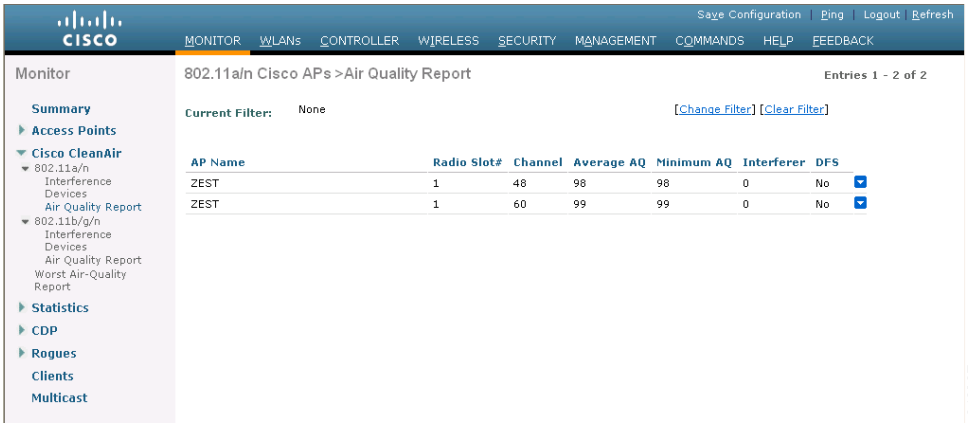
Note Cisco WCS shows all of the reports related to Cisco CleanAir functionality. If you want to view all reports, use WCS and see the *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to Monitor the Air Quality of Radio Bands

To monitor the air quality of radio bands using the controller GUI, follow these steps:

Step 1 Choose **Monitor > Cisco CleanAir > 802.11a/n or 802.11b/g >Air Quality Report** to open the CleanAir > Air Quality Report page see (Figure 12-5).

Figure 12-5 CleanAir > AIr Quality Report Page



This page shows the air quality of both the 802.11a/n and 802.11b/g/n radio bands. Specifically, it shows the following information:

- **AP Name**—The name of the access point that reported the worst air quality for the 802.11a/n or 802.11b/g/n radio band.
- Radio Slot—The slot number where the radio is installed.
- **Channel**—The radio channel where the air quality is monitored.
- **Minimum AQ**—The minimum air quality for this radio channel.
- **Average AQ**—The average air quality for this radio channel.
- **Interferer**—The number of interferers detected by the radios on the 802.11a/n or 802.11b/g/n radio band.
- DFS—Dynamic Frequency Selection. This indicates if DFS is enabled or not.

Using the CLI to Monitor the Air Quality of Radio Bands

Use these commands to monitor the air quality of the 802.11a/n or 802.11b/g/n radio band:

- See a summary of the air quality for the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show {802.11a | 802.11b} cleanair air-quality summary

  Information similar to the following appears:

```
AQ = Air Quality
DFS = Dynamic Frequency Selection

AP Name          Channel  Avg AQ  Min AQ  Interferers DFS
---------------- -------- ------- ------- ------------ ----
CISCO_AP3500      36         95      70       0
CISCO_AP3500      40         93      75       0
CISCO_AP3500      44         95      80       0
CISCO_AP3500      48         97      75       0
CISCO_AP3500      52         98      80       0
...
```

- See information for the 802.11a/n or 802.11b/g/n access point with the air quality by entering this command:

  show {802.11a | 802.11b} cleanair air-quality

  Information similar to the following appears:

```
AQ = Air Quality
DFS = Dynamic Frequency Selection

AP Name          Channel  Avg AQ    Min AQ  Interferers  DFS
---------------- --------- -------- --------- ------------ ------
CISCO_AP3500       1       83       57          3          5
```

- See air quality information for a specific access point on the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show {802.11a | 802.11b} cleanair air-quality *Cisco_AP*

  Information similar to the following appears:

```
Slot Channel Avg AQ  Min AQ  Total Power (dBm) Total Duty Cycle (%)
---- ------- ------- ------  ----------------- --------------------
1    140       100     100         -89                0

Interferer Power (dBm) Interferer Duty Cycle (%) Interferers DFS
---------------------- ------------------------- ----------- ---
-128                        0                         0
```

Using the GUI to Monitor the Worst Air Quality of Radio Bands

To monitor the air quality of the 802.11a/n and 802.11b/g/n radio bands using the controller GUI, follow these steps:

Step 1 Choose **Monitor > Cisco CleanAir > 802.11b/g >Worst Air-Quality** to open the CleanAir > Worst Air Quality Report page (see Figure 12-6).

Figure 12-6 CleanAir > Worst Air Quality Report Page

This page shows the air quality of both the 802.11a/n and 802.11b/g/n radio bands. Specifically, it shows the following information:

- **AP Name**—The name of the access point that reported the worst air quality for the 802.11a/n or 802.11b/g/n radio band.
- **Channel Number**—The radio channel with the worst reported air quality.
- **Minimum Air Quality Index(1 to 100)**—The minimum air quality for this radio channel. An air quality index (AQI) value of 100 is the best, and 1 is the worst.
- **Average Air Quality Index(1 to 100)**—The average air quality for this radio channel. An air quality index (AQI) value of 100 is the best, and 1 is the worst.
- **Interference Device Count**—The number of interferers detected by the radios on the 802.11a/n or 802.11b/g/n radio band.

Step 2 View a list of persistent sources of interference for a specific access point radio as follows:

a. **Choose Wireless > Access Points > Radios > 802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

b. Hover your cursor over the blue drop-down arrow for the desired access point radio and click **CleanAir-RRM**. The 802.11a/n (or 802.11b/g/n) Cisco APs > *Access Point Name* > Persistent Devices page appears. This page lists the device types of persistent sources of interference detected by this access point radio. It also shows the channel on which the interference was detected, the percentage of time that the interferer was active (duty cycle), the received signal strength (RSSI) of the interferer, and the day and time when the interferer was last detected.

Using the CLI to Monitor the Worst Air Quality of Radio Bands

Use these commands to monitor the air quality of the 802.11a/n or 802.11b/g/n radio band:

- See a summary of the air quality for the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show {802.11a | 802.11b} cleanair air-quality summary

  Information similar to the following appears:

```
AQ = Air Quality
DFS = Dynamic Frequency Selection

AP Name        Channel  Avg AQ  Min AQ  Interferers DFS
-------------- -------- ------- ------- ------------ ----
CISCO_AP3500    36         95      70       0
CISCO_AP3500    40         93      75       0
CISCO_AP3500    44         95      80       0
CISCO_AP3500    48         97      75       0
CISCO_AP3500    52         98      80       0
...
```

- See information for the 802.11a/n or 802.11b/g/n access point with the worst air quality by entering this command:

  show {802.11a | 802.11b} cleanair air-quality worst

  Information similar to the following appears:

```
AQ = Air Quality
DFS = Dynamic Frequency Selection

AP Name        Channel  Avg AQ    Min AQ  Interferers  DFS
-------------- --------- -------- --------- ------------ ------
CISCO_AP3500       1       83       57          3          5
```

- See air quality information for a specific access point on the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show {802.11a | 802.11b} cleanair air-quality *Cisco_AP*

  Information similar to the following appears:

```
Slot Channel Avg AQ  Min AQ  Total Power (dBm) Total Duty Cycle (%)
---- ------- ------- ------  ----------------- --------------------
1    140       100     100         -89                0

Interferer Power (dBm) Interferer Duty Cycle (%) Interferers DFS
---------------------- ------------------------- ----------- ---
-128                       0                          0
```

- See information for all of the interferers detected by a specific access point on the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show {802.11a | 802.11b} cleanair device ap *Cisco_AP*

  Information similar to the following appears:

```
DC = Duty Cycle (%)
ISI = Interference Severity Index (1-Low Interference, 100-High Interference)
RSSI  = Received Signal Strength Index (dBm)
DevID = Device ID

No  ClusterID           DevID  Type       AP Name      ISI  RSSI  DC   Channel
--- ------------------ ------ ---------- ------------ ---- ----- ---- -------------
1   c2:f7:40:00:00:03  0x8001 DECT phone CISCO_AP3500 1    -43   3   149,153,157,161
2   c2:f7:40:00:00:51  0x8002 Radar      CISCO_AP3500 1    -81   2   153,157,161,165
3   c2:f7:40:00:00:03  0x8005 Canopy     CISCO_AP3500 2    -62   2   153,157,161,165
```

- See information for all of the interferers of a specific device type on the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show {802.11a | 802.11b} cleanair device type *type*

  where *type* is one of the following:

- **802.11-fh—**An 802.11 frequency-hopping device (802.11b/g/n only)
- **802.11-inv**—A device using spectrally inverted Wi-Fi signals
- **802.11-nonstd**—A device using nonstandard Wi-Fi channels
- **802.15.4**—An 802.15.4 device (802.11b/g/n only)
- **all**—All interference device types (this is the default value)
- **bt-discovery**—A bluetooth discovery (802.11b/g/n only)
- **bt-link**—A bluetooth link (802.11b/g/n only)
- **canopy**—A canopy device
- **cont-tx**—A continuous transmitter
- **dect-like**—A digital enhanced cordless communication (DECT)-compatible phone
- **jammer**—A jamming device
- **mw-oven—**A microwave oven (802.11b/g/n only)
- **radar**—A radar device (802.11a/n only)
- **superag**—An 802.11 SuperAG device
- **tdd-tx**—A time division duplex (TDD) transmitter
- **video camera**—An analog video camera
- **wimax-fixed**—A WiMAX fixed device
- **wimax-mobile**—A WiMAX mobile device
- **xbox**—A Microsoft Xbox (802.11b/g/n only)

Information similar to the following appears:

```
DC = Duty Cycle (%)
ISI = Interference Severity Index (1-Low Interference, 100-High Interference)
RSSI  = Received Signal Strength Index (dBm)
DevID = Device ID
  * indicates cluster center device

No  ClusterID          DevID  Type        AP Name     ISI  RSSI DC   Channel
--- ----------------- ------ ------------ ----------- ---- ----- --- --------------
1   b4:f7:40:00:00:03 0x4185 DECT-like (26) CISCO_AP35001  -58   3  153,157,161,165
```

- See a list of persistent sources of interference for a specific access point on the 802.11a/n or 802.11b/g/n radio band by entering this command:

  show ap auto-rf {**802.11a** | **802.11b**} *Cisco_AP*

  Information similar to the following appears:

```
Number Of Slots.................................. 2
AP Name.......................................... CISCO_AP3500
...
Persistent Interferers
  Classtype                  Channel  DC (%)  RSSI (dBm)  Last Update Time
  -------------------------  -------  ------  ----------  -------------------------
    802.11FH                  149     3       -58         Thu Jan 1 00:20:34 2009
    Radar                     153     2       -81         Thu Jan 1 00:20:35 2009
    Continuous Transmitter    157     2       -62         Thu Jan 1 00:20:36 2009
    ...
    All third party trademarks are the property of their respective owners.
```

Configuring a Spectrum Expert Connection

To obtain detailed spectrum data that can be used to generate RF analysis plots similar to those provided by a spectrum analyzer, you can configure a Cisco CleanAir-enabled access point to connect directly to a Microsoft Windows XP or Vista PC running the Spectrum Expert application (referred to as a *Spectrum Expert console*). You can initiate the Spectrum Expert connection semi-automatically from WCS or by manually launching it from the controller. This section provides instructions for the latter.

Note See the *Wireless Control System Configuration Guide, Release 7.0.172.0,* for information on initiating a Spectrum Expert connection using WCS.

Note Spectrum Expert (Windows XP laptop client) and AP should be pingable, otherwise; it will not work.

To configure a Spectrum Expert, follow these steps:

Step 1 Prior to establishing a connection between the Spectrum Expert console and the access point, make sure that IP address routing is properly configured and the network spectrum interface (NSI) ports are open in any intervening firewalls.

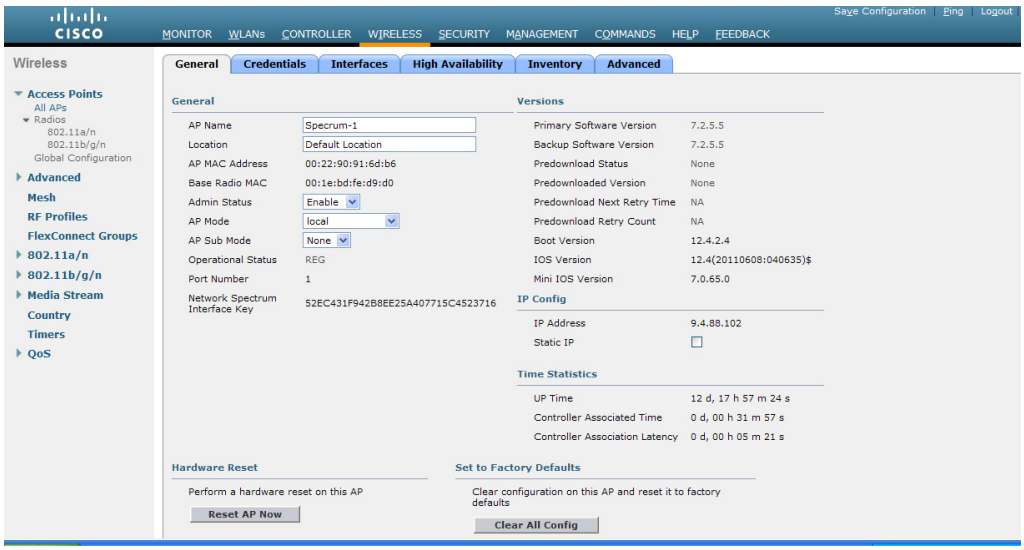
Step 2 Make sure that Cisco CleanAir functionality is enabled for the access point that will be connected to the Spectrum Expert console.

Step 3 Configure the access point for SE-Connect mode using the controller GUI or CLI.

Note The SE-Connect mode is set for the entire access point, not just a single radio. However, the Spectrum Expert console connects to a single radio at a time.

- If you are using the controller GUI, follow these steps:
  a. Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.
  b. Click the name of the desired access point to open the All APs > Details for page (see Figure 12-7).

Figure 12-7 All APs > Details For Spectrum



c. Choose **SE-Connect** from the AP Mode drop-down list. This mode is available only for access points that are capable of supporting Cisco CleanAir functionality. For the SE-Connect mode to appear as an available option, the access point must have at least one spectrum-capable radio in the Enable state.

d. Click **Apply** to commit your changes.

e. Click **OK** when prompted to reboot the access point.

- If you are using the controller CLI, follow these steps:

a. To configure the access point for SE-Connect mode, enter this command:

config ap mode se-connect *Cisco_AP*

b. When prompted to reboot the access point, enter **Y.**

c. To verify the SE-Connect configuration status for the access point, enter this command:

show ap config {**802.11a** | **802.11b**} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 0
Cisco AP Name.................................... CISCO_AP3500
...
Spectrum Management Information
        Spectrum Management Capable.............. Yes
        Spectrum Management Admin State.......... Enabled
        Spectrum Management Operation State...... Up
        Rapid Update Mode........................ Disabled
        Spectrum Expert connection.............. Enabled
       Spectrum Sensor State.................. Configured (Error code = 0)
```

Step 4 On the Windows PC, access the Cisco Software Center from this URL:

http://www.cisco.com/cisco/software/navigator.html?a=a&i=rpm

Step 5 Click **Product > Wireless > Cisco Spectrum Intelligence > Cisco Spectrum Expert > Cisco Spectrum Expert Wi-Fi**, and then download the Spectrum Expert 4.0 executable (*.exe) file.

Step 6 Run the Spectrum Expert application on the PC.

Step 7 When the Connect to Sensor dialog box appears, enter the IP address of the access point, choose the access point radio, and enter the 16-byte network spectrum interface (NSI) key to authenticate. The Spectrum Expert application opens a TCP/IP connection directly to the access point using the NSI protocol.

Note The access point must be a TCP server listening on ports 37540 for 2.4 GHz and 37550 for 5 GHz frequencies. These ports must be opened for the spectrum expert application to connect to the access point using the NSI protocol.

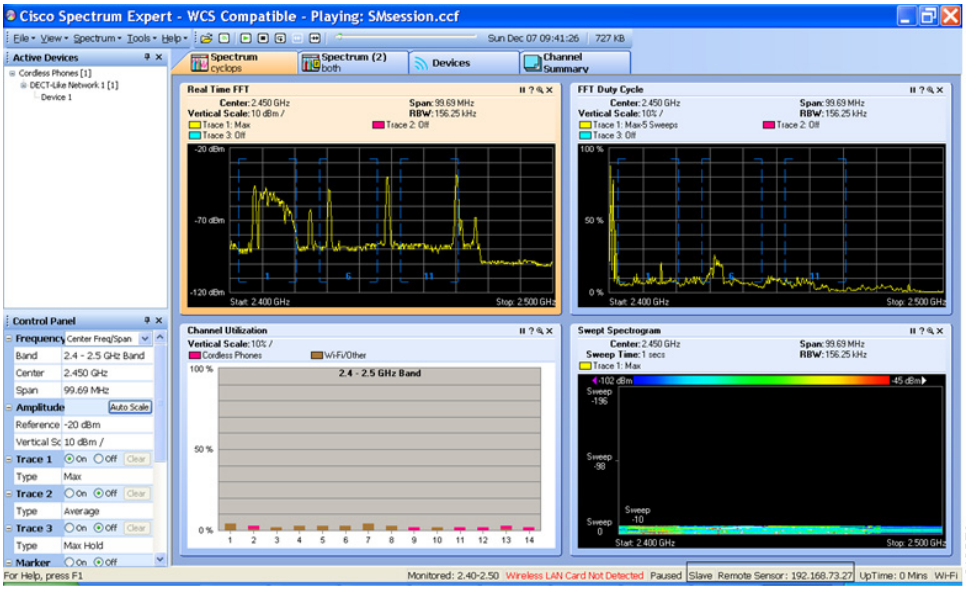
Note On the controller GUI, the NSI key appears in the Network Spectrum Interface Key field (below the Port Number field) on the All APs > Details for page. To view the NSI key from the controller CLI, enter the **show** {**802.11a** | **802.11b**} **spectrum se-connect** *Cisco_AP command.* This parameter is shown only for CleanAir capable access points for only Local, HREAP, and SE Connected mode.

When an access point in SE-Connect mode joins a controller, it sends a Spectrum Capabilities notification message, and the controller responds with a Spectrum Configuration Request. The request contains the 16-byte random NSI key generated by the controller for use in NSI authentication. The controller generates one key per access point, which the access point stores until it is rebooted.

Note You can establish up to three Spectrum Expert console connections per access point radio. The Number of Spectrum Expert Connections text box on the 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page of the controller GUI shows the number of Spectrum Expert applications that are currently connected to the access point radio.

Step 8 Verify that the Spectrum Expert console is connected to the access point by selecting the Slave Remote Sensor text box in the bottom right corner of the Spectrum Expert application (see Figure 12-8). If the two devices are connected, the IP address of the access point appears in this text box.

Figure 12-8 Spectrum Expert Application



Step 9 Use the Spectrum Expert application to view and analyze spectrum data from the access point.

Note See the *Cisco Spectrum Expert Users Guide, Release 4.0,* for information on using the Spectrum Expert application.

CHAPTER 13

Configuring Radio Resource Management

This chapter describes radio resource management (RRM) and explains how to configure it on the controllers. It contains these sections:

Overview of Radio Resource Management

The Radio Resource Management (RRM) software embedded in the controller acts as a built-in RF engineer to consistently provide real-time RF management of your wireless network. RRM enables controllers to continually monitor their associated lightweight access points for the following information:

- Traffic load—The total bandwidth used for transmitting and receiving traffic. It enables wireless LAN managers to track and plan network growth ahead of client demand.
- Interference—The amount of traffic coming from other 802.11 sources.
- Noise—The amount of non-802.11 traffic that is interfering with the currently assigned channel.
- Coverage—The received signal strength (RSSI) and signal-to-noise ratio (SNR) for all connected clients.
- Other —The number of nearby access points.

Using this information, RRM can periodically reconfigure the 802.11 RF network for best efficiency. To do this, RRM performs these functions:

- Radio resource monitoring
- Transmit power control

- Dynamic channel assignment
- Coverage hole detection and correction

Note The OEAP 600 series access points do not support RRM. The radios for the 600 series OEAP access points are controlled through the local GUI of the 600 series access points and not through the wireless LAN controller. Attempting to control the spectrum channel or power, or disabling the radios through the controller will fail to have any effect on the 600 series OEAP.

Radio Resource Monitoring

RRM automatically detects and configures new controllers and lightweight access points as they are added to the network. It then automatically adjusts associated and nearby lightweight access points to optimize coverage and capacity.

Lightweight access points can simultaneously scan all valid 802.11a/b/g channels for the country of operation as well as for channels available in other locations. The access points go “off-channel” for a period not greater than 60 ms to monitor these channels for noise and interference. Packets collected during this time are analyzed to detect rogue access points, rogue clients, ad-hoc clients, and interfering access points.

Note In the presence of voice traffic (in the last 100 ms), the access points defer off-channel measurements.

Each access point spends only 0.2 percent of its time off-channel. This activity is distributed across all access points so that adjacent access points are not scanning at the same time, which could adversely affect wireless LAN performance.

Note When there are numerous rogue access points in the network, the chance of detecting rogues on channels 157 or 161 by a hybrid-REAP or local mode access point is small. In such cases, the monitor mode AP can be used for rogue detection.

Transmit Power Control

The controller dynamically controls access point transmit power based on real-time wireless LAN conditions. Typically, power can be kept low to gain extra capacity and reduce interference. The controller attempts to balance the access points’ transmit power according to how the access points are seen by their third strongest neighbor.

The transmit power control (TPC) algorithm both increases and decreases an access point’s power in response to changes in the RF environment. In most instances, TPC seeks to lower an access point's power to reduce interference, but in the case of a sudden change in the RF coverage—for example, if an access point fails or becomes disabled—TPC can also increase power on surrounding access points. This feature is different from coverage hole detection, which is primarily concerned with clients. TPC provides enough RF power to achieve desired coverage levels while avoiding channel interference between access points.

Note See Step 7 on page 13-36 for an explanation of the transmit power levels.

Dynamic Channel Assignment

Two adjacent access points on the same channel can cause either signal contention or signal collision. In a collision, data is not received by the access point. This functionality can become a problem, for example, when someone reading e-mail in a café affects the performance of the access point in a neighboring business. Even though these are completely separate networks, someone sending traffic to the café on channel 1 can disrupt communication in an enterprise using the same channel. Controllers can dynamically allocate access point channel assignments to avoid conflict and to increase capacity and performance. Channels are "reused" to avoid wasting scarce RF resources. In other words, channel 1 is allocated to a different access point far from the café, which is more effective than not using channel 1 altogether.

The controller's dynamic channel assignment (DCA) capabilities are also useful in minimizing adjacent channel interference between access points. For example, two overlapping channels in the 802.11b/g band, such as 1 and 2, cannot both simultaneously use 11/54 Mbps. By effectively reassigning channels, the controller keeps adjacent channels separated.

Note We recommend that you use only non-overlapping channels (1,6,11, and so on).

The controller examines a variety of real-time RF characteristics to efficiently handle channel assignments as follows:

- Access point received energy—The received signal strength measured between each access point and its nearby neighboring access points. Channels are optimized for the highest network capacity.
- Noise—Noise can limit signal quality at the client and access point. An increase in noise reduces the effective cell size and degrades user experience. By optimizing channels to avoid noise sources, the controller can optimize coverage while maintaining system capacity. If a channel is unusable due to excessive noise, that channel can be avoided.
- 802.11 Interference—Interference is any 802.11 traffic that is not part of your wireless LAN, including rogue access points and neighboring wireless networks. Lightweight access points constantly scan all channels looking for sources of interference. If the amount of 802.11 interference exceeds a predefined configurable threshold (the default is 10 percent), the access point sends an alert to the controller. Using the RRM algorithms, the controller may then dynamically rearrange channel assignments to increase system performance in the presence of the interference. Such an adjustment could result in adjacent lightweight access points being on the same channel, but this setup is preferable to having the access points remain on a channel that is unusable due to an interfering foreign access point.

  In addition, if other wireless networks are present, the controller shifts the usage of channels to complement the other networks. For example, if one network is on channel 6, an adjacent wireless LAN is assigned to channel 1 or 11. This arrangement increases the capacity of the network by limiting the sharing of frequencies. If a channel has virtually no capacity remaining, the controller may choose to avoid this channel. In very dense deployments in which all nonoverlapping channels are occupied, the controller does its best, but you must consider RF density when setting expectations.
- Utilization—When utilization monitoring is enabled, capacity calculations can consider that some access points are deployed in ways that carry more traffic than other access points (for example, a lobby versus an engineering area). The controller can then assign channels to improve the access point with the worst performance reported.

- Load—The load is taken into account when changing the channel structure to minimize the impact on clients currently in the wireless LAN. This metric keeps track of every access point's transmitted and received packet counts to determine how busy the access points are. New clients avoid an overloaded access point and associate to a new access point. This parameter is disabled by default.

The controller combines this RF characteristic information with RRM algorithms to make system-wide decisions. Conflicting demands are resolved using soft-decision metrics that guarantee the best choice for minimizing network interference. The end result is optimal channel configuration in a three-dimensional space, where access points on the floor above and below play a major factor in an overall wireless LAN configuration.

In controller software releases prior to 5.1, only radios using 20-MHz channels are supported by DCA. In controller software release 5.1 or later releases, DCA is extended to support 802.11n 40-MHz channels in the 5-GHz band. 40-MHz channelization allows radios to achieve higher instantaneous data rates (potentially 2.25 times higher than 20-MHz channels). In controller software release 5.1 or later releases, you can choose if DCA works at 20 or 40 MHz.

Note Radios using 40-MHz channels in the 2.4-GHz band are not supported by DCA.

The RRM startup mode is invoked in the following conditions:

- In a single-controller environment, the RRM startup mode is invoked after the controller is rebooted.
- In a multiple-controller environment, the RRM startup mode is invoked after an RF Group leader is elected.

RRM startup mode runs for 100 minutes (10 iterations at 10-minute intervals). The duration of the RRM startup mode is independent of the DCA interval, sensitivity, and network size. The startup mode consists of 10 DCA runs with high sensitivity (making channel changes easy and sensitive to the environment) to converge to a steady state channel plan. After the startup mode is finished, DCA continues to run at the specified interval and sensitivity.

Coverage Hole Detection and Correction

The RRM coverage hole detection algorithm can detect areas of radio coverage in a wireless LAN that are below the level needed for robust radio performance. This feature can alert you to the need for an additional (or relocated) lightweight access point.

If clients on a lightweight access point are detected at threshold levels (RSSI, failed client count, percentage of failed packets, and number of failed packets) lower than those specified in the RRM configuration, the access point sends a "coverage hole" alert to the controller. The alert indicates the existence of an area where clients are continually experiencing poor signal coverage, without having a viable access point to which to roam. The controller discriminates between coverage holes that can and cannot be corrected. For coverage holes that can be corrected, the controller mitigates the coverage hole by increasing the transmit power level for that specific access point. The controller does not mitigate coverage holes caused by clients that are unable to increase their transmit power or are statically set to a power level because increasing their downstream transmit power might increase interference in the network.

Note While transmit power control and DCA can operate in multiple-controller environments (based on RF domains), coverage hole detection is performed on a per-controller basis. In controller software release 5.2 or later releases, you can disable coverage hole detection on a per-WLAN basis. See the "Disabling Coverage Hole Detection per WLAN" section on page 7-67 for more information.

RRM Benefits

RRM produces a network with optimal capacity, performance, and reliability. It frees you from having to continually monitor the network for noise and interference problems, which can be transient and difficult to troubleshoot. RRM ensures that clients enjoy a seamless, trouble-free connection throughout the Cisco unified wireless network.

RRM uses separate monitoring and control for each deployed network: 802.11a and 802.11b/g. The RRM algorithms run separately for each radio type (802.11a and 802.11b/g). RRM uses both measurements and algorithms. RRM measurements can be adjusted using monitor intervals, but they cannot be disabled. RRM algorithms are enabled automatically but can be disabled by statically configuring channel and power assignment. The RRM algorithms run at a specified updated interval, which is 600 seconds by default.

Overview of RF Groups

An RF group is a logical collection of controllers that coordinate to perform RRM in a globally optimized manner to perform network calculations on a per-radio basis. An RF group exists for each 802.11 network type. Clustering controllers into a single RF group enable the RRM algorithms to scale beyond the capabilities of a single controller.

Lightweight access points periodically send out neighbor messages over the air. Access points using the the same RF group name validate messages from each other.

When access points on different controllers hear validated neighbor messages at a signal strength of –80 dBm or stronger, the controllers dynamically form an RF neighborhood in auto mode. In static mode, the leader is manually selected and the members are added to the RF Group. To know more about RF Group modes, see "RF Group Leader" section on page 13-6.

Note RF groups and mobility groups are similar in that they both define clusters of controllers, but they are different in terms of their use. An RF group facilitates scalable, system-wide dynamic RF management while a mobility group facilitates scalable, system-wide mobility and controller redundancy. See Chapter 14, "Configuring Mobility Groups," for more information on mobility groups.

RF Grouping Support for Controllers and Access Points

Controller software release 4.2.99.0 or later releases support up to 20 controllers and 1000 access points in an RF group. For example, a Cisco WiSM controller supports up to 150 access points, so you can have up to 6 WiSM controllers in an RF group (150 access points x 6 controllers = 900 access points, which is less than 1000). Similarly, a 4404 controller supports up to 100 access points, so you can have up to ten (10) 4404 controllers in an RF group (100 x 10 = 1000). The Cisco 2100 Series Controller supports a maximum of 25 access points, so you can have up to 20 of these controllers in an RF group.

Note In controller software release 4.2.61.0 or earlier releases, RRM supports no more than five Cisco 4400 Series Controllers in an RF group.

Starting in the 7.0.116.0 release, the RF group members are added based on the following criteria:

- Maximum number of APs Supported: The maximum limit for the number of access points in an RF group is 1000. The number of access points supported is determined by the number of APs licensed to operate on the controller.
- Twenty controllers: Only 20 controllers (including the leader) can be part of an RF group if the sum of the access points of all controllers combined is less than or equal to the upper access point limit.

RF Group Leader

Starting in the 7.0.116.0 release, the RF Group Leader can be configured in two ways as follows:

- Auto Mode—In this mode, the members of an RF group elect an RF group leader to maintain a "master" power and channel scheme for the group. The RF grouping algorithm dynamically chooses the RF group leader and ensures that an RF group leader is always present. Group leader assignments can and do change (for instance, if the current RF group leader becomes inoperable or if RF group members experience major changes).
- Static Mode—In this mode, the user selects a controller as an RF group leader manually. In this mode, the leader and the members are manually configured and are therefore fixed. If the members are unable to join the RF group, the reason is indicated. The leader tries to establish a connection with a member every 1 minute if the member has not joined in the previous attempt.

The RF group leader analyzes real-time radio data collected by the system, calculates the power and channel assignments, and sends them to each of the controllers in the RF group. The RRM algorithms ensure system-wide stability and restrain channel and power scheme changes to the appropriate local RF neighborhoods.

In controller software releases prior to 6.0, the dynamic channel assignment (DCA) search algorithm attempts to find a good channel plan for the radios associated to controllers in the RF group, but it does not adopt a new channel plan unless it is considerably better than the current plan. The channel metric of the worst radio in both plans determines which plan is adopted. Using the worst-performing radio as the single criterion for adopting a new channel plan can result in pinning or cascading problems.

Pinning occurs when the algorithm could find a better channel plan for some of the radios in an RF group but is prevented from pursuing such a channel plan change because the worst radio in the network does not have any better channel options. The worst radio in the RF group could potentially prevent other radios in the group from seeking better channel plans. The larger the network, the more likely pinning becomes.

Cascading occurs when one radio's channel change results in successive channel changes to optimize the remaining radios in the RF neighborhood. Optimizing these radios could lead to their neighbors and their neighbors' neighbors having a suboptimal channel plan and triggering their channel optimization. This effect could propagate across multiple floors or even multiple buildings, if all the access point radios belong to the same RF group. This change results in considerable client confusion and network instability.

The main cause of both pinning and cascading is the way in which the search for a new channel plan is performed and that any potential channel plan changes are controlled by the RF circumstances of a single radio. In controller software release 6.0, the DCA algorithm has been redesigned to prevent both pinning and cascading. The following changes have been implemented:

- Multiple local searches—The DCA search algorithm performs multiple local searches initiated by different radios within the same DCA run rather than performing a single global search driven by a single radio. This change addresses both pinning and cascading while maintaining the desired flexibility and adaptability of DCA and without jeopardizing stability.

- Multiple channel plan change initiators (CPCIs)—Previously, the single worst radio was the sole initiator of a channel plan change. Now each radio within the RF group is evaluated and prioritized as a potential initiator. Intelligent randomization of the resulting list ensures that every radio is eventually evaluated, which eliminates the potential for pinning.
- Limiting the propagation of channel plan changes (Localization)—For each CPCI radio, the DCA algorithm performs a local search for a better channel plan, but only the CPCI radio itself and its one-hop neighboring access points are actually allowed to change their current transmit channels. The impact of an access point triggering a channel plan change is felt only to within two RF hops from that access point, and the actual channel plan changes are confined to within a one-hop RF neighborhood. Because this limitation applies across all CPCI radios, cascading cannot occur.
- Non-RSSI-based cumulative cost metric—A cumulative cost metric measures how well an entire region, neighborhood, or network performs with respect to a given channel plan. The individual cost metrics of all access points in that area are considered in order to provide an overall understanding of the channel plan's quality. These metrics ensure that the improvement or deterioration of each single radio is factored into any channel plan change. The objective is to prevent channel plan changes in which a single radio improves but at the expense of multiple other radios experiencing a considerable performance decline.

The RRM algorithms run at a specified updated interval, which is 600 seconds by default. Between update intervals, the RF group leader sends keepalive messages to each of the RF group members and collects real-time RF data.

Note Several monitoring intervals are also available. See the "Configuring RRM" section on page 13-10 for details.

RF Group Name

A controller is configured with an RF group name, which is sent to all access points joined to the controller and used by the access points as the shared secret for generating the hashed MIC in the neighbor messages. To create an RF group, you configure all of the controllers to be included in the group with the same RF group name.

If there is any possibility that an access point joined to a controller may hear RF transmissions from an access point on a different controller, you should configure the controllers with the same RF group name. If RF transmissions between access points can be heard, then system-wide RRM is recommended to avoid 802.11 interference and contention as much as possible.

Configuring an RF Group

This section describes how to configure RF groups through either the GUI or the CLI.

Note The RF group name is generally set at deployment time through the Startup Wizard. However, you can change it as necessary.

Note When the multiple-country feature is being used, all controllers intended to join the same RF group must be configured with the same set of countries, configured in the same order.

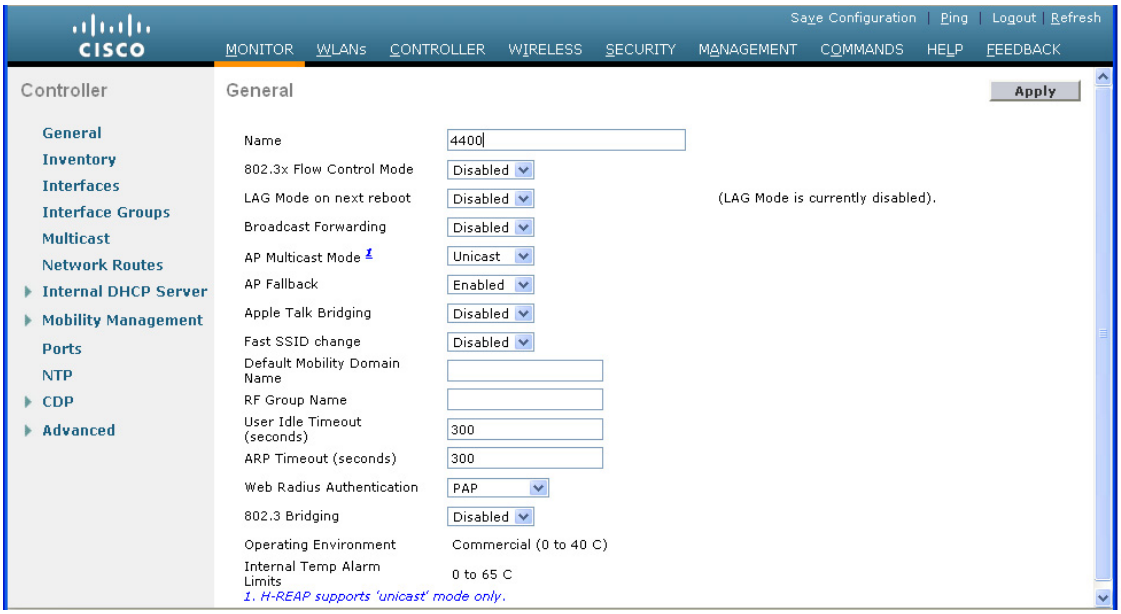
Note You can also configure RF groups using the Cisco Wireless Control System (WCS). See the *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to Configure an RF Group Name

To create an RF group name using the controller GUI, follow these steps:

Step 1 Choose **Controller** > **General** to open the General page (see Figure 13-1).

Figure 13-1 General Page



Step 2 Enter a name for the RF group in the RF-Network Name text box. The name can contain up to 19 ASCII characters.

Step 3 Click **Apply** to commit your changes.

Step 4 Click **Save Configuration** to save your changes.

Step 5 Repeat this procedure for each controller that you want to include in the RF group.

Using the CLI to Configure an RF Group Name

To configure an RF group name using the controller CLI, follow these steps:

Step 1 Create an RF group by entering the **config network rf-network-name** *name* command:

Note Enter up to 19 ASCII characters for the group name.

Step 2 See the RF group by entering the **show network** command.

Step 3 Save your settings by entering the **save config** command.

Step 4 Repeat this procedure for each controller that you want to include in the RF group.

Viewing the RF Group Status

This section describes how to view the status of the RF group through either the GUI or the CLI.

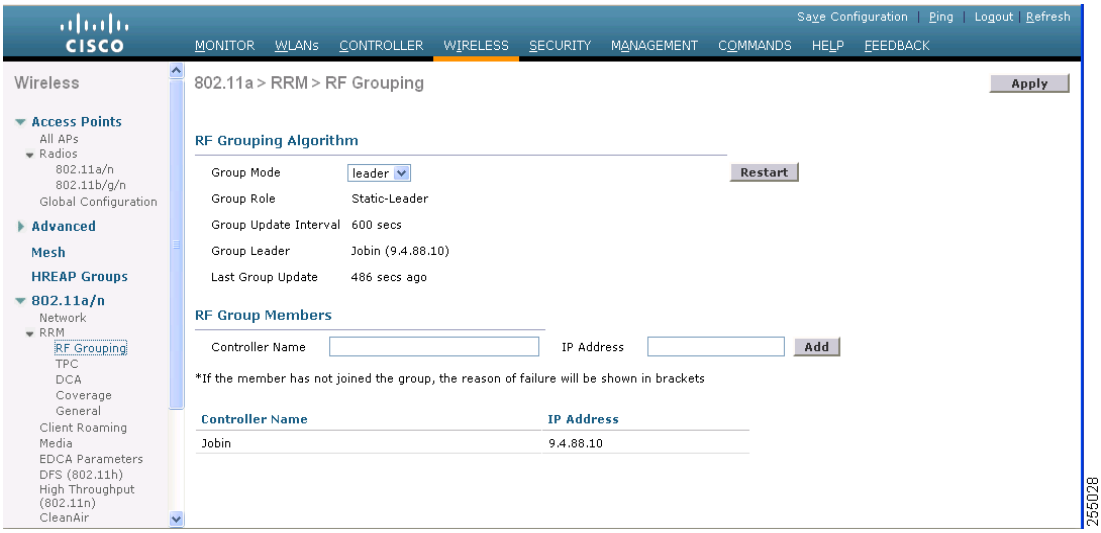
Note You can also view the status of RF groups using the Cisco Wireless Control System (WCS). See *Cisco Wireless Control System Configuration Guide* for instructions.

Using the GUI to View RF Group Status

To view the status of the RF group using the controller GUI, follow these steps:

Step 1 Choose **Wireless > 802.11a/n** or **802.11b/g/n > RRM > RF Grouping** to open the 802.11a (or 802.11b/g) RRM > RF Grouping page (see Figure 13-2).

Figure 13-2 802.11a > RRM > RF Grouping Page



This page shows the details of the RF group, displaying the configurable parameter **RF Group mode**, the **RF Group role** of this controller, the **Update Interval** and the controller name and IP address of the **Group Leader** to this controller.

Note RF grouping mode can be set using the **Group Mode** drop-down. See the "Using the GUI to Configure RF Group Mode" section on page 13-11 for more information on this parameter.

Tip Once a controller has joined as a static member and you want to change the grouping mode, we recommend that you remove the member from the configured static-leader and also make sure that a member controller has not been configured to be a member on multiple static leaders. This is to avoid repeated join attempts from one or more RF static leaders.

Step 2 (Optional) Repeat this procedure for the network type that you did not select (802.11a or 802.11b/g).

Using the CLI to View RF Group Status

To view the RF group status using the controller CLI, follow these steps:

Step 1 See which controller is the RF group leader for the 802.11a RF network by entering this command:

show advanced 802.11a group

Information similar to the following appears:

```
Radio RF Grouping
  802.11a Group Mode.............................. STATIC
  802.11a Group Update Interval................... 600 seconds
  802.11a Group Leader............................ test (209.165.200.225)
    802.11a Group Member.......................... test (209.165.200.225)
  802.11a Last Run................................ 397 seconds ago
```

This output shows the details of the RF group, specifically the grouping mode for the controller, how often the group information is updated (600 seconds by default), the IP address of the RF group leader, the IP address of this controller, and the last time the group information was updated.

Note If the IP addresses of the group leader and the group member are identical, this controller is currently the group leader.

Note A * indicates that the controller has not joined as a static member.

Step 2 See which controller is the RF group leader for the 802.11b/g RF network by entering this command:

show advanced 802.11b group

Configuring RRM

The controller's preconfigured RRM settings are optimized for most deployments. However, you can modify the controller's RRM configuration parameters at any time through either the GUI or the CLI.

Note You can configure these parameters on controllers that are part of an RF group or on controllers that are not part of an RF group.

Note The RRM parameters should be set to the same values on every controller in an RF group. The RF group leader can change as a result of controller reboots or depending on which radios hear each other. If the RRM parameters are not identical for all RF group members, varying results can occur when the group leader changes.

Configuring RRM

Using the controller GUI, you can configure the following RRM parameters: RF group mode, transmit power control, dynamic channel assignment, coverage hole detection, profile thresholds, monitoring channels, and monitor intervals.

Using the GUI to Configure RF Group Mode

To configure RF group mode using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **RF Grouping** to open the 802.11a (or 802.11b/g) RRM > RF Grouping page (see Figure 13-2).

Step 2 From the **Group Mode** drop-down box, select the mode you want to configure for this controller.

You can configure RF grouping in the following modes:

- auto—Sets the RF group selection to automatic update mode.
- leader—Sets the RF group selection to static mode, and sets this controller as the group leader.
- off—Sets the RF group selection off. Every controller optimizes its own access point parameters.

Note A configured static leader cannot become a member of another controller until its mode is set to "auto".

Note A controller with a lower priority cannot assume the role of a group leader if a controller with a higher priority is available. Here priority is related to the processing power of the controller.

Note We recommend that controllers participate in automatic RF grouping. You can override RRM settings without disabling automatic RF group participation. See the "Overriding RRM" section on page 13-32 for instructions.

Step 3 Click **Restart** to restart RRM RF Grouping algorithm.

Step 4 If you configured RF Grouping mode for this controller as a static leader, you can add group members from the RF Group Members section as follows:

a. In the Controller Name text box, enter the controller that you want to add as a member to this group.

b. In the IP Address text box, enter the IP address of the controller.

c. Click **Add Member** to add the member to this group.

Note If the member has not joined the static leader, the reason of the failure is shown in parentheses.

To know more about the number of access points and controllers you can add as members, see "RF Grouping Support for Controllers and Access Points" section on page 13-5.

Step 5 Click **Apply** to save your changes.

Using the CLI to Configure the RF Group Mode

To configure the RF Group mode using the CLI, follow these steps:

Step 1 Configure the RF Grouping mode by entering this command:

config advanced {802.11a | 802.11b} group-mode {auto | leader| off | restart}

- auto—Sets the RF group selection to automatic update mode.
- leader—Sets the RF group selection to static mode, and sets this controller as the group leader.
- off—Sets the RF group selection off. Every controller optimizes its own access point parameters.
- restart—Restarts the RF group selection.

Note A configured static leader cannot become a member of another controller until its mode is set to "auto".

Note A controller with a lower priority cannot assume the role of a group leader if a controller with higher priority is available. Here priority is related to the processing power of the controller.

Step 2 Add or remove a controller as a static member of the RF group (if the mode is set to "leader") by entering the these commands:

- **config advanced {802.11a | 802.11 b} group-member add** *controller_name controller_ip_address*
- **config advanced {802.11a | 802.11 b}** group-member remove controller_name *controller_ip_address*

Step 3 To see RF grouping status, by entering these commands:

show advanced {802.11 a | 802.11 b} group

Using the GUI to Configure Transmit Power Control

To configure transmit power control settings using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **TPC** to open the 802.11a (or 802.11b/g) > RRM > Tx Power Control (TPC) page.

Step 2 Choose one of the following options from the Power Level Assignment Method drop-down list to specify the controller's dynamic power assignment mode:

- **Automatic**—Causes the controller to periodically evaluate and, if necessary, update the transmit power for all joined access points. This is the default value.
- **On Demand**—Causes the controller to periodically evaluate the transmit power for all joined access points. However, the controller updates the power, if necessary, only when you click **Invoke Power Update Now**.

Note The controller does not evaluate and update the transmit power immediately after you click **Invoke Power Update Now**. It waits for the next 600-second interval. This value is not configurable.

- **Fixed**—Prevents the controller from evaluating and, if necessary, updating the transmit power for joined access points. The power level is set to the fixed value chosen from the drop-down list.

Note The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. See Step 7 on page 13-36 for information on available transmit power levels.

Note For optimal performance, we recommend that you use the Automatic setting. See the "Disabling Dynamic Channel and Power Assignment Globally for a Controller" section on page 13-39 for instructions if you need to disable the controller's dynamic channel and power settings.

Step 3 Enter the maximum and minimum power level assignment values in the Maximum Power Level Assignment and Minimum Power Level Assignment text boxes.

The range for the Maximum Power Level Assignment is -10 to 30 dBm.

The range for the Minimum Power Level Assignment is -10 to 30 dBm.

Step 4 In the Power Threshold text box, enter the cutoff signal level used by RRM when determining whether to reduce an access point's power. The default value for this parameter is –70 dBm but can be changed when access points are transmitting at higher (or lower) than desired power levels.

The range for this parameter is –80 to –50 dBm. Increasing this value (between –65 and –50 dBm) causes the access points to operate at higher transmit power rates. Decreasing the value has the opposite effect.

In applications with a dense population of access points, it may be useful to decrease the threshold to –80 or –75 dBm to reduce the number of BSSIDs (access points) and beacons seen by the wireless clients. Some wireless clients might have difficulty processing a large number of BSSIDs or a high beacon rate and might exhibit problematic behavior with the default threshold.

This page also shows the following nonconfigurable transmit power level parameter settings:

- Power Neighbor Count—The minimum number of neighbors an access point must have for the transmit power control algorithm to run.
- Power Assignment Leader—The MAC address of the RF group leader, which is responsible for power level assignment.
- **L**ast Power Level Assignmen**t**—The last time RRM evaluated the current transmit power level assignments.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Off-Channel Scanning Defer

In deployments with certain power-save clients, you sometimes need to defer RRM's normal off-channel scanning to avoid missing critical information from low-volume clients (for example, medical devices that use power-save mode and periodically send telemetry information). This feature improves the way that QoS interacts with the RRM scan defer feature.

You can use a client's WMM UP marking to configure the access point to defer off-channel scanning for a configurable period of time if it receives a packet marked UP.

Off-Channel Scanning Defer is essential to the operation of RRM, which gathers information about alternate channel choices such as noise and interference. Additionally, Off-Channel Scanning Defer is responsible for rogue detection. Devices that need to defer Off-Channel Scanning Defer should use the same WLAN as often as possible. If there are many of these devices (and the possibility exists that Off-Channel Defer scanning could be completely disabled by the use of this feature), you should implement an alternative to local AP Off-Channel Scanning Defer, such as monitor access points, or other access points in the same location that do not have this WLAN assigned.

Assignment of a QoS policy (bronze, silver, gold, and platinum) to a WLAN affects how packets are marked on the downlink connection from the access point regardless of how they were received on the uplink from the client. UP=1,2 is the lowest priority, and UP=0,3 is the next higher priority. The marking results of each QoS policy are as follows:

- Bronze marks all downlink traffic to UP= 1.
- Silver marks all downlink traffic to UP= 0.
- Gold marks all downlink traffic to UP=4.
- Platinum marks all downlink traffic to UP=6.

Using the GUI to Configure Off-Channel Scanning Defer for a WLAN

To configure Off-Channel Scanning Defer for a WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN to which you want to configure off-channel scanning Defer.

Step 3 Choose the **Advanced** tab from the WLANs > Edit page.

Step 4 From the Off Channel Scanning Defer section, set the **Scan Defer Priority** by clicking on the priority argument.

Step 5 Set the time in milliseconds in the Scan Defer Time text box.

Valid values are 100 through 60000. The default value is 100 milliseconds.

Step 6 Click **Apply** to save your configuration.

Using the CLI to Configure Off Channel Scanning Defer for a WLAN

To configure the controller to defer normal off-channel scanning for a WLAN using the controller CLI, follow these steps:

Step 1 Assign a defer-priority for the channel scan by entering this command:

config wlan channel-scan defer-priority priority [enable | disable] WLAN-id

The valid range for the priority argument is 0 to 7.

The priority is 0 to 7 (this value should be set to 6 on the client and on the WLAN).

Use this command to configure the amount of time that scanning will be deferred following an UP packet in the queue.

Step 2 Assign the channel scan defer time (in milliseconds) by entering this command:

config wlan channel-scan defer-time msec WLAN-id

The time value is in miliseconds (ms) and the valid range is 100 (default) to 60000 (60 seconds). This setting should match the requirements of the equipment on your wireless LAN.

You can also configure this feature on the controller GUI by selecting WLANs, and either edit an existing WLAN or create a new one.

Overriding the TPC Algorithm with Minimum and Maximum Transmit Power Settings

The TPC algorithm has undergone a major rework in this release and it should do an adequate job of balancing RF power in many diverse RF environments. However, it is possible that automatic power control will not be able to resolve some scenarios in which an adequate RF design was not possible to implement due to architectural restrictions or site restrictions—for example, when all access points must be mounted in a central hallway, placing the access points close together, but requiring coverage out to the edge of the building.

In these scenarios, you can configure maximum and minimum transmit power limits to override TPC recommendations. The maximum and minimum TPC power settings only apply to access points attached to a controller from which they are configured; it is not a global RRM command. The default settings essentially disable this feature, and you should use care when overriding TPC recommendations.

To set the Maximum Power Level Assignment and Minimum Power Level Assignment text boxes, enter the maximum and minimum transmit power used by RRM on the Tx Power Control page. The range for these parameters is -10 to 30 dBM. The minimum value cannot be greater than the maximum value; the maximum value cannot be less than the minimum value.

If you configure a maximum transmit power, RRM does not allow any access point attached to the controller to exceed this transmit power level (whether the power is set by RRM TPC or by coverage hole detection). For example, if you configure a maximum transmit power of 11 dBm, then no access point would transmit above 11 dBm, unless the access point is configured manually.

Using the GUI to Configure Dynamic Channel Assignment

To specify the channels that the dynamic channel assignment (DCA) algorithm considers when selecting the channels to be used for RRM scanning using the controller GUI, follow these steps:

Note This functionality is helpful when you know that the clients do not support certain channels because they are legacy devices or they have certain regulatory restrictions.

Step 1 Disable the 802.11a or 802.11b/g network as follows:

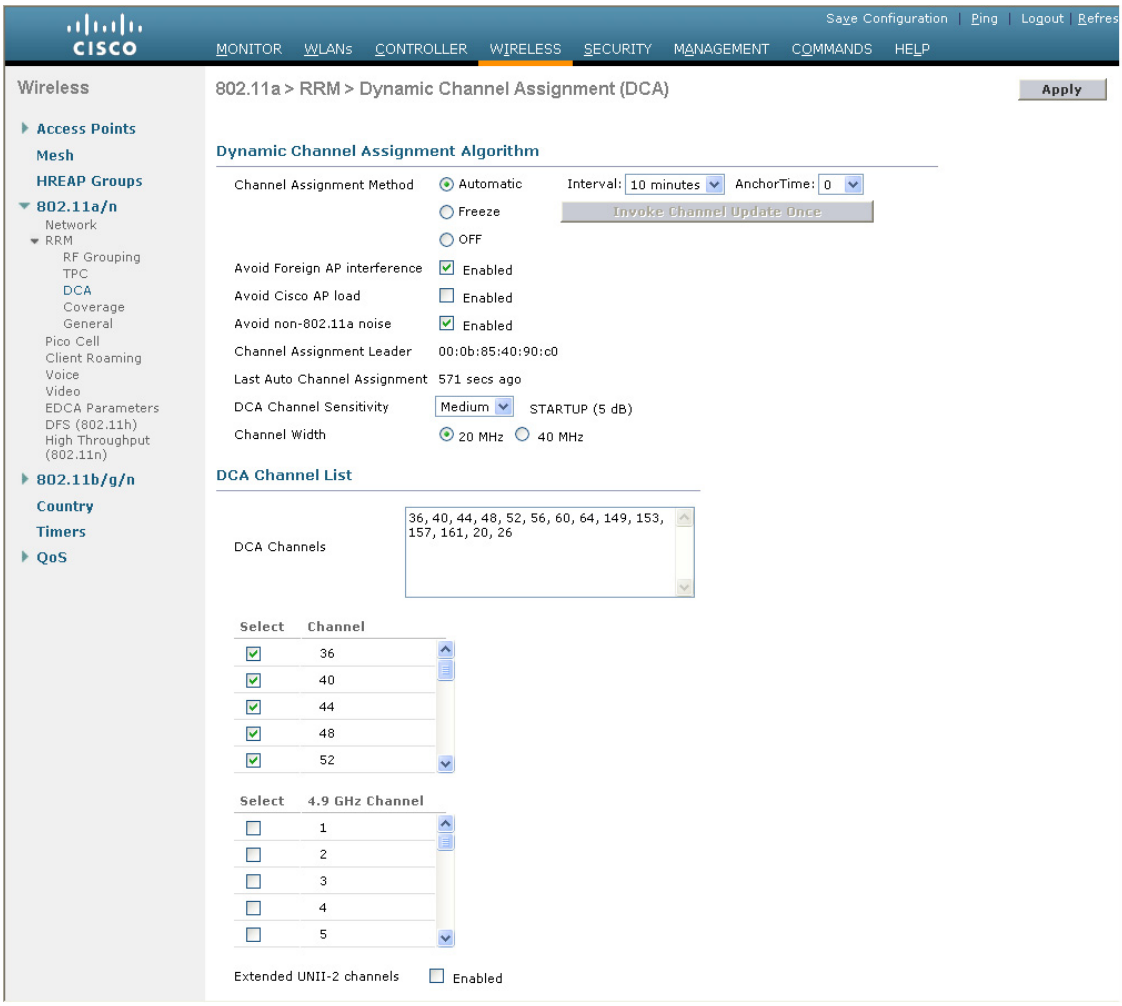
a. Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Unselect the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 2 Choose **Wireless > 802.11a/n** or **802.11b/g/n > RRM > DCA** to open the 802.11a (or 802.11b/g) > RRM > Dynamic Channel Assignment (DCA) page (see Figure 13-3).

Figure 13-3 802.11a > RRM > Dynamic Channel Assignment (DCA) Page



Step 3 Choose one of the following options from the Channel Assignment Method drop-down list to specify the controller's DCA mode:

- **Automatic**—Causes the controller to periodically evaluate and, if necessary, update the channel assignment for all joined access points. This is the default value.
- **Freeze**—Causes the controller to evaluate and update the channel assignment for all joined access points, if necessary, but only when you click **Invoke Channel Update Once**.

Note The controller does not evaluate and update the channel assignment immediately after you click **Invoke Channel Update Once**. It waits for the next interval to elapse.

- **OFF**—Turns off DCA and sets all access point radios to the first channel of the band, which is the default value. If you choose this option, you must manually assign channels on all radios.

Note For optimal performance, we recommend that you use the Automatic setting. See the "Disabling Dynamic Channel and Power Assignment Globally for a Controller" section on page 13-39 for instructions if you need to disable the controller's dynamic channel and power settings.

Step 4 From the Interval drop-down list, choose one of the following options to specify how often the DCA algorithm is allowed to run: **10 minutes**, **1 hour**, **2 hours**, **3 hours**, 4 hours, **6 hours**, **8 hours**, **12 hours**, or **24 hours**. The default value is 10 minutes.

Note If your controller supports only OfficeExtend access points, we recommend that you set the DCA interval to 6 hours for optimal performance. For deployments with a combination of OfficeExtend access points and local access points, the range of 10 minutes to 24 hours can be used.

Step 5 From the AnchorTime drop-down list, choose a number to specify the time of day when the DCA algorithm is to start. The options are numbers between 0 and 23 (inclusive) representing the hour of the day from 12:00 a.m. to 11:00 p.m.

Step 6 Select the **Avoid Foreign AP Interference** check box to cause the controller's RRM algorithms to consider 802.11 traffic from foreign access points (those not included in your wireless network) when assigning channels to lightweight access points, or unselect it to disable this feature. For example, RRM may adjust the channel assignment to have access points avoid channels close to foreign access points. The default value is selected.

Step 7 Select the **Avoid Cisco AP Load** check box to cause the controller's RRM algorithms to consider 802.11 traffic from Cisco lightweight access points in your wireless network when assigning channels, or unselect it to disable this feature. For example, RRM can assign better reuse patterns to access points that carry a heavier traffic load. The default value is unselected.

Step 8 Select the **Avoid Non-802.11a (802.11b) Noise** check box to cause the controller's RRM algorithms to consider noise (non-802.11 traffic) in the channel when assigning channels to lightweight access points, or unselect it to disable this feature. For example, RRM may have access points avoid channels with significant interference from nonaccess point sources, such as microwave ovens. The default value is selected.

Step 9 Select the **Avoid Persistent Non-WiFi Interference** check box to enable the controller to ignore persistent non-WiFi interference.

Step 10 From the DCA Channel Sensitivity drop-down list, choose one of the following options to specify how sensitive the DCA algorithm is to environmental changes such as signal, load, noise, and interference when determining whether to change channels:

- **Low**—The DCA algorithm is not particularly sensitive to environmental changes.
- **Medium**—The DCA algorithm is moderately sensitive to environmental changes.
- **High**—The DCA algorithm is highly sensitive to environmental changes.

The default value is Medium. The DCA sensitivity thresholds vary by radio band, as noted in Table 13-1.

Table 13-1 DCA Sensitivity Thresholds

Option	2.4-GHz DCA Sensitivity Threshold	5-GHz DCA Sensitivity Threshold
High	5 dB	5 dB
Medium	15 dB	20 dB
Low	30 dB	35 dB

Step 11 For 802.11a/n networks only, choose one of the following channel width options to specify the channel bandwidth supported for all 802.11n radios in the 5-GHz band:

- **20 MHz**—The 20-MHz channel bandwidth (default)

- **40 MHz**—The 40-MHz channel bandwidth

Note If you choose 40 MHz, be sure to choose at least two adjacent channels from the DCA Channel List in Step 13 (for example, a primary channel of 36 and an extension channel of 40). If you choose only one channel, that channel is not used for 40-MHz channel width.

Note If you choose 40 MHz, you can also configure the primary and extension channels used by individual access points. See the "Using the GUI to Statically Assign Channel and Transmit Power Settings" section on page 13-32 for configuration instructions.

Note To override the globally configured DCA channel width setting, you can statically configure an access point's radio for 20- or 40-MHz mode on the 802.11a/n Cisco APs > Configure page. if you then change the static RF channel assignment method to Global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using. It can take up to 30 minutes (depending on how often DCA is configured to run) for the change to take effect.

Note If you choose 40 MHz on the A radio, you cannot pair channels 116, 140, and 165 with any other channels.

This page also shows the following nonconfigurable channel parameter settings:

- Channel Assignment Leader—The MAC address of the RF group leader, which is responsible for channel assignment.
- Last Auto Channel Assignment—The last time RRM evaluated the current channel assignments.

Step 12 Select the **Avoid check for non-DFS channel** to enable the controller to avoid checks for non-DFS channels. DCA configuration requires at least one non-DFS channel in the list. In the EU countries, outdoor deployments do not support non-DFS channels. Customers based in EU or regions with similar regulations must enable this option or at least have one non-DFS channel in the DCA list even if the channel is not supported by the APs.

Note This parameter is applicable only for deployments having outdoor access points such as 1522 and 1524.

Step 13 In the DCA Channel List area, the DCA Channels text box shows the channels that are currently selected. To choose a channel, select its check box in the Select column. To exclude a channel, unselect its check box.

The ranges are as follows:
802.11a—36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140, 149, 153, 157, 161, 165, 190, 196
802.11b/g—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

The defaults are as follows:
802.11a—36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 132, 136, 140, 149, 153, 157, 161
802.11b/g—1, 6, 11

Note These extended UNII-2 channels in the 802.11a band do not appear in the channel list: 100, 104, 108, 112, 116, 132, 136, and 140. If you have Cisco Aironet 1520 series mesh access points in the -E regulatory domain, you must include these channels in the DCA channel list before you start operation. If you are upgrading from a previous release, verify that these channels are included in the DCA channel list. To include these channels in the channel list, select the **Extended UNII-2 Channels** check box.

Step 14 If you are using Cisco Aironet 1520 series mesh access points in your network, you need to set the 4.9-GHz channels in the 802.11a band on which they are to operate. The 4.9-GHz band is for public safety client access traffic only. To choose a 4.9-GHz channel, select its check box in the Select column. To exclude a channel, unselect its check box.

The ranges are as follows:
802.11a—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26

The defaults are as follows:
802.11a—20, 26

Step 15 Click **Apply** to commit your changes.

Step 16 Reenable the 802.11a or 802.11b/g network as follows:

a. Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Select the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 17 Click **Save Configuration** to save your changes.

Note To see why the DCA algorithm changed channels, choose **Monitor** and then choose **View All** under Most Recent Traps. The trap provides the MAC address of the radio that changed channels, the previous channel and the new channel, the reason why the change occurred, the energy before and after the change, the noise before and after the change, and the interference before and after the change.

Using the GUI to Configure Coverage Hole Detection

To enable coverage hole detection using the controller GUI, follow these steps:

Note In controller software release 5.2 or later releases, you can disable coverage hole detection on a per-WLAN basis. See the "Disabling Coverage Hole Detection per WLAN" section on page 7-67 for more information.

Step 1 Disable the 802.11a or 802.11b/g network as follows:

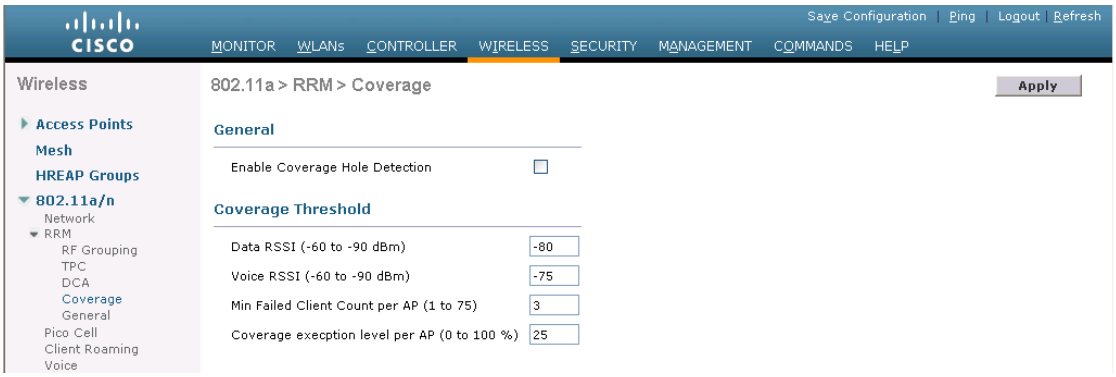
a. Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Unselect the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 2 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **Coverage** to open the 802.11a (or 802.11b/g) > RRM > Coverage page (see Figure 13-4).

Figure 13-4 802.11a > RRM > Coverage Page



Step 3 Select the **Enable Coverage Hole Detection** check box to enable coverage hole detection, or unselect it to disable this feature. If you enable coverage hole detection, the controller automatically determines, based on data received from the access points, if any access points have clients that are potentially located in areas with poor coverage. The default value is selected.

Step 4 In the Data RSSI text box, enter the minimum receive signal strength indication (RSSI) value for data packets received by the access point. The value that you enter is used to identify coverage holes (or areas of poor coverage) within your network. If the access point receives a packet in the data queue with an RSSI value below the value that you enter here, a potential coverage hole has been detected. The valid range is –90 to –60 dBm, and the default value is –80 dBm. The access point takes data RSSI measurements every 5 seconds and reports them to the controller in 90-second intervals.

Step 5 In the Voice RSSI text box, enter the minimum receive signal strength indication (RSSI) value for voice packets received by the access point. The value that you enter is used to identify coverage holes within your network. If the access point receives a packet in the voice queue with an RSSI value below the value that you enter here, a potential coverage hole has been detected. The valid range is –90 to –60 dBm, and the default value is –75 dBm. The access point takes voice RSSI measurements every 5 seconds and reports them to the controller in 90-second intervals.

Step 6 In the Min Failed Client Count per AP text box, enter the minimum number of clients on an access point with an RSSI value at or below the data or voice RSSI threshold. The valid range is 1 to 75, and the default value is 3.

Step 7 In the Coverage Exception Level per AP text box, enter the percentage of clients on an access point that are experiencing a low signal level but cannot roam to another access point. The valid range is 0 to 100%, and the default value is 25%.

Note If both the number and percentage of failed packets exceed the values configured for Failed Packet Count and Failed Packet Percentage (configurable through the controller CLI) for a 5-second period, the client is considered to be in a pre-alarm condition. The controller uses this information to distinguish between real and false coverage holes. False positives are generally due to the poor roaming logic implemented on most clients. A coverage hole is detected if both the number and percentage of failed clients meet or exceed the values entered in the Min Failed Client Count per AP and Coverage Exception Level per AP text boxes over a 90-second period. The controller determines if the coverage hole can be corrected and, if appropriate, mitigates the coverage hole by increasing the transmit power level for that specific access point.

Step 8 Click **Apply** to commit your changes.

Step 9 Reenable the 802.11a or 802.11b/g network as follows:

a. Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Select the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

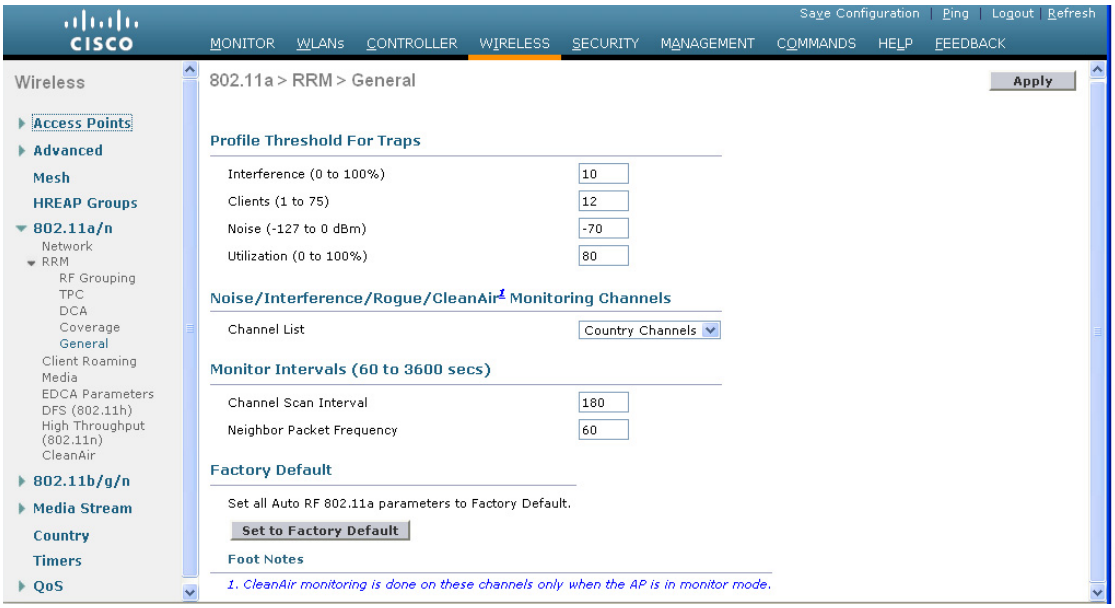
Step 10 Click **Save Configuration** to save your changes.

Using the GUI to Configure RRM Profile Thresholds, Monitoring Channels, and Monitor Intervals

To configure RRM profile thresholds, monitoring channels, and monitor intervals using the controller GUI, follow these steps:

Step 1 Choose **Wireless > 802.11a/n** or **802.11b/g/n > RRM > General** to open the 802.11a (or 802.11b/g) > RRM > General page (see Figure 13-5).

Figure 13-5 802.11a > RRM > General Page



Step 2 Configure profile thresholds used for alarming as follows:

Note The profile thresholds have no bearing on the functionality of the RRM algorithms. Lightweight access points send an SNMP trap (or an alert) to the controller when the values set for these threshold parameters are exceeded.

a. In the Interference text box, enter the percentage of interference (802.11 traffic from sources outside of your wireless network) on a single access point. The valid range is 0 to 100%, and the default value is 10%.

b. In the Clients text box, enter the number of clients on a single access point. The valid range is 1 to 75, and the default value is 12.

c. In the Noise text box, enter the level of noise (non-802.11 traffic) on a single access point. The valid range is –127 to 0 dBm, and the default value is –70 dBm.

d. In the Utilization text box, enter the percentage of RF bandwidth being used by a single access point. The valid range is 0 to 100%, and the default value is 80%.

Step 3 From the Channel List drop-down list, choose one of the following options to specify the set of channels that the access point uses for RRM scanning:

- **All Channels**—RRM channel scanning occurs on all channels supported by the selected radio, which includes channels not allowed in the country of operation.
- **Country Channels**—RRM channel scanning occurs only on the data channels in the country of operation. This is the default value.
- **DCA Channels**—RRM channel scanning occurs only on the channel set used by the DCA algorithm, which by default includes all of the non-overlapping channels allowed in the country of operation. However, you can specify the channel set to be used by DCA if desired. To do so, follow the instructions in the "Using the GUI to Configure Dynamic Channel Assignment" section on page 13-16.

Step 4 Configure monitor intervals as follows:

a. In the Channel Scan Interval text box, enter (in seconds) the sum of the time between scans for each channel within a radio band. The entire scanning process takes 50 ms per channel, per radio and runs at the interval configured here. The time spent listening on each channel is determined by the non-configurable 50-ms scan time and the number of channels to be scanned. For example, in the U.S. all 11 802.11b/g channels are scanned for 50 ms each within the default 180-second interval. So every 16 seconds, 50 ms is spent listening on each scanned channel (180/11 = ~16 seconds). The Channel Scan Interval parameter determines the interval at which the scanning occurs.The valid range is 60 to 3600 seconds, and the default value is 60 seconds for 802.11a radios and 180 seconds for the 802.11b/g radios.

Note If your controller supports only OfficeExtend access points, we recommend that you set the channel scan interval to 1800 seconds for optimal performance. For deployments with a combination of OfficeExtend access points and local access points, the range of 60 to 3600 seconds can be used.

b. In the Neighbor Packet Frequency text box, enter (in seconds) how frequently neighbor packets (messages) are sent, which eventually builds the neighbor list. The valid range is 60 to 3600 seconds, and the default value is 60 seconds.

Note If your controller supports only OfficeExtend access points, we recommend that you set the neighbor packet frequency to 600 seconds for optimal performance. For deployments with a combination of OfficeExtend access points and local access points, the range of 60 to 3600 seconds can be used.

Note In controller software release 4.1.185.0 or later releases, if the access point radio does not receive a neighbor packet from an existing neighbor within 60 minutes, the controller deletes that neighbor from the neighbor list. In controller software releases prior to 4.1.185.0, the controller waits only 20 minutes before deleting an unresponsive neighbor radio from the neighbor list.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Note Click **Set to Factory Default** if you want to return all of the controller's RRM parameters to their factory-default values.

Using the CLI to Configure RRM

To configure RRM using the controller CLI, follow these steps:

Step 1 Disable the 802.11a or 802.11b/g network by entering this command:

config {802.11a | 802.11b} disable network

Step 2 Perform one of the following to configure transmit power control:

- To have RRM automatically set the transmit power for all 802.11a or 802.11b/g radios at periodic intervals, enter this command:

  config {802.11a | 802.11b} txPower global auto

- To have RRM automatically reset the transmit power for all 802.11a or 802.11b/g radios one time, enter this command:

  config {802.11a | 802.11b} txPower global once

- To configure the transmit power range that overrides the Transmit Power Control algorithm, use this command to enter the maximum and minimum transmit power used by RRM:

  config {802.11a | 802.11b} txPower global {max | min} *txpower*

  where *txpower* is a value from –126 to 126 dBM. The minimum value cannot be greater than the maximum value; the maximum value cannot be less than the minimum value.

  If you configure a maximum transmit power, RRM does not allow any access point to exceed this transmit power (whether the maximum is set at RRM startup, or by coverage hole detection). For example, if you configure a maximum transmit power of 11 dBm, then no access point would transmit above 11 dBm, unless the access point is configured manually.

- To manually change the default transmit power setting of –70 dBm, enter this command:

  config advanced {802.11a | 802.11b} tx-power-control-thresh *threshold*

  where *threshold* is a value from –80 to –50 dBm. Increasing this value (between –65 and –50 dBm) causes the access points to operate at higher transmit power rates. Decreasing the value has the opposite effect.

  In applications with a dense population of access points, it may be useful to decrease the threshold to –80 or –75 dBm in order to reduce the number of BSSIDs (access points) and beacons seen by the wireless clients. Some wireless clients may have difficulty processing a large number of BSSIDs or a high beacon rate and may exhibit problematic behavior with the default threshold.

Step 3 Perform one of the following to configure dynamic channel assignment (DCA):

- To have RRM automatically configure all 802.11a or 802.11b/g channels based on availability and interference, enter this command:

  config {802.11a | 802.11b} channel global auto

- To have RRM automatically reconfigure all 802.11a or 802.11b/g channels one time based on availability and interference, enter this command:

  config {802.11a | 802.11b} channel global once

- To disable RRM and set all channels to their default values, enter this command:

  config {802.11a | 802.11b} channel global off

- To specify the channel set used for DCA, enter this command:

  config advanced {802.11a | 802.11b} channel {add | delete} *channel_number*

  You can enter only one channel number per command. This command is helpful when you know that the clients do not support certain channels because they are legacy devices or they have certain regulatory restrictions.

Step 4 Configure additional DCA parameters by entering these commands:

- **config advanced {802.11a | 802.11b} channel dca anchor-time** *value*—Specifies the time of day when the DCA algorithm is to start. *valu*e is a number between 0 and 23 (inclusive) representing the hour of the day from 12:00 a.m. to 11:00 p.m.

- **config advanced** {**802.11a** | **802.11b**} **channel dca interval** *value*—Specifies how often the DCA algorithm is allowed to run. *valu*e is one of the following: 1, 2, 3, 4, 6, 8, 12, or 24 hours or 0, which is the default value of 10 minutes (or 600 seconds).

Note If your controller supports only OfficeExtend access points, we recommend that you set the DCA interval to 6 hours for optimal performance. For deployments with a combination of OfficeExtend access points and local access points, the range of 10 minutes to 24 hours can be used.

- **config advanced** {**802.11a** | **802.11b**} **channel dca sensitivity** {**low** | **medium** | **high**}—Specifies how sensitive the DCA algorithm is to environmental changes such as signal, load, noise, and interference when determining whether to change channel.
  - **low** means that the DCA algorithm is not particularly sensitive to environmental changes.
  - **medium** means that the DCA algorithm is moderately sensitive to environmental changes.
  - **high** means that the DCA algorithm is highly sensitive to environmental changes.

  The DCA sensitivity thresholds vary by radio band, as noted in Table 13-2.

Table 13-2 DCA Sensitivity Thresholds

Option	2.4-GHz DCA Sensitivity Threshold	5-GHz DCA Sensitivity Threshold
High	5 dB	5 dB
Medium	15 dB	20 dB
Low	30 dB	35 dB

- **config advanced 802.11a channel dca chan-width-11n** {**20** | **40**}—Configures the DCA channel width for all 802.11n radios in the 5-GHz band.

  where
  - **20** sets the channel width for 802.11n radios to 20 MHz. This is the default value.
  - **40** sets the channel width for 802.11n radios to 40 MHz.

Note If you choose 40, be sure to set at least two adjacent channels in the **config advanced 802.11a channel** {**add** | **delete**} *channel_number* command in Step 3 (for example, a primary channel of 36 and an extension channel of 40). If you set only one channel, that channel is not used for 40-MHz channel width.

Note If you choose 40, you can also configure the primary and extension channels used by individual access points. See the "Using the CLI to Statically Assign Channel and Transmit Power Settings" section on page 13-37 for configuration instructions.

Note To override the globally configured DCA channel width setting, you can statically configure an access point's radio for 20- or 40-MHz mode using the **config 802.11a chan_width** *Cisco_AP* {**20** | **40**} command. if you then change the static configuration to global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using. It can take up to 30 minutes (depending on how often DCA is configured to run) for the change to take effect.

- **config advanced {802.11a | 802.11b} channel outdoor-ap-dca {enable | disable}**—Enables or disables to the controller to avoid checks for non-DFS channels.

Note This parameter is applicable only for deployments having outdoor access points such as 1522 and 1524.

- **config advanced** {**802.11a** | **802.11b**} **channel foreign** {**enable** | **disable**}—Enables or disables foreign access point interference avoidance in the channel assignment.
- **config advanced** {**802.11a** | **802.11b**} **channel load** {**enable** | **disable**}—Enables or disables load avoidance in the channel assignment.
- **config advanced** {**802.11a** | **802.11b**} **channel noise** {**enable** | **disable**}—Enables or disables noise avoidance in the channel assignment.
- **config advanced** {**802.11a** | **802.11b**} **channel update**—Initiates an update of the channel selection for every Cisco access point.

Step 5 Configure coverage hole detection by entering these commands:

Note In controller software release 5.2 or later releases, you can disable coverage hole detection on a per-WLAN basis. See the "Disabling Coverage Hole Detection per WLAN" section on page 7-67 for more information.

- **config advanced** {**802.11a** | **802.11b**} **coverage** {**enable** | **disable**}—Enables or disables coverage hole detection. If you enable coverage hole detection, the controller automatically determines, based on data received from the access points, if any access points have clients that are potentially located in areas with poor coverage. The default value is enabled.
- **config advanced** {**802.11a** | **802.11b**} **coverage** {**data** | **voice**} **rssi-threshold** *rssi*—Specifies the minimum receive signal strength indication (RSSI) value for packets received by the access point. The value that you enter is used to identify coverage holes (or areas of poor coverage) within your network. If the access point receives a packet in the data or voice queue with an RSSI value below the value you enter here, a potential coverage hole has been detected. The valid range is –90 to –60 dBm, and the default value is –80 dBm for data packets and –75 dBm for voice packets. The access point takes RSSI measurements every 5 seconds and reports them to the controller in 90-second intervals.
- **config advanced** {**802.11a** | **802.11b**} **coverage level global** *clients*—Specifies the minimum number of clients on an access point with an RSSI value at or below the data or voice RSSI threshold. The valid range is 1 to 75, and the default value is 3.
- **config advanced** {**802.11a** | **802.11b**} **coverage exception global** *percent*—Specifies the percentage of clients on an access point that are experiencing a low signal level but cannot roam to another access point. The valid range is 0 to 100%, and the default value is 25%.

- **config advanced** {**802.11a** | **802.11b**} **coverage** {**data** | **voice**} **packet-count** *packets*—Specifies the minimum failure count threshold for uplink data or voice packets. The valid range is 1 to 255 packets, and the default value is 10 packets.
- **config advanced** {**802.11a** | **802.11b**} **coverage** {**data** | **voice**} **fail-rate** *percent*—Specifies the failure rate threshold for uplink data or voice packets. The valid range is 1 to 100%, and the default value is 20%.

Note If both the number and percentage of failed packets exceed the values entered in the **packet-count** and **fail-rate** commands for a 5-second period, the client is considered to be in a pre-alarm condition. The controller uses this information to distinguish between real and false coverage holes. False positives are generally due to the poor roaming logic implemented on most clients. A coverage hole is detected if both the number and percentage of failed clients meet or exceed the values entered in the **coverage level global** and **coverage exception global** commands over a 90-second period. The controller determines if the coverage hole can be corrected and, if appropriate, mitigates the coverage hole by increasing the transmit power level for that specific access point.

Step 6 Enable the 802.11a or 802.11b/g network by entering this command:

config {**802.11a** | **802.11b**} **enable network**

Note To enable the 802.11g network, enter **config 802.11b 11gSupport enable** after the **config 802.11b enable network** command.

Step 7 Save your settings by entering this command:

save config

Using the CLI to View RRM Settings

To see 802.11a and 802.11b/g RRM settings, use these commands:

show advanced {**802.11a** | **802.11b**} *?*

where *?* is one of the following:

- **ccx** {**global** | *Cisco_AP*}—Shows the CCX RRM configuration.

```
802.11a Client Beacon Measurements:
    disabled
```

- **channel**—Shows the channel assignment configuration and statistics.

```
Automatic Channel Assignment
  Channel Assignment Mode..................... ONCE
  Channel Update Interval..................... 600 seconds
  Anchor time (Hour of the day)............... 20
  Channel Update Count........................ 0
  Channel Update Contribution................. S.IU
  Channel Assignment Leader................... 00:0b:85:40:90:c0
  Last Run.................................... 532 seconds ago
  DCA Sensitivity Level....................... MEDIUM (20 dB)
  DCA 802.11n Channel Width................... 40 MHz
  Channel Energy Levels
```

```
    Minimum..................................... unknown
    Average..................................... unknown
    Maximum..................................... unknown
  Channel Dwell Times
    Minimum..................................... unknown
    Average..................................... unknown
    Maximum..................................... unknown
  Auto-RF Allowed Channel List.................. 36,40
  Auto-RF Unused Channel List................... 44,48,52,56,60,64,100,104,
    ..................................... 108,112,116,132,136,140,149,
    ..................................... 153,157,161,165,190,196
  DCA Outdoor AP option...................... Disabled
```

- **coverage**—Shows the coverage hole detection configuration and statistics.

```
Coverage Hole Detection
  802.11a Coverage Hole Detection Mode........... Enabled
  802.11a Coverage Voice Packet Count............ 10 packets
  802.11a Coverage Voice Packet Percentage....... 20%
  802.11a Coverage Voice RSSI Threshold.......... -75 dBm
  802.11a Coverage Data Packet Count............. 10 packets
  802.11a Coverage Data Packet Percentage........ 20%
  802.11a Coverage Data RSSI Threshold........... -80 dBm
  802.11a Global coverage exception level........ 25%
  802.11a Global client minimum exception lev. 3 clients
```

- **logging**—Shows the RF event and performance logging.

```
RF Event and Performance Logging
  Channel Update Logging......................... Off
  Coverage Profile Logging....................... Off
  Foreign Profile Logging........................ Off
  Load Profile Logging........................... Off
  Noise Profile Logging.......................... Off
  Performance Profile Logging.................... Off
  TxPower Update Logging..................... Off
```

- **monitor**—Shows the Cisco radio monitoring.

```
Default 802.11a AP monitoring
  802.11a Monitor Mode........................... enable
  802.11a Monitor Channels....................... Country channels
  802.11a AP Coverage Interval................... 180 seconds
  802.11a AP Load Interval....................... 60 seconds
  802.11a AP Noise Interval...................... 180 seconds
  802.11a AP Signal Strength Interval......... 60 seconds
```

- **profile** {**global** | *Cisco_AP*}—Shows the access point performance profiles.

```
Default 802.11a AP performance profiles
  802.11a Global Interference threshold.......... 10%
  802.11a Global noise threshold................. -70 dBm
  802.11a Global RF utilization threshold........ 80%
  802.11a Global throughput threshold............ 1000000 bps
  802.11a Global clients threshold............. 12 clients
```

- **receiver**—Shows the 802.11a or 802.11b/g receiver configuration and statistics.

```
802.11a Advanced Receiver Settings
 RxStart  : Signal Threshold..................... 15
 RxStart  : Signal Jump Threshold................ 5
 RxStart  : Preamble Power Threshold............. 2
 RxRestart: Signal Jump Status................... Enabled
 RxRestart: Signal Jump Threshold................ 10
 TxStomp  : Low RSSI Status...................... Enabled
```

```
 TxStomp  : Low RSSI Threshold..................... 30
 TxStomp  : Wrong BSSID Status..................... Enabled
 TxStomp  : Wrong BSSID Data Only Status......... Enabled
 RxAbort  : Raw Power Drop Status................. Disabled
 RxAbort  : Raw Power Drop Threshold.............. 10
 RxAbort  : Low RSSI Status....................... Disabled
 RxAbort  : Low RSSI Threshold.................... 0
 RxAbort  : Wrong BSSID Status.................... Disabled
 RxAbort  : Wrong BSSID Data Only Status......... Disabled
 ---------------------------------------------....
 pico-cell-V2 parameters in dbm units:...........

 RxSensitivity: Min,Max,Current RxSense Thres.... 0,0,0
 CCA Threshold: Min,Max,Current Clear Channel.... 0,0,0
Tx Pwr: Min,Max,Current Transmit Power for A.... 0,0,0
 ---------------------------------------------....
```

- **summary**—Shows the configuration and statistics of the 802.11a or 802.11b/g access points.

```
AP Name   MAC Address        Admin State  Operation State Channel TxPower
-------- ------------------ ------------ --------------- -------- -------
AP1140   00:22:90:96:5b:d0    ENABLED         DOWN        64*     1(*)
AP1240   00:21:1b:ea:36:60    ENABLED         DOWN       161*     1(*)
AP1130   00:1f:ca:cf:b6:60    ENABLED      REGISTERED    48*     1(*)
```

- **txpower**—Shows the transmit power assignment configuration and statistics.

```
Automatic Transmit Power Assignment
  Transmit Power Assignment Mode.................. AUTO
  Transmit Power Update Interval.................. 600 seconds
  Transmit Power Update Count..................... 0
  Transmit Power Threshold........................ -70 dBm
  Transmit Power Neighbor Count................... 3 APs
  Min Transmit Power.............................. -100 dBm
  Max Transmit Power.............................. 100 dBm
  Transmit Power Update Contribution.............. SNI.
  Transmit Power Assignment Leader................ 00:0b:85:40:90:c0
  Last Run........................................ 354 seconds ago
```

Using the CLI to Debug RRM Issues

Use these commands to troubleshoot and verify RRM behavior:

debug airewave-director *?*

where *?* is one of the following:

- **all**—Enables debugging for all RRM logs.
- **channel**—Enables debugging for the RRM channel assignment protocol.
- **detail**—Enables debugging for RRM detail logs.
- **error**—Enables debugging for RRM error logs.
- **group**—Enables debugging for the RRM grouping protocol.
- **manager**—Enables debugging for the RRM manager.
- **message**—Enables debugging for RRM messages.
- **packet**—Enables debugging for RRM packets.
- **power**—Enables debugging for the RRM power assignment protocol as well as coverage hole detection.

- **profile**—Enables debugging for RRM profile events.
- **radar**—Enables debugging for the RRM radar detection/avoidance protocol.
- **rf-change**—Enables debugging for RRM RF changes.

RRM Neighbor Discovery Packet

The Cisco Neighbor Discovery Packet (NDP) is the fundamental tool for RRM and other wireless applications that provides information about the neighbor radio information. Starting in the 7.0.116.0 releases and later, you can configure the controller to encrypt neighbor discovery packets.

This feature enables you to be compliant with the PCI specifications.

Important Notes about RRM NDP and RF Grouping

An RF group can only be formed between controllers that have the same encryption mechanism. That is, an access point associated to a controller that is encrypted can not be neighbors with an access point associated to a controller that is not encrypted. The two controllers and their access points will not recognize each other as neighbors and cannot form an RF group. It is possible to assign two controllers in a static RF group configuration that has mismatched encryption settings. In this case, the two controllers do not function as a single RF group because the access points belonging to the mismatched controllers do not recognize one another as neighbors in the group.

For more information on RF groups, see Configuring an RF Group, page 13-7.

Caution Inter-operation between 7.0.116.0 release and earlier releases: Because the NDP feature has been introduced from the 7.0.116.0 release, only transparent settings can ensure a RF-group formation between these cases. Previous controller releases do not have the NDP encryption mechanism.

Caution Inter-release 7.0.116.0: Controllers that are intended to be in the same RF group must have the same protection settings.

Configuring RRM NDP Using the CLI

To configure RRM NDP using the controller CLI, follow these steps:

config advanced 802.11{a|b} monitor ndp-mode {protected | transparent}

This command configures NDP mode. By default, the mode is set to “transparent”. The following options are available:

- Protected—Packets are encrypted.
- Transparent—Packets are sent as is.

Use the following command to see the discovery type:

show advanced 802.11{a|b} monitor

Overriding RRM

In some deployments, it is desirable to statically assign channel and transmit power settings to the access points instead of relying on the RRM algorithms provided by Cisco. Typically, this is true in challenging RF environments and non standard deployments but not the more typical carpeted offices.

Note If you choose to statically assign channels and power levels to your access points and/or to disable dynamic channel and power assignment, you should still use automatic RF grouping to avoid spurious rogue device events.

You can disable dynamic channel and power assignment globally for a controller, or you can leave dynamic channel and power assignment enabled and statically configure specific access point radios with a channel and power setting. Follow the instructions in one of the following sections:

- Statically Assigning Channel and Transmit Power Settings to Access Point Radios, page 13-32
- Disabling Dynamic Channel and Power Assignment Globally for a Controller, page 13-39

Note While you can specify a global default transmit power parameter for each network type that applies to all the access point radios on a controller, you must set the channel for each access point radio when you disable dynamic channel assignment. You may also want to set the transmit power for each access point instead of leaving the global transmit power in effect.

Statically Assigning Channel and Transmit Power Settings to Access Point Radios

This section provides instructions for statically assigning channel and power settings using the controller GUI or CLI.

Note We recommend that you assign different nonoverlapping channels to access points that are within close proximity to each other. The nonoverlapping channels in the U.S. are 36, 40, 44, 48, 52, 56, 60, 64, 149, 153, 157, and 161 in an 802.11a network and 1, 6, and 11 in an 802.11b/g network.

Note We recommend that you do not assign all access points that are within close proximity to each other to the maximum power level.

Using the GUI to Statically Assign Channel and Transmit Power Settings

To statically assign channel and/or power settings on a per access point radio basis using the controller GUI, follow these steps:

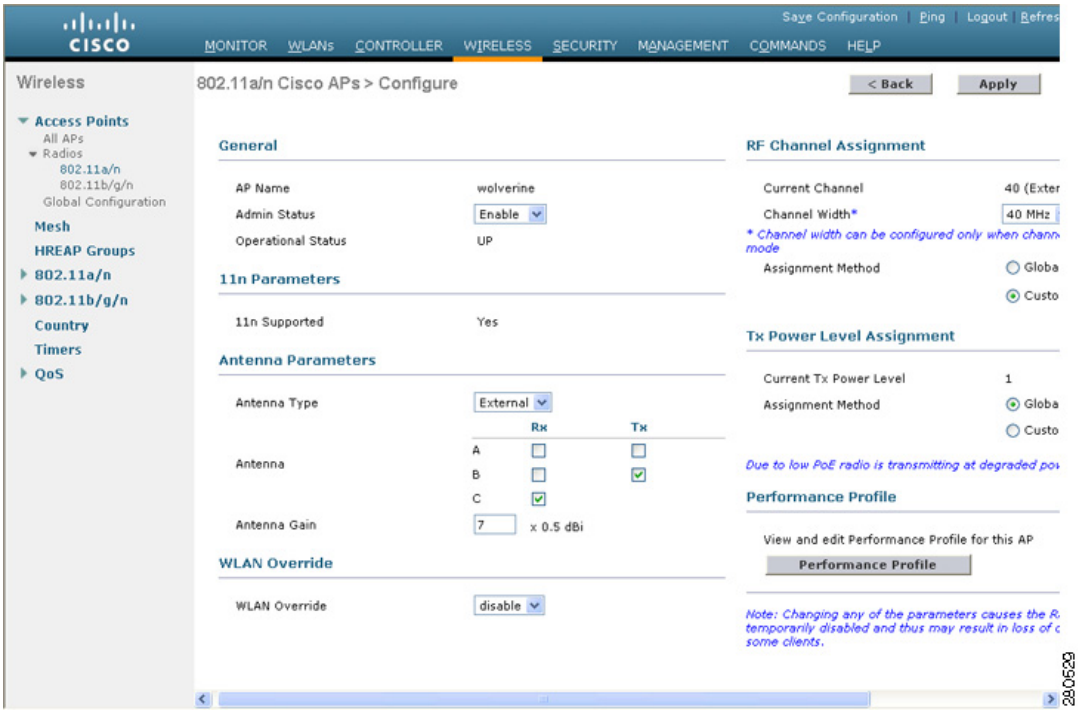
Step 1 Choose **Wireless** > **Access Points** > **Radios** > **802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page (see Figure 13-6).

Figure 13-6 802.11a/n Radios Page

This page shows all the 802.11a/n or 802.11b/g/n access point radios that are joined to the controller and their current settings. The Channel text box shows both the primary and extension channels and uses an asterisk to indicate if they are globally assigned.

Step 2 Hover your cursor over the blue drop-down arrow for the access point for which you want to modify the radio configuration and choose **Configure**. The 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page appears (see Figure 13-7).

Figure 13-7 802.11a/n Cisco APs > Configure Page



Step 3 Choose **Custom** for the Assignment Method under RF Channel Assignment to be able to assign primary and extension channels to the access point radio.

Step 4 Choose one of the following options from the Channel Width drop-down list:

- **20 MHz**—Allows the radio to communicate using only 20-MHz channels. Choose this option for legacy 802.11a radios, 20-MHz 802.11n radios, or 40-MHz 802.11n radios that you want to operate using only 20-MHz channels. This is the default value.

- **40 MHz**—Allows 40-MHz 802.11n radios to communicate using two adjacent 20-MHz channels bonded together. The radio uses the primary channel that you choose in Step 6 as well as its extension channel for faster throughput. Each channel has only one extension channel (36 and 40 are a pair, 44 and 48 are a pair, and so on). For example, if you choose a primary channel of 44, the controller would use channel 48 as the extension channel. If you choose a primary channel of 48, the controller would use channel 44 as the extension channel.

Note You cannot configure access points supporting 40 MHz channel width on 2.4 GHz.

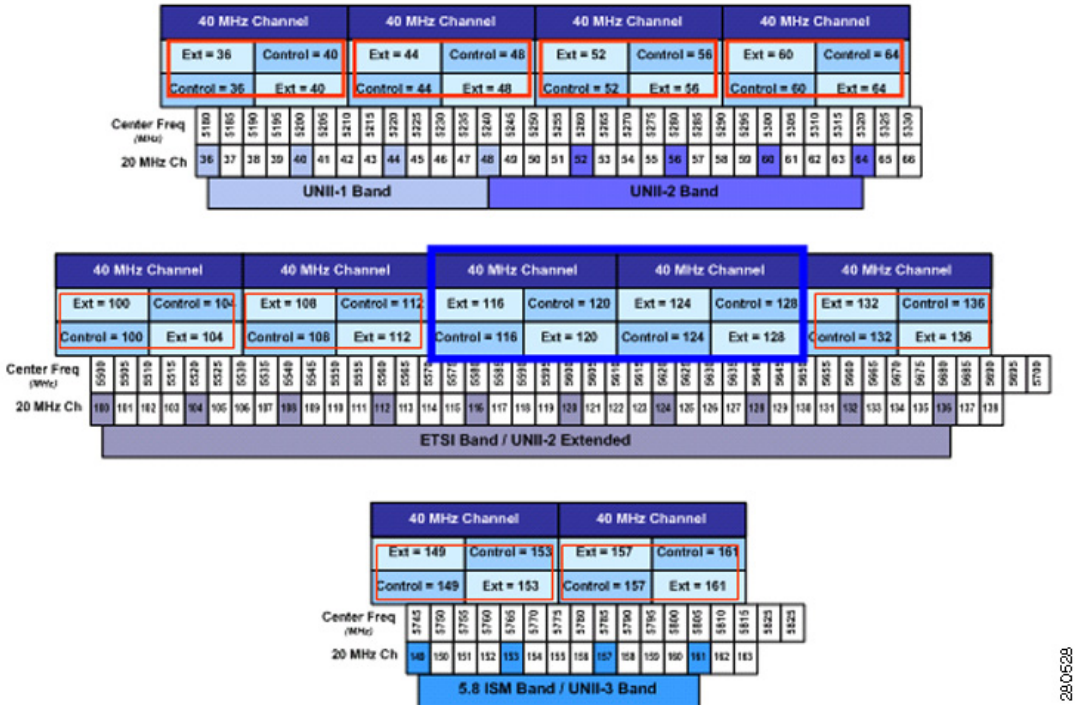
Note The Channel Width parameter can be configured for 802.11a/n radios only if the RF channel assignment method is in custom mode.

Note Statically configuring an access point's radio for 20- or 40-MHz mode overrides the globally configured DCA channel width setting on the 802.11a > RRM > Dynamic Channel Assignment (DCA) page. If you change the static RF channel assignment method back to Global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using. It can take up to 30 minutes (depending on how often DCA is configured to run) for the change to take effect.

Figure 13-8 shows channel bonding in the 5-GHz band. Low channels are preferred.

Note Channels 116, 120, 124, and 128 are not available in the U.S. and Canada for 40-MHz channel bonding.

Figure 13-8 Channel Bonding in the 5-GHz Band



Step 5 Configure the antenna parameters for this radio as follows:

a. From the Antenna Type drop-down list, choose **Internal** or **External** to specify the type of antennas used with the access point radio.

b. Select and unselect the check boxes in the Antenna text box to enable and disable the use of specific antennas for this access point, where A, B, and C are specific antenna ports. A is the right antenna port, B is the left antenna port, and C is the center antenna port. For example, to enable transmissions from antenna ports A and B and receptions from antenna port C, you would select the following check boxes: Tx: A and B and Rx: C.

c. In the Antenna Gain text box, enter a number to specify an external antenna's ability to direct or focus radio energy over a region of space. High-gain antennas have a more focused radiation pattern in a specific direction. The antenna gain is measured in 0.5 dBi units, and the default value is 7 times 0.5 dBi, or 3.5 dBi.

If you have a high-gain antenna, enter a value that is twice the actual dBi value (see *Cisco Aironet Antenna Reference Guide* for antenna dBi values). Otherwise, enter 0. For example, if your antenna has a 4.4-dBi gain, multiply the 4.4 dBi by 2 to get 8.8 and then round down to enter only the whole number (8). The controller reduces the actual equivalent isotropic radiated power (EIRP) to make sure that the antenna does not violate your country's regulations.

d. Choose one of the following options from the Diversity drop-down list:

- **Enabled**—Enables the antenna connectors on both sides of the access point. This is the default value.
- **Side A** or **Right**—Enables the antenna connector on the right side of the access point.
- **Side B** or **Left**—Enables the antenna connector on the left side of the access point.

Step 6 Choose **Custom** for the Assignment Method under RF Channel Assignment and choose a channel from the drop-down list to assign an RF channel to the access point radio.

The channel you choose is the primary channel (for example, channel 36), which is used for communication by legacy 802.11a radios and 802.11n 20-MHz radios. 802.11n 40-MHz radios use this channel as the primary channel but also use an additional bonded extension channel for faster throughput, if you chose 40 MHz for the channel width in Step 4.

Note The Current Channel text box shows the current primary channel. If you chose 40 MHz for the channel width in Step 4, the extension channel appears in parentheses after the primary channel.

Note Changing the operating channel causes the access point radio to reset.

Step 7 Choose **Custom** for the Assignment Method under Tx Power Level Assignment and choose a transmit power level from the drop-down list to assign a transmit power level to the access point radio.

The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. The number of available power levels varies based on the access point model. However, power level 1 is always the maximum power level allowed per country code setting, with each successive power level representing 50% of the previous power level. For example, 1 = maximum power level in a particular regulatory domain, 2 = 50% power, 3 = 25% power, 4 = 12.5% power, and so on.

Note See the hardware installation guide for your access point for the maximum transmit power levels supported per regulatory domain. Also, see the data sheet for your access point for the number of power levels supported.

Note If the access point is not operating at full power, the "Due to low PoE, radio is transmitting at degraded power" message appears under the Tx Power Level Assignment section. See the "Configuring Power over Ethernet" section on page 8-128 for more information on PoE power levels.

Step 8 Choose **Enable** from the Admin Status drop-down list to enable this configuration for the access point.

Step 9 Click **Apply** to commit your changes.

Step 10 Have the controller send the access point radio admin state immediately to WCS as follows:

a. Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page.

b. Select the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Step 12 Repeat this procedure for each access point radio for which you want to assign a static channel and power level.

Using the CLI to Statically Assign Channel and Transmit Power Settings

To statically assign channel and/or power settings on a per access point radio basis using the controller CLI, follow these steps:

Step 1 Disable the radio of a particular access point on the 802.11a or 802.11b/g network by entering this command:

config {**802.11a** | **802.11b**} **disable** *Cisco_AP*

Step 2 Configure the channel width for a particular access point by entering this command:

config {**802.11a** | **802.11b**} **chan_width** *Cisco_AP* {**20** | **40**}

where

- **20** allows the radio to communicate using only 20-MHz channels. Choose this option for legacy 802.11a radios, 20-MHz 802.11n radios, or 40-MHz 802.11n radios that you want to operate using only 20-MHz channels. This is the default value.
- **40** allows 40-MHz 802.11n radios to communicate using two adjacent 20-MHz channels bonded together. The radio uses the primary channel that you choose in Step 5 as well as its extension channel for faster throughput. Each channel has only one extension channel (36 and 40 are a pair, 44 and 48 are a pair, and so on). For example, if you choose a primary channel of 44, the controller would use channel 48 as the extension channel. If you choose a primary channel of 48, the controller would use channel 44 as the extension channel.

Note This parameter can be configured only if the primary channel is statically assigned.

Note Statically configuring an access point's radio for 20- or 40-MHz mode overrides the globally configured DCA channel width setting (configured using the **config advanced 802.11a channel dca chan-width-11n** {**20** | **40**} command). If you ever change the static configuration back to global on the access point radio, the global DCA configuration overrides the channel width configuration that the access point was previously using. It can take up to 30 minutes (depending on how often DCA is configured to run) for the change to take effect.

Figure 13-8 on page 13-35 shows channel bonding in the 5-GHz band. Low channels are preferred.

Note Channels 116, 120, 124, and 128 are not available in the U.S. and Canada for 40-MHz channel bonding.

Step 3 Enable or disable the use of specific antennas for a particular access point by entering this command:

config {**802.11a** | **802.11b**} **11nsupport antenna** {**tx** | **rx**} *Cisco_AP* {**A** | **B** | **C**} {**enable** | **disable**}

where A, B, and C are antenna ports. A is the right antenna port, B is the left antenna port, and C is the center antenna port. For example, to enable transmissions from the antenna in access point AP1's antenna port C on the 802.11a network, you would enter this command:

config 802.11a 11nsupport antenna tx AP1 C enable

Step 4 Specify the external antenna gain, which is a measure of an external antenna's ability to direct or focus radio energy over a region of space entering this command:

config {**802.11a** | **802.11b**} **antenna extAntGain** *antenna_gain Cisco_AP*

High-gain antennas have a more focused radiation pattern in a specific direction. The antenna gain is measured in 0.5 dBi units, and the default value is 7 times 0.5 dBi, or 3.5 dBi.

If you have a high-gain antenna, enter a value that is twice the actual dBi value (see *Cisco Aironet Antenna Reference Guide* for antenna dBi values). Otherwise, enter 0. For example, if your antenna has a 4.4-dBi gain, multiply the 4.4 dBi by 2 to get 8.8 and then round down to enter only the whole number (8). The controller reduces the actual equivalent isotropic radiated power (EIRP) to make sure that the antenna does not violate your country's regulations.

Step 5 Specify the channel that a particular access point is to use by entering this command:

config {**802.11a** | **802.11b**} **channel ap** *Cisco_AP channel*

For example, to configure 802.11a channel 36 as the default channel on AP1, enter the **config 802.11a channel ap AP1 36** command.

The channel you choose is the primary channel (for example, channel 36), which is used for communication by legacy 802.11a radios and 802.11n 20-MHz radios. 802.11n 40-MHz radios use this channel as the primary channel but also use an additional bonded extension channel for faster throughput, if you chose 40 for the channel width in Step 2.

Note Changing the operating channel causes the access point radio to reset.

Step 6 Specify the transmit power level that a particular access point is to use by entering this command:

config {**802.11a** | **802.11b**} **txPower ap** *Cisco_AP power_level*

For example, to set the transmit power for 802.11a AP1 to power level 2, enter the **config 802.11a txPower ap AP1 2** command.

The transmit power level is assigned an integer value instead of a value in mW or dBm. The integer corresponds to a power level that varies depending on the regulatory domain in which the access points are deployed. The number of available power levels varies based on the access point model. However, power level 1 is always the maximum power level allowed per country code setting, with each successive power level representing 50% of the previous power level. For example, 1 = maximum power level in a particular regulatory domain, 2 = 50% power, 3 = 25% power, 4 = 12.5% power, and so on.

Note See the hardware installation guide for your access point for the maximum transmit power levels supported per regulatory domain. Also, see data sheet for your access point for the number of power levels supported.

Step 7 Save your settings by entering this command:

save config

Step 8 Repeat Step 2 through Step 7 for each access point radio for which you want to assign a static channel and power level.

Step 9 Reenable the access point radio by entering this command:

config {**802.11a** | **802.11b**} **enable** *Cisco_AP*

Step 10 Have the controller send the access point radio admin state immediately to WCS by entering this command:

config {**802.11a** | **802.11b**} **enable network**

Step 11 Save your changes by entering this command:

save config

Step 12 See the configuration of a particular access point by entering this command:

show ap config {**802.11a** | **802.11b**} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 7
Cisco AP Name.................................... AP1
...
Tx Power
Num Of Supported Power Levels ............. 8
      Tx Power Level 1 ........................... 20 dBm
      Tx Power Level 2 ........................... 17 dBm
      Tx Power Level 3 ........................... 14 dBm
      Tx Power Level 4 ........................... 11 dBm
      Tx Power Level 5 ........................... 8 dBm
      Tx Power Level 6 ........................... 5 dBm
      Tx Power Level 7 ........................... 2 dBm
      Tx Power Level 8 ........................... -1 dBm
      Tx Power Configuration ..................... CUSTOMIZED
      Current Tx Power Level ..................... 1

Phy OFDM parameters
      Configuration .............................. CUSTOMIZED
      Current Channel ............................ 36
      Extension Channel .......................... 40
      Channel Width............................... 40 Mhz
      Allowed Channel List........................ 36,44,52,60,100,108,116,132,
        ........................................... 149,157
      TI Threshold ............................... -50
      Antenna Type................................ EXTERNAL_ANTENNA
      External Antenna Gain (in .5 dBi units).... 7
      Diversity................................... DIVERSITY_ENABLED

802.11n Antennas
        Tx
         A..................................... ENABLED
         B..................................... ENABLED
        Rx
         A..................................... DISABLED
         B..................................... DISABLED
         C..................................... ENABLED
```

Disabling Dynamic Channel and Power Assignment Globally for a Controller

This section provides instructions for disabling dynamic channel and power assignment using the GUI or CLI.

Using the GUI to Disable Dynamic Channel and Power Assignment

To configure disable dynamic channel and power assignment using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **802.11a/n** or **802.11b/g/n** > **RRM** > **Auto RF** to open the 802.11a (or 802.11b/g) Global Parameters > Auto RF page (see Figure 13-2).

Step 2 Disable dynamic channel assignment by choosing **OFF** under RF Channel Assignment.

Step 3 Disable dynamic power assignment by choosing **Fixed** under Tx Power Level Assignment and choosing a default transmit power level from the drop-down list.

Note See Step 7 on page 13-36 for information on transmit power levels.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Step 6 If you are overriding the default channel and power settings on a per radio basis, assign static channel and power settings to each of the access point radios that are joined to the controller.

Step 7 (Optional) Repeat this procedure for the network type that you did not select (802.11a or 802.11b/g).

Using the CLI to Disable Dynamic Channel and Power Assignment

To disable RRM for all 802.11a or 802.11b/g radios using the controller CLI, follow these steps:

Step 1 Disable the 802.11a or 802.11b/g network by entering this command:

config {802.11a | 802.11b} disable network

Step 2 Disable RRM for all 802.11a or 802.11b/g radios and set all channels to the default value by entering this command:

config {802.11a | 802.11b} channel global off

Step 3 Enable the 802.11a or 802.11b/g network by entering this command:

config {802.11a | 802.11b} enable network

Note To enable the 802.11g network, enter the **config 802.11b 11gSupport enable** command after the **config 802.11b enable network** command.

Step 4 Save your changes by entering this command:

save config

Enabling Rogue Access Point Detection in RF Groups

After you have created an RF group of controllers, you need to configure the access points connected to the controllers to detect rogue access points. The access points will then select the beacon/probe-response frames in neighboring access point messages to see if they contain an authentication information element (IE) that matches that of the RF group. If the select is successful, the frames are authenticated. Otherwise, the authorized access point reports the neighboring access point as a rogue, records its BSSID in a rogue table, and sends the table to the controller.

Using the GUI to Enable Rogue Access Point Detection in RF Groups

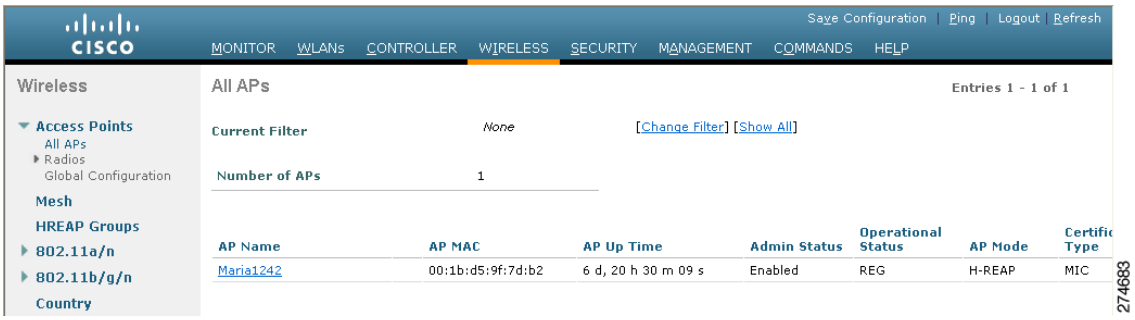
To enable rogue access point detection in RF groups using the controller GUI, follow these steps:

Step 1 Make sure that each controller in the RF group has been configured with the same RF group name.

Note The name is used to verify the authentication IE in all beacon frames. If the controllers have different names, false alarms will occur.

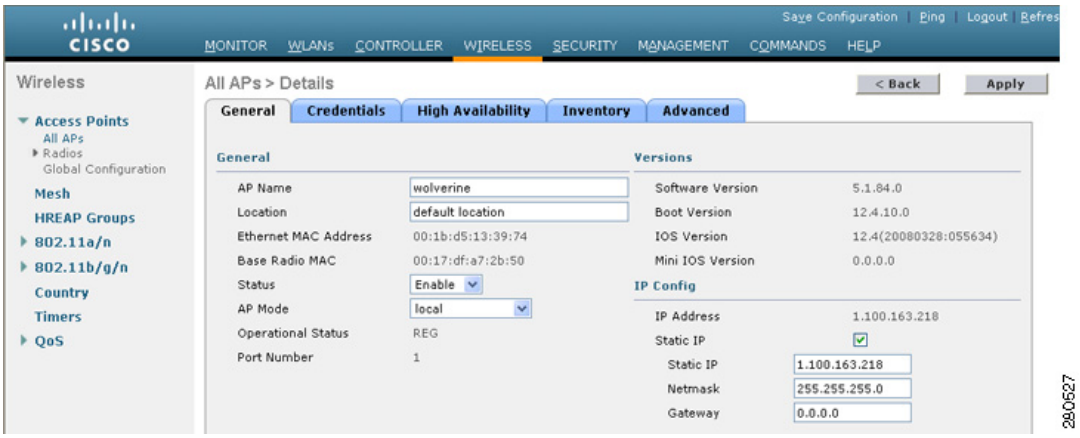
Step 2 Choose **Wireless** to open the All APs page (see Figure 13-9).

Figure 13-9 All APs Page



Step 3 Click the name of an access point to open the All APs > Details page (see Figure 13-10).

Figure 13-10 All APs > Details Page



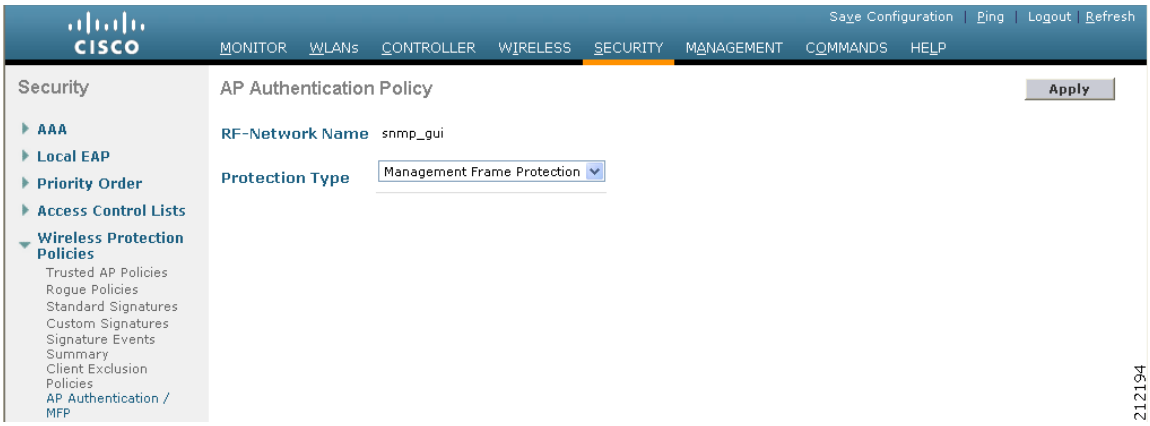
Step 4 Choose either **local** or **monitor** from the AP Mode drop-down list and click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

Step 6 Repeat Step 2 through Step 5 for every access point connected to the controller.

Step 7 Choose **Security > Wireless Protection Policies > AP Authentication/MFP** to open the AP Authentication Policy page (see Figure 13-11).

Figure 13-11 AP Authentication Policy Page



The name of the RF group to which this controller belongs appears at the top of the page.

Step 8 Choose **AP Authentication** from the Protection Type drop-down list to enable rogue access point detection.

Step 9 Enter a number in the Alarm Trigger Threshold edit box to specify when a rogue access point alarm is generated. An alarm occurs when the threshold value (which specifies the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.

Note The valid threshold range is from1 to 255, and the default threshold value is 1. To avoid false alarms, you may want to set the threshold to a higher value.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Step 12 Repeat this procedure on every controller in the RF group.

Note If rogue access point detection is not enabled on every controller in the RF group, the access points on the controllers with this feature disabled are reported as rogues.

Using the CLI to Enable Rogue Access Point Detection in RF Groups

To enable rogue access point detection in RF groups using the controller CLI, follow these steps:

Step 1 Make sure that each controller in the RF group has been configured with the same RF group name.

Note The name is used to verify the authentication IE in all beacon frames. If the controllers have different names, false alarms will occur.

Step 2 Configure a particular access point for local (normal) mode or monitor (listen-only) mode by entering this command:

config ap mode local *Cisco_AP* or **config ap mode monitor** *Cisco_AP*

Step 3 Save your changes by entering this command:

save config

Step 4 Repeat Step 2 and Step 3 for every access point connected to the controller.

Step 5 Enable rogue access point detection by entering this command:

config wps ap-authentication

Step 6 Specify when a rogue access point alarm is generated by entering this command. An alarm occurs when the threshold value (which specifies the number of access point frames with an invalid authentication IE) is met or exceeded within the detection period.

config wps ap-authentication *threshold*

Note The valid threshold range is from 1 to 255, and the default threshold value is 1. To avoid false alarms, you may want to set the threshold to a higher value.

Step 7 Save your changes by entering this command:

save config

Step 8 Repeat Step 5 through Step 7 on every controller in the RF group.

Note If rogue access point detection is not enabled on every controller in the RF group, the access points on the controllers with this feature disabled are reported as rogues.

Configuring Beamforming

Beamforming (also called *ClientLink*) is a spatial-filtering mechanism used at a transmitter to improve the received signal power or signal-to-noise (SNR) ratio at an intended receiver (client).

Cisco Aironet 1140 and 1250 series access points support beamforming. Beamforming uses multiple transmit antennas to focus transmissions in the direction of an 802.11a or 802.11g client, which increases the downlink SNR and the data rate to the client, reduces coverage holes, and enhances overall system performance. Beamforming works with all existing 802.11a and 802.11g clients.

Beamforming starts only when the signal from the client falls below these thresholds:

- **802.11a clients**—RSSI of –60 dBm or weaker
- **802.11g clients**—RSSI of –50 dBm or weaker

Note 802.11b clients do not support beamforming.

The access point actively maintains beamforming data for up to 15 clients per radio.

In the receive data path, the access point updates the beamforming data (the transmit steering matrix) for the active entries when packets are received from an address that matches an active entry. If a packet is received from a beamforming client that is not an active entry, the access point automatically replaces the oldest active entry.

In the transmit data path, if the packet is destined for an active entry, the access point links the packets based on the recorded beamforming data.

Guidelines for Using Beamforming

Follow these guidelines for using beamforming:

- Beamforming is supported only for legacy orthogonal frequency-division multiplexing (OFDM) data rates (6, 9, 12, 18, 24, 36, 48, and 54 Mbps).

Note Beamforming is not supported for complementary code keying (CCK) data rates (1, 2, 5.5, and 11 Mbps).

- Only access points that support 802.11n (currently the 1140 and 1250 series access points) can use beamforming.
- Two or more antennas must be enabled for transmission.
- All three antennas must be enabled for reception.
- OFDM data rates must be enabled.
- Beamforming must be enabled.

Note If the antenna configuration restricts operation to a single transmit antenna or if OFDM data rates are disabled, beamforming is not used.

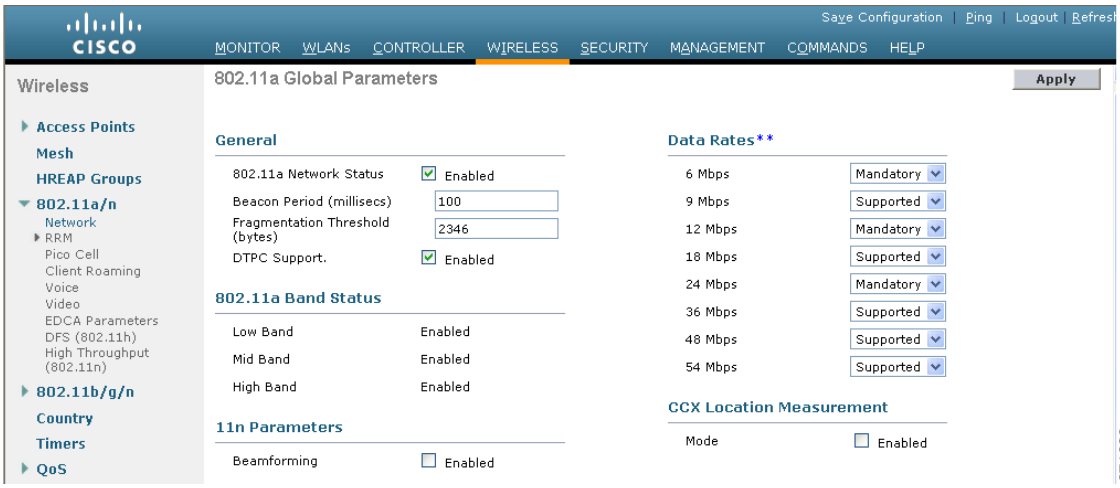
Using the GUI to Configure Beamforming

To configure beamforming using the controller GUI, follow these steps:

Step 1 Disable the 802.11a or 802.11b/g network as follows:

a. Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page (see Figure 13-12).

Figure 13-12 802.11a Global Parameters Page



b. Unselect the **802.11a** (or **802.11b/g**) **Network Status** check box.

c. Click **Apply** to commit your changes.

Step 2 Select the **Beamforming** check box to globally enable beamforming on your 802.11a or 802.11g network, or leave it unselected to disable this feature. The default value is disabled.

Step 3 Reenable the network by selecting the **802.11a** (or **802.11b/g**) **Network Status** check box.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your changes.

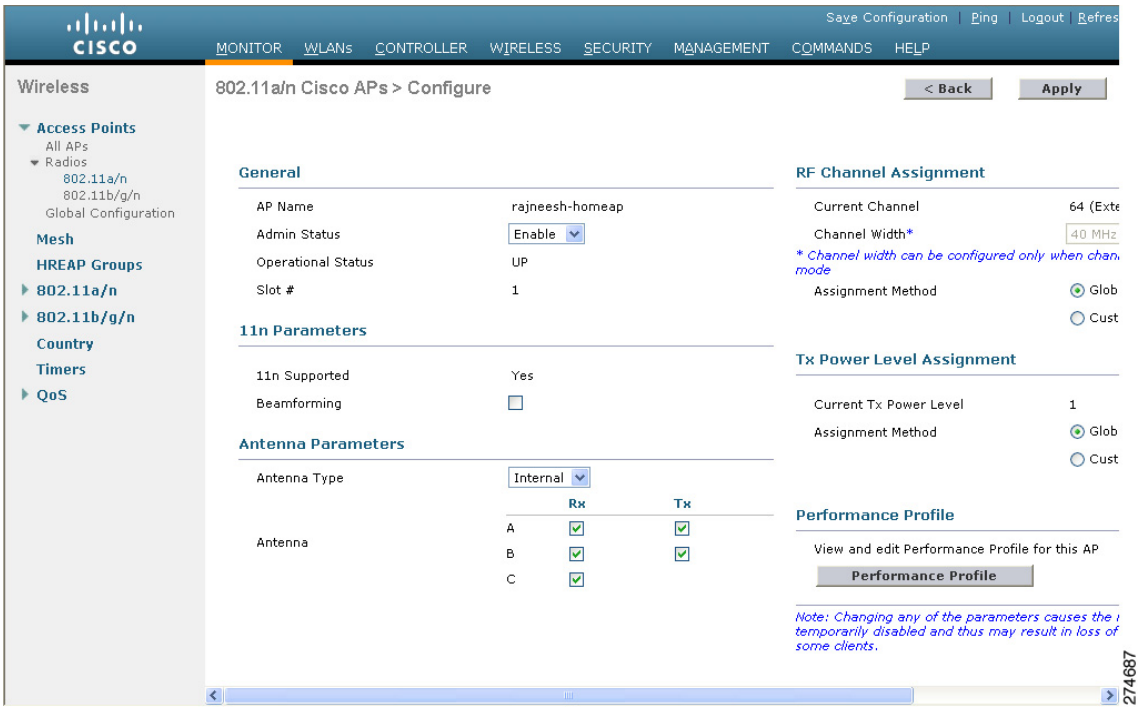
Note After you enable beamforming on the network, it is automatically enabled for all the radios applicable to that network type.

Step 6 Override the global configuration and enable or disable beamforming for a specific access point as follows:

a. Choose **Wireless** > **Access Points** > **Radios** > **802.11a/n** or **802.11b/g/n** to open the 802.11a/n (or 802.11b/g/n) Radios page.

b. Hover your cursor over the blue drop-down arrow for the access point for which you want to modify the radio configuration and choose **Configure**. The 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page appears (see Figure 13-13).

Figure 13-13 802.11a/n Cisco APs > Configure Page



Step 7 In the 11n Parameters section, select the **Beamforming** check box to enable beamforming for this access point or leave it unselected to disable this feature. The default value is unselected if beamforming is disabled on the network and selected if beamforming is enabled on the network.

Note If the access point does not support 802.11n, the beamforming option is not available.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure Beamforming

To configure beamforming using the controller CLI, follow these steps:

Step 1 Disable the 802.11a or 802.11b/g network by entering this command:

config {802.11a | 802.11b} disable network

Step 2 Globally enable or disable beamforming on your 802.11a or 802.11g network by entering this command:

config {802.11a | 802.11b} beamforming global {enable | disable}

The default value is disabled.

Note After you enable beamforming on the network, it is automatically enabled for all the radios applicable to that network type.

Step 3 Override the global configuration and enable or disable beamforming for a specific access point by entering this command:

config {**802.11a** | **802.11b**} **beamforming ap** *Cisco_AP* **{enable | disable}**

The default value is disabled if beamforming is disabled on the network and enabled if beamforming is enabled on the network.

Step 4 Reenable the network by entering this command:

config {**802.11a** | **802.11b**} **enable network**

Step 5 Save your changes by entering this command:

save config

Step 6 See the beamforming status for your network by entering this command:

show {**802.11a** | **802.11b**}

Information similar to the following appears:

```
802.11a Network.............................. Enabled
11nSupport................................... Enabled
      802.11a Low Band....................... Enabled
      802.11a Mid Band....................... Enabled
      802.11a High Band...................... Enabled
...
Pico-Cell-V2 Status.......................... Disabled
TI Threshold................................. -50
Legacy Tx Beamforming setting.............. Enabled
```

Step 7 See the beamforming status for a specific access point by entering this command:

show ap config {**802.11a** | **802.11b**} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.......................... 14
Cisco AP Name................................ 1250-1
Country code................................. US  - United States
Regulatory Domain allowed by Country............. 802.11bg:-A     802.11a:-A
...
Phy OFDM parameters
      Configuration ......................... AUTOMATIC
      Current Channel ....................... 149
      Extension Channel ..................... NONE
      Channel Width.......................... 20 Mhz
      Allowed Channel List................... 36,40,44,48,52,56,60,64,100,
        ..................................... 104,108,112,116,132,136,140,
        ..................................... 149,153,157,161,165
      TI Threshold .......................... -50
      Legacy Tx Beamforming Configuration ....... CUSTOMIZED
      Legacy Tx Beamforming ..................... ENABLED
```

Configuring CCX Radio Management Features

You can configure two parameters that affect client location calculations:

- Radio measurement requests
- Location calibration

These parameters are supported in Cisco Client Extensions (CCX) v2 and later releases are designed to enhance location accuracy and timeliness for participating CCX clients. See the "Configuring Cisco Client Extensions" section on page 7-52 for more information on CCX.

For the location features to operate properly, the access points must be configured for normal, monitor, or hybrid-REAP mode. However, for hybrid-REAP mode, the access point must be connected to the controller.

Note CCX is not supported on the AP1030.

Radio Measurement Requests

When you enable the radio measurements requests feature, lightweight access points issue broadcast radio measurement request messages to clients running CCXv2 or later releases. The access points transmit these messages for every SSID over each enabled radio interface at a configured interval. In the process of performing 802.11 radio measurements, CCX clients send 802.11 broadcast probe requests on all the channels specified in the measurement request. The Cisco Location Appliance uses the uplink measurements based on these requests received at the access points to quickly and accurately calculate the client location. You do not need to specify on which channels the clients are to measure. The controller, access point, and client automatically determine which channels to use.

In controller software release 4.1 or later releases, the radio measurement feature has been expanded to enable the controller to also obtain information on the radio environment from the client's perspective (rather than from just that of the access point). In this case, the access points issue unicast radio measurement requests to a particular CCXv4 or v5 client. The client then sends various measurement reports back to the access point and onto the controller. These reports include information about the radio environment and data used to interpret the location of the clients. To prevent the access points and controller from being overwhelmed by radio measurement requests and reports, only two clients per access point and up to 20 clients per controller are supported. You can view the status of radio measurement requests for a particular access point or client as well as radio measurement reports for a particular client from the controller CLI.

Controller software release 4.1 or later releases improve the ability of the Location Appliance to accurately interpret the location of a device through a CCXv4 feature called location-based services. The controller issues a path-loss request to a particular CCXv4 or v5 client. If the client chooses to respond, it sends a path-loss measurement report to the controller. These reports contain the channel and transmit power of the client.

Note Non-CCX and CCXv1 clients ignore the CCX measurement requests and do not participate in the radio measurement activity.

Location Calibration

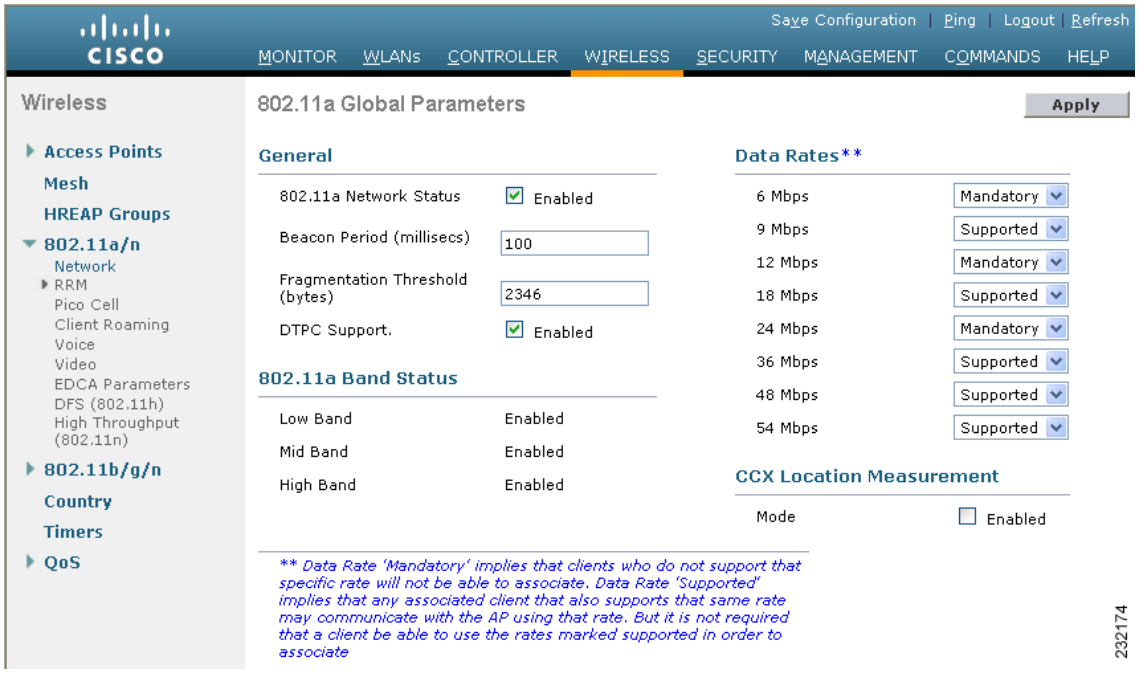
For CCX clients that need to be tracked more closely (for example, when a client calibration is performed), the controller can be configured to command the access point to send unicast measurement requests to these clients at a configured interval and whenever a CCX client roams to a new access point. These unicast requests can be sent out more often to these specific CCX clients than the broadcast measurement requests, which are sent to all clients. When location calibration is configured for non-CCX and CCXv1 clients, the clients are forced to disassociate at a specified interval to generate location measurements.

Using the GUI to Configure CCX Radio Management

To configure CCX radio management using the controller GUI, follow these steps:

Step 1 Choose **Wireless > 802.11a/n** or **802.11b/g/n > Network** to open the 802.11a (or 802.11b/g) Global Parameters page (see Figure 13-14).

Figure 13-14 802.11a Global Parameters Page



Step 2 Under CCX Location Measurement, select the **Mode** check box to globally enable CCX radio management. This parameter causes the access points connected to this controller to issue broadcast radio measurement requests to clients running CCX v2 or later releases. The default value is disabled (or unselected).

Step 3 If you selected the Mode check box in the previous step, enter a value in the Interval text box to specify how often the access points are to issue the broadcast radio measurement requests.

The range is 60 to 32400 seconds.

The default is 60 seconds.

Step 4 Click **Apply** to commit your changes.

Step 5 Click **Save Configuration** to save your settings.

Step 6 Follow the instructions in Step 2 of the "Using the CLI to Configure CCX Radio Management" section below to enable access point customization.

Note To enable CCX radio management for a particular access point, you must enable access point customization, which can be done only through the controller CLI.

Step 7 If desired, repeat this procedure for the other radio band (802.11a or 802.11b/g).

Using the CLI to Configure CCX Radio Management

To enable CCX radio management using the controller CLI, follow these steps:

Step 1 Globally enable CCX radio management by entering this command:

config advanced {**802.11a** | **802.11b**} **ccx location-meas global enable** *interval_seconds*

The range for the *interval_seconds* parameter is 60 to 32400 seconds, and the default value is 60 seconds. This command causes all access points connected to this controller in the 802.11a or 802.11b/g network to issue broadcast radio measurement requests to clients running CCXv2 or later releases.

Step 2 Enable access point customization by entering these commands:

- **config advanced** {**802.11a** | **802.11b**} **ccx customize** *Cisco_AP* {**on** | **off**}

  This command enables or disables CCX radio management features for a particular access point in the 802.11a or 802.11b/g network.

- **config advanced** {**802.11a** | **802.11b**} **ccx location-meas ap** *Cisco_AP* **enable** *interval_seconds*

  The range for the *interval_seconds* parameter is 60 to 32400 seconds, and the default value is 60 seconds. This command causes a particular access point in the 802.11a or 802.11b/g network to issue broadcast radio measurement requests to clients running CCXv2 or higher.

Step 3 Enable or disable location calibration for a particular client by entering this command:

config client location-calibration {**enable** | **disable**} *client _mac interval_seconds*

Note You can configure up to five clients per controller for location calibration.

Step 4 Save your settings by entering this command:

save config

Using the CLI to Obtain CCX Radio Management Information

Use these commands to obtain information about CCX radio management on the controller:

- To see the CCX broadcast location measurement request configuration for all access points connected to this controller in the 802.11a or 802.11b/g network, enter this command:

  show advanced {802.11a | 802.11b} ccx global

- To see the CCX broadcast location measurement request configuration for a particular access point in the 802.11a or 802.11b/g network, enter this command:

  show advanced {802.11a | 802.11b} ccx ap *Cisco_AP*

- To see the status of radio measurement requests for a particular access point, enter this command:

  show ap ccx rm *Cisco_AP* **status**

  Information similar to the following appears:

```
A Radio

  Beacon Request.............................. Enabled
  Channel Load Request........................ Enabled
  Frame Request............................... Disabled
  Noise Histogram Request..................... Disabled
  Path Loss Request........................... Disabled
  Interval.................................... 60
  Iteration................................... 5

B Radio

  Beacon Request.............................. Disabled
  Channel Load Request........................ Enabled
  Frame Request............................... Disabled
  Noise Histogram Request..................... Enabled
  Path Loss Request........................... Disabled
  Interval.................................... 60
  Iteration................................... 5
```

- To see the status of radio measurement requests for a particular client, enter this command:

  show client ccx rm *client_mac* **status**

  Information similar to the following appears:

```
Client Mac Address.......................... 00:40:96:ae:53:b4
Beacon Request.............................. Enabled
Channel Load Request........................ Disabled
Frame Request............................... Disabled
Noise Histogram Request..................... Disabled
Path Loss Request........................... Disabled
Interval.................................... 5
Iteration................................... 3
```

- To see radio measurement reports for a particular client, enter these commands:
  - **show client ccx rm** *client_mac* **report beacon**—Shows the beacon report for the specified client.
  - **show client ccx rm** *client_mac* **report chan-load**—Shows the channel-load report for the specified client.
  - **show client ccx rm** *client_mac* **report noise-hist**—Shows the noise-histogram report for the specified client.
  - **show client ccx rm** *client_mac* **report frame**—Shows the frame report for the specified client.
- To see the clients configured for location calibration, enter this command:

  show client location-calibration summary

- To see the RSSI reported for both antennas on each access point that heard the client, enter this command:

  show client detail *client_mac*

Using the CLI to Debug CCX Radio Management Issues

Use these commands if you experience any CCX radio management problems.

- To debug CCX broadcast measurement request activity, enter this command:

  debug airewave-director message {**enable** | **disable**}

- To debug client location calibration activity, enter this command:

  debug ccxrm [**all** | **error** | **warning** | **message** | **packet** | **detail** {**enable** | **disable**}]

- The CCX radio measurement report packets are encapsulated in Internet Access Point Protocol (IAPP) packets. Therefore, if the previous **debug ccxrm** command does not provide any debugs, enter this command to provide debugs at the IAPP level:

  debug iapp error {**enable** | **disable**}

- To debug the output for forwarded probes and their included RSSI for both antennas, enter this command:

  debug dot11 load-balancing

CHAPTER 14

Configuring Mobility Groups

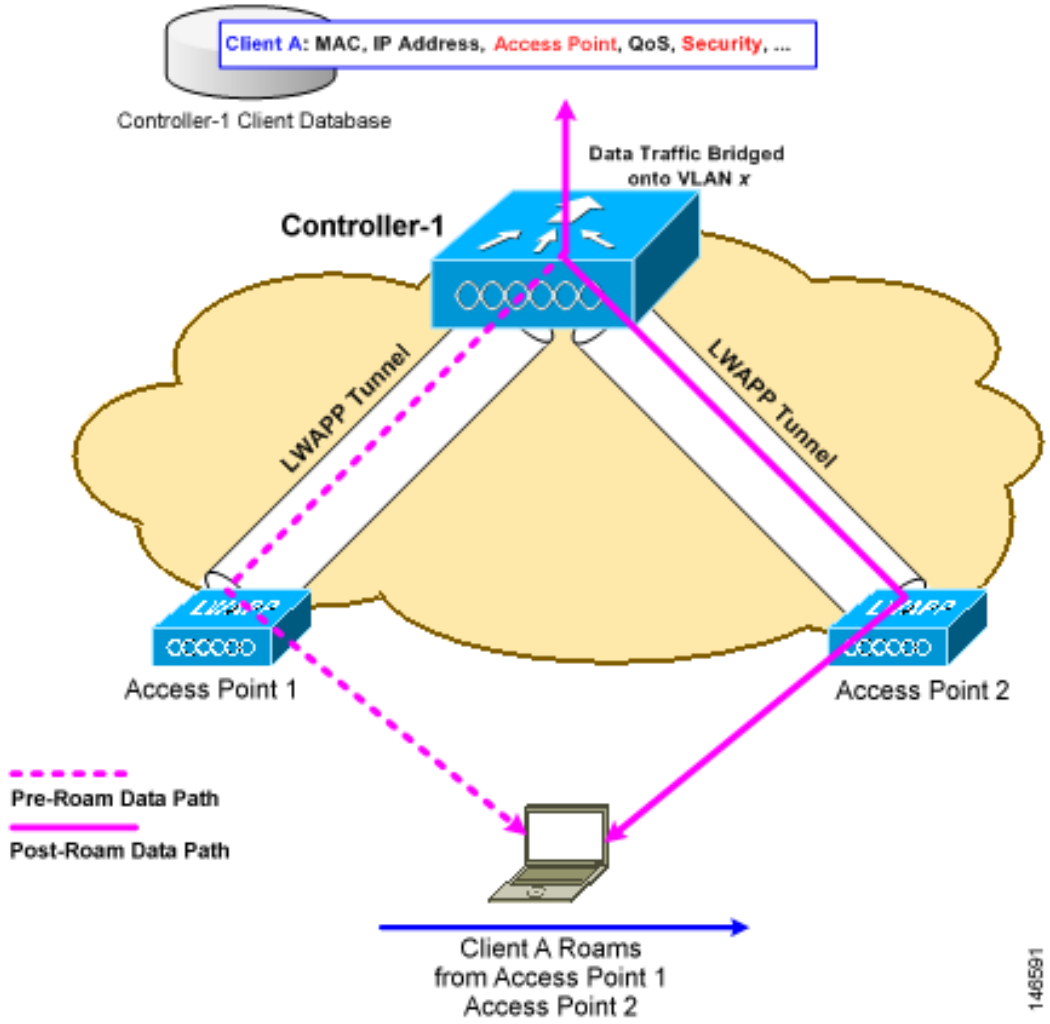
This chapter describes mobility groups and explains how to configure them on the controllers. It contains these sections:

Overview of Mobility

Mobility, or roaming, is a wireless LAN client's ability to maintain its association seamlessly from one access point to another securely and with as little latency as possible. This section explains how mobility works when controllers are included in a wireless network.

When a wireless client associates and authenticates to an access point, the access point's controller places an entry for that client in its client database. This entry includes the client's MAC and IP addresses, security context and associations, quality of service (QoS) contexts, the WLAN, and the associated access point. The controller uses this information to forward frames and manage traffic to and from the wireless client. Figure 14-1 shows a wireless client that roams from one access point to another when both access points are joined to the same controller.

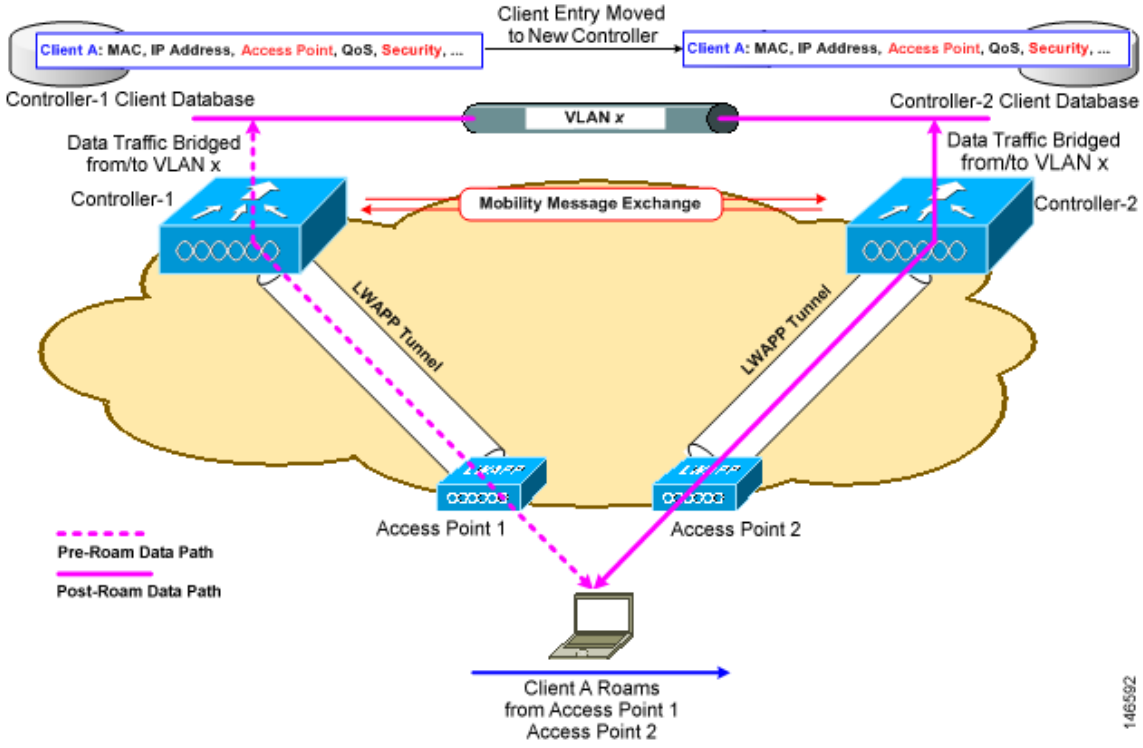
Figure 14-1 Intra-Controller Roaming



When the wireless client moves its association from one access point to another, the controller simply updates the client database with the newly associated access point. If necessary, new security context and associations are established as well.

The process becomes more complicated, however, when a client roams from an access point joined to one controller to an access point joined to a different controller. It also varies based on whether the controllers are operating on the same subnet. Figure 14-2 shows inter-controller roaming, which occurs when the controllers' wireless LAN interfaces are on the same IP subnet.

Figure 14-2 Inter-Controller Roaming

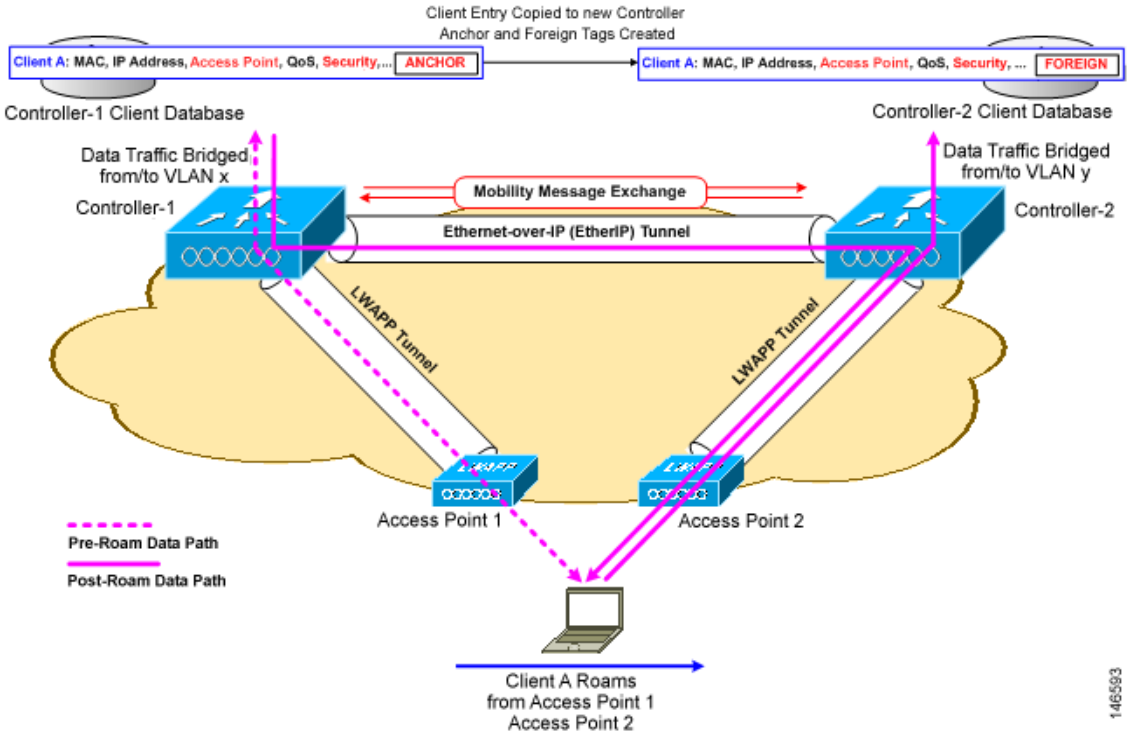


When the client associates to an access point joined to a new controller, the new controller exchanges mobility messages with the original controller, and the client database entry is moved to the new controller. New security context and associations are established if necessary, and the client database entry is updated for the new access point. This process remains transparent to the user.

Note All clients configured with 802.1X/Wi-Fi Protected Access (WPA) security complete a full authentication in order to comply with the IEEE standard.

Figure 14-3 shows inter-subnet roaming, which occurs when the controllers' wireless LAN interfaces are on different IP subnets.

Figure 14-3 Inter-Subnet Roaming



Inter-subnet roaming is similar to inter-controller roaming in that the controllers exchange mobility messages on the client roam. However, instead of moving the client database entry to the new controller, the original controller marks the client with an "Anchor" entry in its own client database. The database entry is copied to the new controller client database and marked with a "Foreign" entry in the new controller. The roam remains transparent to the wireless client, and the client maintains its original IP address.

In inter-subnet roaming, WLANs on both anchor and foreign controllers need to have the same network access privileges and no source-based routing or source-based firewalls in place. Otherwise, the clients may have network connectivity issues after the handoff.

Note Currently, multicast traffic cannot be passed during inter-subnet roaming. You would not want to design an inter-subnet network for SpectraLink phones that need to send multicast traffic while using push to talk.

Note If a client roams in web authentication state, the client is considered as a new client on another controller instead of considering it as a mobile client.

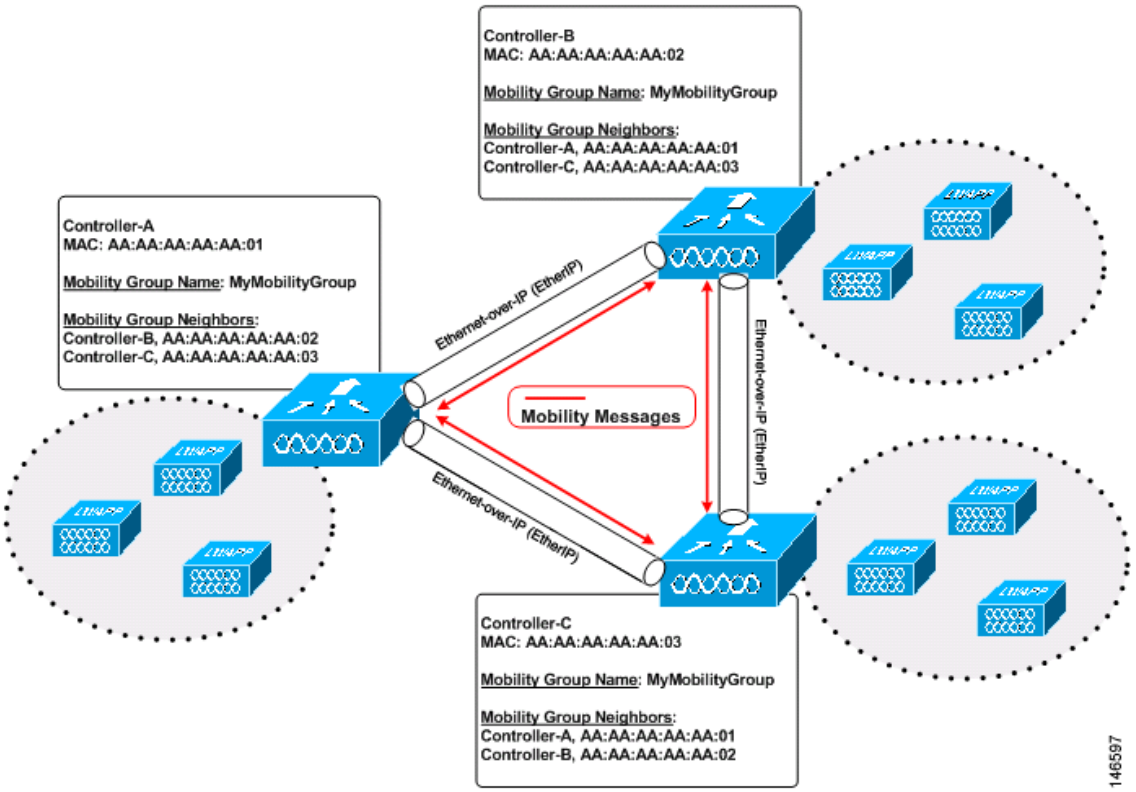
Overview of Mobility Groups

A mobility group is a set of controllers, identified by the same mobility group name, that defines the realm of seamless roaming for wireless clients. By creating a mobility group, you can enable multiple controllers in a network to dynamically share information and forward data traffic when inter-controller

or inter-subnet roaming occurs. Controllers in the same mobility group can share the context and state of client devices as well as their list of access points so that they do not consider each other's access points as rogue devices. With this information, the network can support inter-controller wireless LAN roaming and controller redundancy. Figure 14-4 shows an example of a mobility group.

Note Controllers do not have to be of the same model to be a member of a mobility group. Mobility groups can be comprised of any combination of controller platforms.

Figure 14-4 Single Mobility Group



As shown above, each controller is configured with a list of the other members of the mobility group. Whenever a new client joins a controller, the controller sends out a unicast message (or multicast message if mobility multicast is configured) to all of the controllers in the mobility group. The controller to which the client was previously connected passes on the status of the client.

Note Controller software release 5.1 or later releases support up to 24 controllers in a single mobility group. The number of access points supported in a mobility group is bound by the number of controllers and controller types in the group.

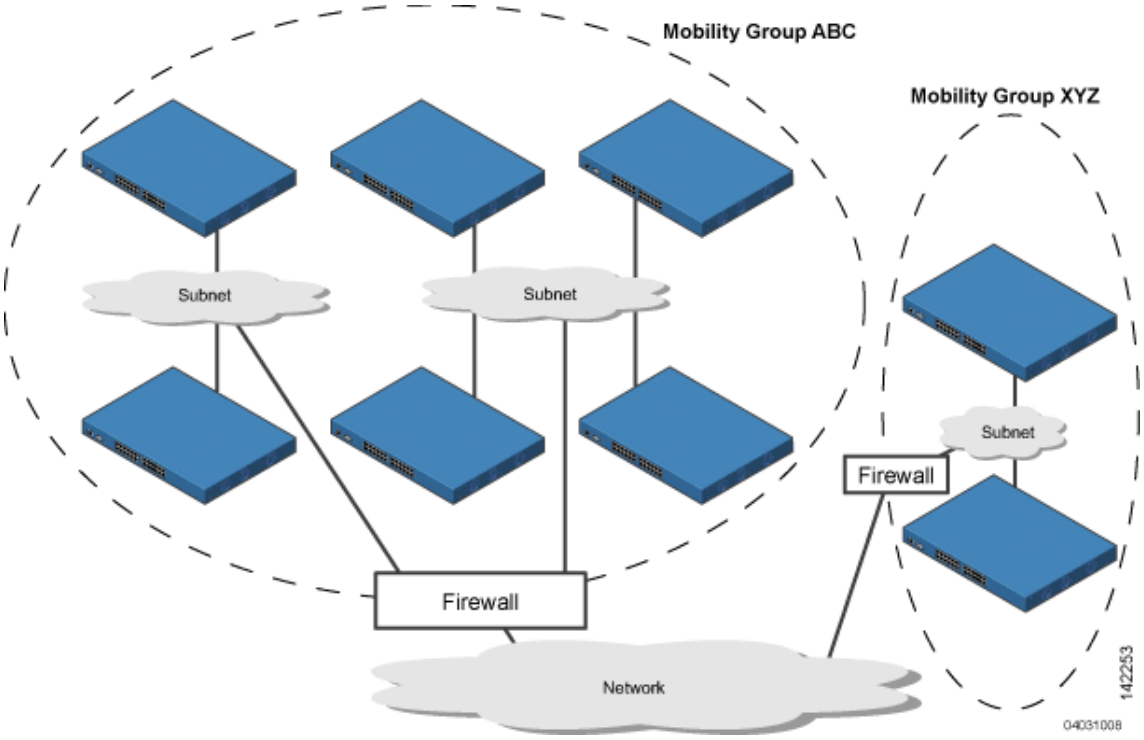
Examples:

1. A 4404-100 controller supports up to 100 access points. Therefore, a mobility group that consists of 24 4404-100 controllers supports up to 2400 access points (24 * 100 = 2400 access points).

2. A 4402-25 controller supports up to 25 access points, and a 4402-50 controller supports up to 50 access points. Therefore, a mobility group that consists of 12 4402-25 controllers and 12 4402-50 controllers supports up to 900 access points (12 * 25 + 12 * 50 = 300 + 600 = 900 access points).

Mobility groups enable you to limit roaming between different floors, buildings, or campuses in the same enterprise by assigning different mobility group names to different controllers within the same wireless network. Figure 14-5 shows the results of creating distinct mobility group names for two groups of controllers.

Figure 14-5 Two Mobility Groups



The controllers in the ABC mobility group share access point and client information with each other. The controllers in the ABC mobility group do not share the access point or client information with the XYZ controllers, which are in a different mobility group. Likewise, the controllers in the XYZ mobility group do not share access point or client information with the controllers in the ABC mobility group. This feature ensures mobility group isolation across the network.

Every controller maintains information about its peer controllers in a mobility list. Controllers can communicate across mobility groups and clients may roam between access points in different mobility groups if the controllers are included in each other's mobility lists. In the following example, controller 1 can communicate with either controller 2 or 3, but controller 2 and controller 3 can communicate only with controller 1 and not with each other. Similarly, clients can roam between controller 1 and controller 2 or between controller 1 and controller 3 but not between controller 2 and controller 3.

Example:

```
Controller 1                Controller 2                Controller 3
Mobility group: A           Mobility group: A           Mobility group: C
Mobility list:              Mobility list:              Mobility list:
    Controller 1 (group A)      Controller 1 (group A)      Controller 1 (group A)
    Controller 2 (group A)      Controller 2 (group A)      Controller 3 (group C)
```

```
Controller 3 (group C)
```

Note Controller software release 5.1 or later releases support up to 72 controllers in a controller's mobility list. The support for 24 controllers in a mobility group has been the same across all releases.

The controller supports seamless roaming across multiple mobility groups. During seamless roaming, the client maintains its IP address across all mobility groups; however, Cisco Centralized Key Management (CCKM) and public key cryptography (PKC) are supported only for inter-mobility-group roaming. When a client crosses a mobility group boundary during a roam, the client is fully authenticated, but the IP address is maintained, and mobility tunneling is initiated for Layer 3 roaming.

Note Controller software release 5.0 release supports up to 48 controllers in a mobility list.

Determining When to Include Controllers in a Mobility Group

If it is possible for a wireless client in your network to roam from an access point joined to one controller to an access point joined to another controller, but both controllers should be in the same mobility group.

Messaging Among Mobility Groups

The controller provides inter-subnet mobility for clients by sending mobility messages to other member controllers. In controller software release 5.0 or later releases, two improvements have been made to mobility messaging, each of which is especially useful when sending messages to the full list of mobility members:

- Sending Mobile Announce messages within the same group first and then to other groups in the list

  The controller sends a Mobile Announce message to members in the mobility list each time that a new client associates to it. In controller software releases prior to 5.0, the controller sends this message to all members in the list irrespective of the group to which they belong. However, in controller software release 5.0 or later releases, the controller sends the message only to those members that are in the same group as the controller (the local group) and then includes all of the other members while sending retries.

- Sending Mobile Announce messages using multicast instead of unicast

  In controller software releases prior to 5.0, the controller sends all mobility messages using unicast mode, which requires sending a copy of the messages to every mobility member. This behavior is not efficient because many messages (such as Mobile Announce, PMK Update, AP List Update, and IDS Shun) are meant for all members in the group. In controller software release 5.0 or later releases, the controller may be configured to use multicast to send the Mobile Announce messages. This behavior allows the controller to send only one copy of the message to the network, which destines it to the multicast group that contains all the mobility members. To derive the maximum benefit from multicast messaging, we recommend that it be enabled on all group members.

Using Mobility Groups with NAT Devices

In controller software releases prior to 4.2, mobility between controllers in the same mobility group does not work if one of the controllers is behind a network address translation (NAT) device. This behavior creates a problem for the guest anchor feature where one controller is expected to be outside the firewall.

Mobility message payloads carry IP address information about the source controller. This IP address is validated with the source IP address of the IP header. This behavior is a problem when a NAT device is introduced in the network because it changes the source IP address in the IP header. In the guest WLAN feature, any mobility packet, that is being routed through a NAT device is dropped because of the IP address mismatch.

In controller software release 4.2 or later releases, the mobility group lookup is changed to use the MAC address of the source controller. Because the source IP address is changed due to the mapping in the NAT device, the mobility group database is searched before a reply is sent to get the IP address of the requesting controller. This process is done using the MAC address of the requesting controller.

When configuring the mobility group in a network where NAT is enabled, enter the IP address that is sent to the controller from the NAT device rather than the controller's management interface IP address. Also, make sure that the following ports are open on the firewall if you are using a firewall such as PIX:

- UDP 16666 for tunnel control traffic
- IP protocol 97 for user data traffic
- UDP 161 and 162 for SNMP

Note Client mobility among controllers works only if auto-anchor mobility (also called guest tunneling) or symmetric mobility tunneling is enabled. Asymmetric tunneling is not supported when mobility controllers are behind the NAT device. See the "Configuring Auto-Anchor Mobility" and "Using Symmetric Mobility Tunneling" sections for details on these mobility options.

Figure 14-6 shows an example mobility group configuration with a NAT device. In this example, all packets pass through the NAT device (that is, packets from the source to the destination and vice versa). Figure 14-7 shows an example mobility group configuration with two NAT devices. In this example, one NAT device is used between the source and the gateway, and the second NAT device is used between the destination and the gateway.

Figure 14-6 Mobility Group Configuration with One NAT Device

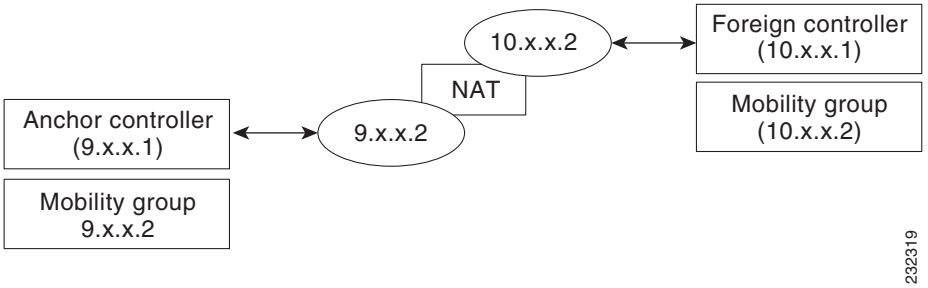
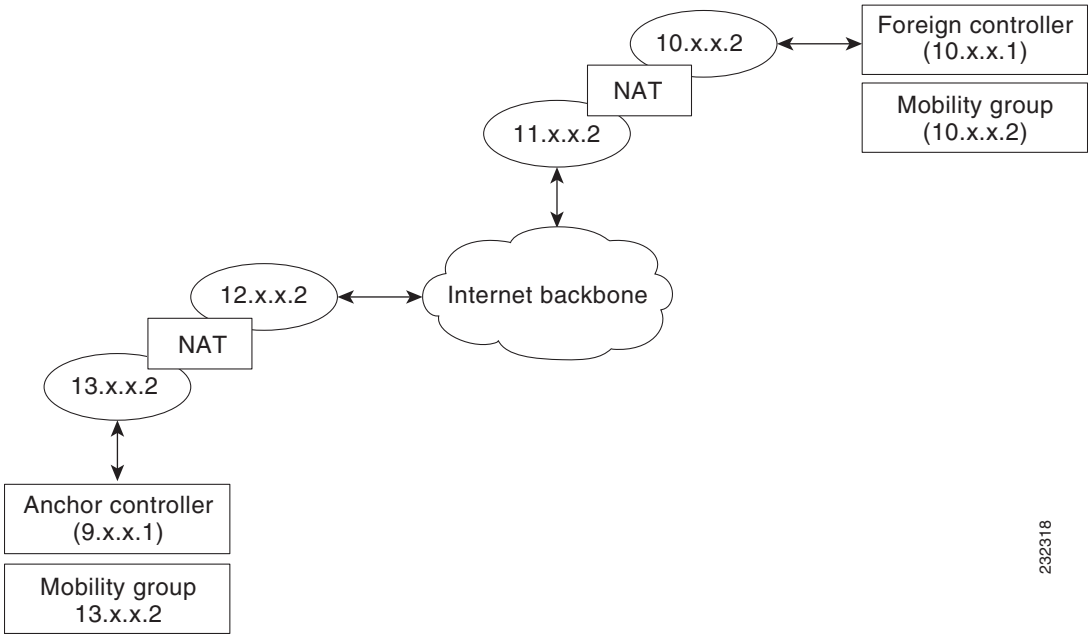


Figure 14-7 Mobility Group Configuration with Two NAT Devices



Configuring Mobility Groups

This section describes how to configure controller mobility groups through either the GUI or the CLI.

Note You can also configure mobility groups using the Cisco Wireless Control System (WCS). See the *Cisco Wireless Control System Configuration Guide* for instructions.

Prerequisites

Before you add controllers to a mobility group, you must verify that the following requirements have been met for all controllers that are to be included in the group:

- IP connectivity must exist between the management interfaces of all controllers.

  Note You can verify IP connectivity by pinging the controllers.

  Note Mobility control packets can use any interface address as the source, based on routing table. It is recommended that all controllers in the mobility group should have the management interface in the same subnet. A topology where one controller's management interface and other controller's dynamic interface are on same subnet not recommended for seamless mobility.

- All controllers must be configured with the same mobility group name.

Note The mobility group name is generally set at deployment time through the Startup Wizard. However, you can change it if necessary through the Default Mobility Domain Name text box on the Controller > General page. The mobility group name is case sensitive.

Note For the Cisco WiSM, both controllers should be configured with the same mobility group name for seamless routing among 300 access points.

Note If one controller in the mobility group is configured for preferred call configuration, other controllers in the mobility group must also be configured with the same preferred call configuration.

- When controllers in the mobility list use different software versions, Layer 2 or Layer 3 clients have limited roaming support. Layer 2 or Layer 3 client roaming is supported only between controllers that use the same version or with controllers that run versions 4.2.X, 6.0.X, and 7.0.X. See Table 14-2 for more information on mobility support across controllers.

  Note If you inadvertently configure a controller that runs software release 5.2 or later releases with a failover controller that runs a different software release (such as 4.2, 5.0, or 5.1), the access point might take a long time to join the failover controller because the access point starts the discovery process in CAPWAP and then changes to LWAPP discovery.

- All controllers must be configured with the same virtual interface IP address.

  Note If necessary, you can change the virtual interface IP address by editing the virtual interface name on the Controller > Interfaces page. See Chapter 3, "Configuring Ports and Interfaces," for more information on the controller's virtual interface.

  Note If all the controllers within a mobility group are not using the same virtual interface, inter-controller roaming may appear to work, but the handoff does not complete, and the client loses connectivity for a period of time.

- You must have gathered the MAC address and IP address of every controller that is to be included in the mobility group. This information is necessary because you will be configuring all controllers with the MAC address and IP address of all the other mobility group members.

  Note You can find the MAC and IP addresses of the other controllers to be included in the mobility group on the Controller > Mobility Groups page of each controller's GUI.

- When you configure mobility groups using a third-party firewall, for example, Cisco PIX, or Cisco ASA, you must open port 16666, and IP protocol 97.
- For inter-controller CAPWAP data and control traffic for releases 5.0, 6.0, and 7.0, you must open the ports 5247 and 5264.

- For inter-controller LWAPP data and control traffic for prior releases to 5.0, do not open ports 12222 and 12223.

Table 14-1 lists the protocols and port numbers that must be used for management and operational purposes:

Table 14-1 Protocol/Service and Port Number

Protocol/Service	Port Number
SSH/Telnet	TCP Port 22 or 29
TFTP	UDP Port 69
NTP	UDP Port 123
SNMP	UDP Port 161 for gets and sets and UDP port 162 for traps.
HTTPS/HTTP	TCP port 443 for HTTPS and port 80 for HTTP
Syslog	TCP port 514
Radius Auth/Account	UDP port 1812 and 1813

Note You cannot perform port address translation (PAT) on the firewall. You must configure one-to-one network address translation (NAT).

Table 14-2 describes support for mobility across controllers with different software versions.

Table 14-2 Mobility Support Across controller versions

CUWN Service	4.2.X.X	5.0.X.X	5.1.X.X	6.0.X.X	7.0.X.X
Layer 2 and Layer 3 Roaming	X	–	–	X	X
Guest access/termination	X	X	X	X	X
Rogue detection	X	–	–	X	X
Fast roaming (CCKM) in a mobility group	X	–	–	X	X
Location services	X	–	–	X	X
Radio Resource Management (RRM)	X	–	–	X	X
Management Frame Protection (MFP)	X	–	–	X	X
AP failover	X	–	–	X	X

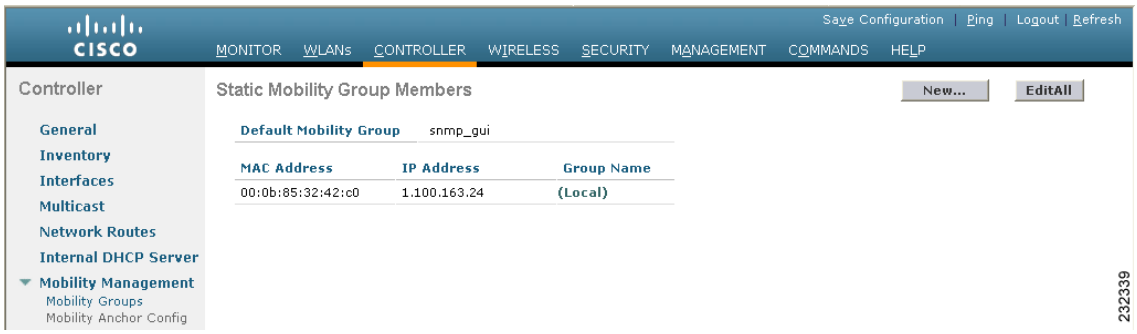
Using the GUI to Configure Mobility Groups

To configure mobility groups using the controller GUI, follow these steps:

Note See the "Using the CLI to Configure Mobility Groups" section on page 14-15 if you would prefer to configure mobility groups using the CLI.

Step 1 Choose **Controller** > **Mobility Management** > **Mobility Groups** to open the Static Mobility Group Members page (see Figure 14-8).

Figure 14-8 Static Mobility Group Members Page



This page shows the mobility group name in the Default Mobility Group text box and lists the MAC address and IP address of each controller that is currently a member of the mobility group. The first entry is the local controller, which cannot be deleted.

Note If you want to delete any of the remote controllers from the mobility group, hover your cursor over the blue drop-down arrow for the desired controller and choose **Remove**.

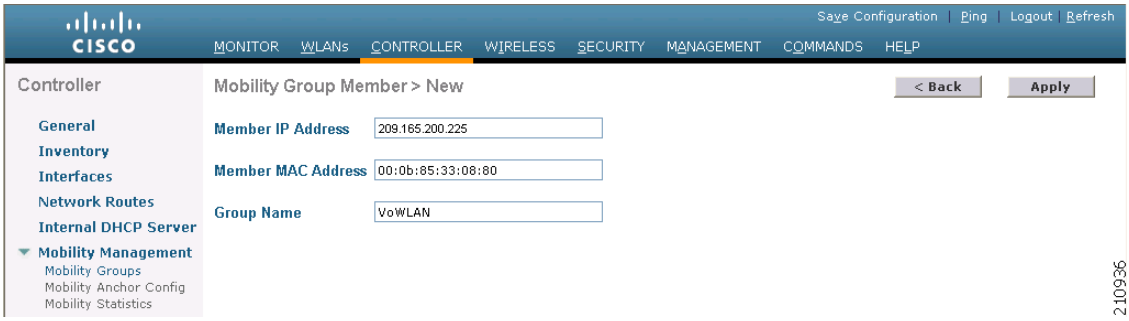
Step 2 Perform one of the following to add controllers to a mobility group:

- If you are adding only one controller or want to individually add multiple controllers, click **New** and go to Step 3.
- If you are adding multiple controllers and want to add them in bulk, click **EditAll** and go to .

Note The EditAll option enables you to enter the MAC and IP addresses of all the current mobility group members and then copy and paste all the entries from one controller to the other controllers in the mobility group.

Step 3 Choose **Controller** > **Mobility Management** > **Mobility Groups** to open the Mobility Group Member > New page (see Figure 14-9).

Figure 14-9 Mobility Group Member > New Page



Step 4 Add a controller to the mobility group as follows:

a. In the Member IP Address text box, enter the management interface IP address of the controller to be added.

Note If you are configuring the mobility group in a network where network address translation (NAT) is enabled, enter the IP address that is sent to the controller from the NAT device rather than the controller's management interface IP address. Otherwise, mobility will fail among controllers in the mobility group.

b. In the Member MAC Address text box, enter the MAC address of the controller to be added.

c. In the Group Name text box, enter the name of the mobility group.

Note The mobility group name is case sensitive.

d. Click **Apply** to commit your changes. The new controller is added to the list of mobility group members on the Static Mobility Group Members page.

e. Click **Save Configuration** to save your changes.

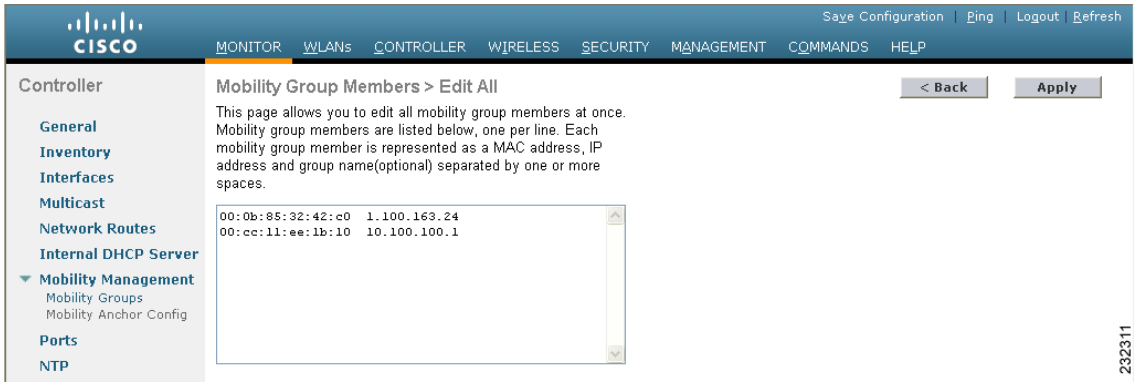
f. Repeat Step a through Step e to add all of the controllers in the mobility group.

g. Repeat this procedure on every controller to be included in the mobility group. All controllers in the mobility group must be configured with the MAC address and IP address of all other mobility group members.

The Mobility Group Members > Edit All page (see Figure 14-10) lists the MAC address, IP address, and mobility group name (optional) of all the controllers currently in the mobility group. The controllers are listed one per line with the local controller at the top of the list.

Note If desired, you can edit or delete any of the controllers in the list.

Figure 14-10 Mobility Group Members > Edit All Page



Step 5 Add more controllers to the mobility group as follows:

a. Click inside the edit box to start a new line.

b. Enter the MAC address, the management interface IP address, and the name of the mobility group for the controller to be added.

Note You should enter these values on one line and separate each value with one or two spaces.

Note The mobility group name is case sensitive.

c. Repeat Step a and Step b for each additional controller that you want to add to the mobility group.

d. Highlight and copy the complete list of entries in the edit box.

e. Click **Apply** to commit your changes. The new controllers are added to the list of mobility group members on the Static Mobility Group Members page.

f. Click **Save Configuration** to save your changes.

g. Paste the list into the text box on the Mobility Group Members > Edit All page of all the other controllers in the mobility group and click **Apply** and **Save Configuration**.

Step 6 Choose **Multicast Messaging** to open the Mobility Multicast Messaging page (see Figure 14-11).

Figure 14-11 Mobility Multicast Messaging Page

The names of all the currently configured mobility groups appear in the middle of the page.

Step 7 On the Mobility Multicast Messaging page, select the **Enable Multicast Messaging** check box to enable the controller to use multicast mode to send Mobile Announce messages to the mobility members. If you leave it unselected, the controller uses unicast mode to send the Mobile Announce messages. The default value is unselected.

Step 8 If you enabled multicast messaging in the previous step, enter the multicast group IP address for the local mobility group in the Local Group Multicast IP Address text box. This address is used for multicast mobility messaging.

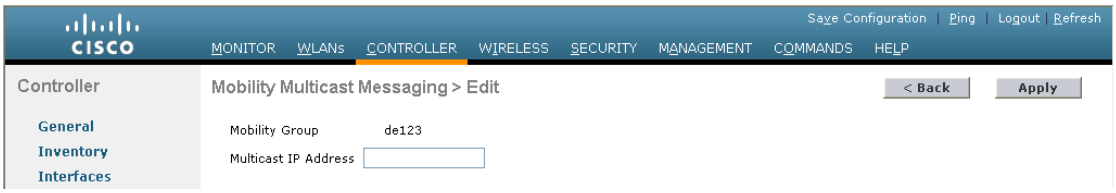
Note In order to use multicast messaging, you must configure the IP address for the local mobility group.

Step 9 Click **Apply** to commit your changes.

Step 10 If desired, you can also configure the multicast group IP address for nonlocal groups within the mobility list. To do so, click the name of a nonlocal mobility group to open the Mobility Multicast Messaging > Edit page (see Figure 14-12), and enter the multicast group IP address for the nonlocal mobility group in the Multicast IP Address text box.

Note If you do not configure the multicast IP address for nonlocal groups, the controller uses unicast mode to send mobility messages to those members.

Figure 14-12 Mobility Multicast Messaging > Edit Page



Step 11 Click **Apply** to commit your changes.

Step 12 Click **Save Configuration** to save your changes.

Using the CLI to Configure Mobility Groups

To configure mobility groups using the controller CLI, follow these steps:

Step 1 Check the current mobility settings by entering this command:

show mobility summary

Information similar to the following appears:

```
Symmetric Mobility Tunneling (current) ..... Enabled
Symmetric Mobility Tunneling (after reboot) ..... Enabled
Mobility Protocol Port..... 16666
Mobility Security Mode..... Disabled
Default Mobility Domain..... snmp_gui
Multicast Mode ..... Disabled
```

```
Mobility Domain ID for 802.11r..................... 0x66bd
Mobility Keepalive Interval....................... 10
Mobility Keepalive Count.......................... 3
Mobility Group Members Configured................. 3
Mobility Control Message DSCP Value.............. 0

Controllers configured in the Mobility Group
 MAC Address        IP Address       Group Name Multicast IP Status
 00:0b:85:32:42:c0 1.100.163.24     snmp_gui     0.0.0.0     Up
 00:cc:11:ee:1b:10 10.100.100.1    VoWLAN        0.0.0.0     Control and Data Path Down
 11:22:11:33:11:44 1.2.3.4         test          0.0.0.0     Control and Data Path Down
```

Step 2 Create a mobility group by entering this command:

config mobility group domain *domain_name*

Note Enter up to 31 case-sensitive ASCII characters for the group name. Spaces are not allowed in mobility group names.

Step 3 Add a group member by entering this command:

config mobility group member add *mac_address ip_address*

Note If you are configuring the mobility group in a network where network address translation (NAT) is enabled, enter the IP address that is sent to the controller from the NAT device rather than the controller's management interface IP address. Otherwise, mobility will fail among controllers in the mobility group.

Note Enter the **config mobility group member delete** *mac_address* command if you want to delete a group member.

Step 4 Enable or disable multicast mobility mode by entering this command:

config mobility multicast-mode {**enable** | **disable**} *local_group_multicast_address*

where *local_group_multicast_address* is the multicast group IP address for the local mobility group. This address is used for multicast mobility messaging.

If you enable multicast mobility mode, the controller uses multicast mode to send Mobile Announce messages to the local group. If you disable multicast mobility mode, the controller uses unicast mode to send the Mobile Announce messages to the local group. The default value is disabled.

Step 5 (Optional) You can also configure the multicast group IP address for nonlocal groups within the mobility list. To do so, enter this command:

config mobility group multicast-address *group_name IP_address*

If you do not configure the multicast IP address for nonlocal groups, the controller uses unicast mode to send mobility messages to those members.

Step 6 Verify the mobility configuration by entering this command:

show mobility summary

Step 7 Save your changes by entering this command:

save config

Step 8 Repeat this procedure on every controller to be included in the mobility group. All controllers in the mobility group must be configured with the MAC address and IP address of all other mobility group members.

Step 9 Enable or disable debugging of multicast usage for mobility messages by entering this command:

debug mobility multicast {**enable** | **disable**}

Viewing Mobility Group Statistics

You can view three types of mobility group statistics from the controller GUI:

- Global statistics—Affect all mobility transactions
- Mobility initiator statistics—Generated by the controller initiating a mobility event
- Mobility responder statistics—Generated by the controller responding to a mobility event

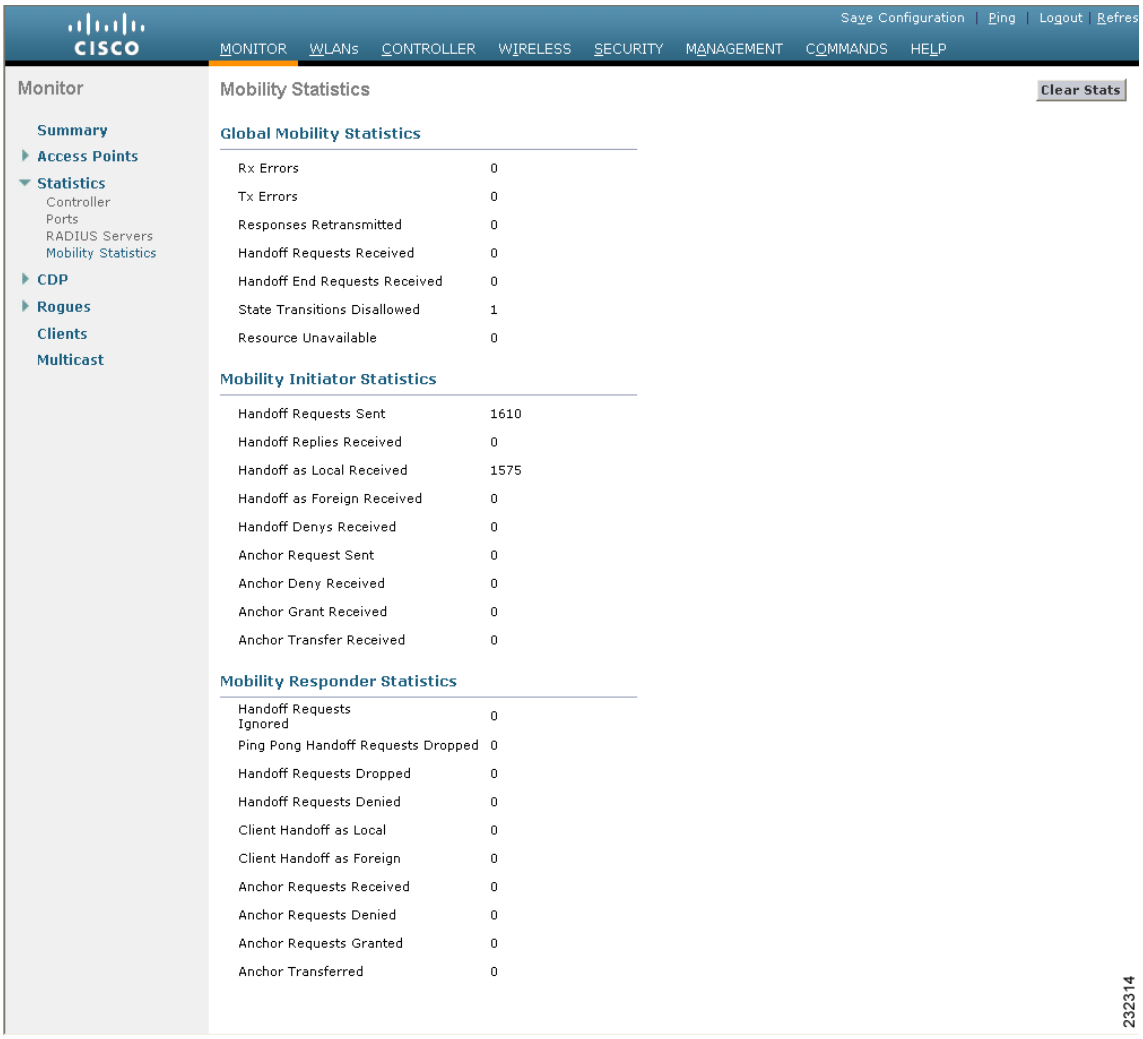
You can view mobility group statistics using the controller GUI or CLI.

Using the GUI to View Mobility Group Statistics

To view mobility group statistics using the controller GUI, follow these steps:

Step 1 Choose **Monitor** > **Statistics** > **Mobility Statistics** to open the Mobility Statistics page (see Figure 14-13).

Figure 14-13 Mobility Statistics Page



Step 2 See Table 14-3 for a description of each statistic.

Table 14-3 Mobility Statistics

Parameter	Description
Group Mobility Statistics	
Rx Errors	Generic protocol packet receive errors, such as packet too short or format incorrect.
Tx Errors	Generic protocol packet transmit errors, such as packet transmission fail.
Responses Retransmitted	Mobility protocol that uses UDP and resends requests several times if it does not receive a response. Because of network or processing delays, the responder may receive one or more retry requests after it initially responds to a request. This text box shows a count of the response resends.

Table 14-3 Mobility Statistics (continued)

Parameter	Description
Handoff Requests Received	Total number of handoff requests received, ignored, or responded to.
Handoff End Requests Received	Total number of handoff end requests received. These requests are sent by the anchor or foreign controller to notify the other about the close of a client session.
State Transitions Disallowed	Policy enforcement module (PEM) that has denied a client state transition, usually resulting in the handoff being aborted.
Resource Unavailable	Necessary resource, such as a buffer, was unavailable, resulting in the handoff being aborted.
Mobility Initiator Statistics	
Handoff Requests Sent	Number of clients that have associated to the controller and have been announced to the mobility group.
Handoff Replies Received	Number of handoff replies that have been received in response to the requests sent.
Handoff as Local Received	Number of handoffs in which the entire client session has been transferred.
Handoff as Foreign Received	Number of handoffs in which the client session was anchored elsewhere.
Handoff Denys Received	Number of handoffs that were denied.
Anchor Request Sent	Number of anchor requests that were sent for a three-party (foreign-to-foreign) handoff. The handoff was received from another foreign controller, and the new controller is requesting the anchor to move the client.
Anchor Deny Received	Number of anchor requests that were denied by the current anchor.
Anchor Grant Received	Number of anchor requests that were approved by the current anchor.
Anchor Transfer Received	Number of anchor requests that closed the session on the current anchor and transferred the anchor back to the requestor.

Table 14-3 Mobility Statistics (continued)

Parameter	Description
Mobility Responder Statistics	
Handoff Requests Ignored	Number of handoff requests or client announcements that were ignored because the controller had no knowledge of that client.
Ping Pong Handoff Requests Dropped	Number of handoff requests that were denied because the handoff period was too short (3 seconds).
Handoff Requests Dropped	Number of handoff requests that were dropped due to either an incomplete knowledge of the client or a problem with the packet.
Handoff Requests Denied	Number of handoff requests that were denied.
Client Handoff as Local	Number of handoff responses sent while the client is in the local role.
Client Handoff as Foreign	Number of handoff responses sent while the client is in the foreign role.
Anchor Requests Received	Number of anchor requests received.
Anchor Requests Denied	Number of anchor requests denied.
Anchor Requests Granted	Number of anchor requests granted.
Anchor Transferred	Number of anchors transferred because the client has moved from a foreign controller to a controller on the same subnet as the current anchor.

Step 3 If you want to clear the current mobility statistics, click **Clear Stats**.

Using the CLI to View Mobility Group Statistics

To view mobility group statistics using the controller CLI, follow these steps:

Step 1 See mobility group statistics by entering this command:

show mobility statistics

Step 2 Refer to Table 14-3 for a description of each statistic.

Step 3 If you want to clear the current mobility statistics, enter this command:

clear stats mobility

Configuring Auto-Anchor Mobility

You can use auto-anchor mobility (also called guest tunneling) to improve load balancing and security for roaming clients on your wireless LANs. Under normal roaming conditions, client devices join a wireless LAN and are anchored to the first controller that they contact. If a client roams to a different

subnet, the controller to which the client roamed sets up a foreign session for the client with the anchor controller. However, when you use the auto-anchor mobility feature, you can specify a controller or set of controllers as the anchor points for clients on a wireless LAN.

In auto-anchor mobility mode, a subset of a mobility group is specified as the anchor controllers for a WLAN. You can use this feature to restrict a WLAN to a single subnet, regardless of a client's entry point into the network. Clients can then access a guest WLAN throughout an enterprise but still be restricted to a specific subnet. Auto-anchor mobility can also provide geographic load balancing because the WLANs can represent a particular section of a building (such as a lobby, a restaurant, and so on), effectively creating a set of home controllers for a WLAN. Instead of being anchored to the first controller that they happen to contact, mobile clients can be anchored to controllers that control access points in a particular vicinity.

When a client first associates to a controller of a mobility group that has been preconfigured as a mobility anchor for a WLAN, the client associates to the controller locally, and a local session is created for the client. Clients can be anchored only to preconfigured anchor controllers of the WLAN. For a given WLAN, you should configure the same set of anchor controllers on all controllers in the mobility group.

When a client first associates to a controller of a mobility group that has not been configured as a mobility anchor for a WLAN, the client associates to the controller locally, a local session is created for the client, and the client is announced to the other controllers in the mobility list. If the announcement is not answered, the controller contacts one of the anchor controllers configured for the WLAN and creates a foreign session for the client on the local switch. Packets from the client are encapsulated through a mobility tunnel using EtherIP and sent to the anchor controller, where they are decapsulated and delivered to the wired network. Packets to the client are received by the anchor controller and forwarded to the foreign controller through a mobility tunnel using EtherIP. The foreign controller decapsulates the packets and forwards them to the client.

In controller software releases prior to 4.1, there is no automatic way of determining if a particular controller in a mobility group is unreachable. As a result, the foreign controller may continually send all new client requests to a failed anchor controller, and the clients remain connected to this failed controller until a session timeout occurs. In controller software release 4.1 or later releases, mobility list members can send ping requests to one another to check the data and control paths among them to find failed members and reroute clients. You can configure the number and interval of ping requests that are sent to each anchor controller. This functionality provides guest N+1 redundancy for guest tunneling and mobility failover for regular mobility.

If multiple controllers are added as mobility anchors for a particular WLAN on a foreign controller, the foregin controller internally sorts the controller by their IP address. The controller with the lowest IP address is the first anchor. For example, a typical ordered list would be 172.16.7.25, 172.16.7.28, 192.168.5.15. If the first client associates to the foreign controller's anchored WLAN, the client database entry is sent to the first anchor controller in the list, the second client is sent to the second controller in the list, and so on, until the end of the anchor list is reached. The process is repeated starting with the first anchor controller. If any of the anchor controller is detected to be down, all the clients anchored to the controller are deauthenticated, and the clients then go through the authentication/anchoring process again in a round-robin manner with the remaining controller in the anchor list. This functionality is also extended to regular mobility clients through mobility failover. This feature enables mobility group members to detect failed members and reroute clients.

Note A Cisco 2100 Series Controller cannot be designated as an anchor for a WLAN. However, a WLAN created on a Cisco 2100 Series Controller can have a Cisco 4400 Series Controller as its anchor.

Note The IPsec and L2TP Layer 3 security policies are unavailable for WLANs that are configured with a mobility anchor.

Guidelines for Using Auto-Anchor Mobility

Follow these guidelines when you configure auto-anchor mobility:

- You must add controllers to the mobility group member list before you can designate them as mobility anchors for a WLAN.
- You can configure multiple controllers as mobility anchors for a WLAN.
- You must disable the WLAN before configuring mobility anchors for it.
- Auto-anchor mobility supports web authorization but does not support other Layer 3 security types.
- You must configure the WLANs on both the foreign controller and the anchor controller with mobility anchors. On the anchor controller, configure the anchor controller itself as a mobility anchor. On the foreign controller, configure the anchor as a mobility anchor.
- Auto-anchor mobility is not supported for use with DHCP option 82.
- When using the guest N+1 redundancy and mobility failover features with a firewall, make sure that the following ports are open:
  - UDP 16666 for tunnel control traffic
  - IP Protocol 97 for user data traffic
  - UDP 161 and 162 for SNMP

Using the GUI to Configure Auto-Anchor Mobility

To create a new mobility anchor for a WLAN using the controller GUI, follow these steps:

Note See the "Using the CLI to Configure Auto-Anchor Mobility" section on page 14-24 if you would prefer to configure auto-anchor mobility using the CLI.

Step 1 Configure the controller to detect failed anchor controllers within a mobility group as follows:

a. Choose **Controller > Mobility Management > Mobility Anchor Config** to open the Mobility Anchor Config page.

b. In the Keep Alive Count text box, enter the number of times a ping request is sent to an anchor controller before the anchor is considered to be unreachable. The valid range is 3 to 20, and the default value is 3.

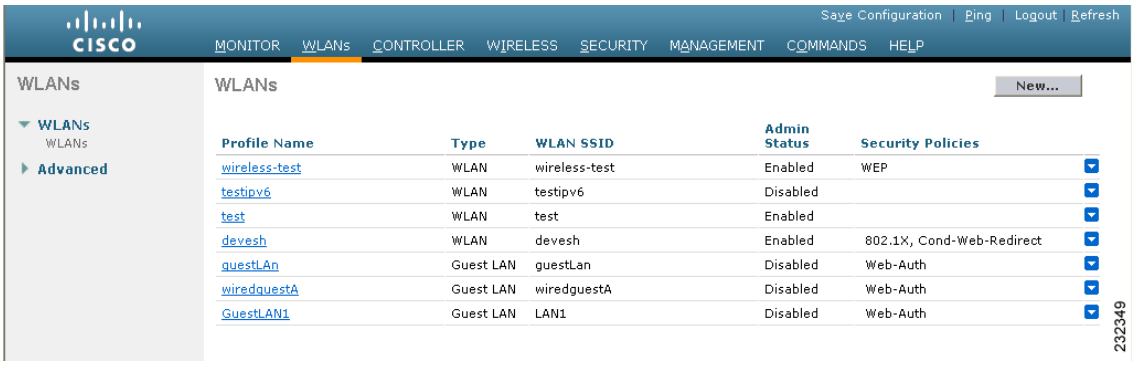
c. In the Keep Alive Interval text box, enter the amount of time (in seconds) between each ping request that is sent to an anchor controller. The valid range is 1 to 30 seconds, and the default value is 10 seconds.

d. In the DSCP Value text box, enter the DSCP value. The default is 0.

e. Click **Apply** to commit your changes.

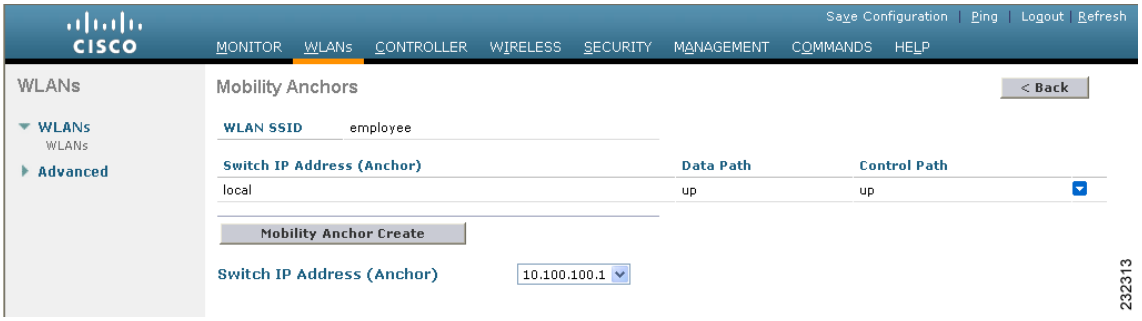
Step 2 Choose **WLANs** to open the WLANs page (see Figure 14-14).

Figure 14-14 WLANs Page



Step 3 Click the blue drop-down arrow for the desired WLAN or wired guest LAN and choose **Mobility Anchors**. The Mobility Anchors page appears (see Figure 14-15).

Figure 14-15 Mobility Anchors Page



This page lists the controllers that have already been configured as mobility anchors and shows the current state of their data and control paths. Controllers within a mobility group communicate among themselves over a well-known UDP port and exchange data traffic through an Ethernet-over-IP (EoIP) tunnel. They send mpings, which test mobility control packet reachability over the management interface over mobility UDP port 16666 and they send epings, which test the mobility data traffic over the management interface over EoIP port 97. The Control Path text box shows whether mpings have passed (up) or failed (down), and the Data Path text box shows whether epings have passed (up) or failed (down). If the Data or Control Path text box shows “down,” the mobility anchor cannot be reached and is considered failed.

Step 4 Select the IP address of the controller to be designated a mobility anchor in the Switch IP Address (Anchor) drop-down list.

Step 5 Click **Mobility Anchor Create**. The selected controller becomes an anchor for this WLAN or wired guest LAN.

Note To delete a mobility anchor for a WLAN or wired guest LAN, hover your cursor over the blue drop-down arrow for the anchor and choose **Remove**.

Step 6 Click **Save Configuration** to save your changes.

Step 7 Repeat Step 4 and Step 6 to set any other controllers as mobility anchors for this WLAN or wired guest LAN.

Step 8 Configure the same set of mobility anchors on every controller in the mobility group.

Using the CLI to Configure Auto-Anchor Mobility

Use these commands to configure auto-anchor mobility using the controller CLI:

Note See the "Using the GUI to Configure Auto-Anchor Mobility" section on page 14-22 for the valid ranges and default values of the parameters used in the CLI commands.

- The controller is programmed to always detect failed mobility list members. To change the parameters for the ping exchange between mobility members, enter these commands:
  - **config mobility group keepalive count** *count*—Specifies the number of times a ping request is sent to a mobility list member before the member is considered to be unreachable. The valid range is 3 to 20, and the default value is 3.
  - **config mobility group keepalive interval** *seconds*—Specifies the amount of time (in seconds) between each ping request sent to a mobility list member. The valid range is 1 to 30 seconds, and the default value is 10 seconds.
- Disable the WLAN or wired guest LAN for which you are configuring mobility anchors by entering this command:

  config {wlan | guest-lan} disable {*wlan_id* | *guest_lan_id*}
- Create a new mobility anchor for the WLAN or wired guest LAN by entering one of these commands:
  - **config mobility group anchor add** {**wlan | guest-lan**} {*wlan_id* | *guest_lan_id*} *anchor_controller_ip_address*
  - **config** {**wlan | guest-lan**} **mobility anchor add** {*wlan_id* | *guest_lan_id*} *anchor_controller_ip_address*

  Note The *wlan_id* or *guest_lan_id* must exist and be disabled, and the *anchor_controller_ip_address* must be a member of the default mobility group.

  Note Auto-anchor mobility is enabled for the WLAN or wired guest LAN when you configure the first mobility anchor.
- Delete a mobility anchor for the WLAN or wired guest LAN by entering one of these commands:
  - **config mobility group anchor delete {wlan | guest-lan}** {*wlan_id* | *guest_lan_id*} *anchor_controller_ip_address*
  - **config {wlan | guest-lan} mobility anchor delete** {*wlan_id* | *guest_lan_id*} *anchor_controller_ip_address*

  Note The *wlan_id* or *guest_lan_id* must exist and be disabled.

Note Deleting the last anchor disables the auto-anchor mobility feature and resumes normal mobility for new associations.

- Save your settings by entering this command:

  save config

- See a list and status of controllers configured as mobility anchors for a specific WLAN or wired guest LAN by entering this command:

  show mobility anchor {**wlan** | **guest-lan**} {*wlan_id* | *guest_lan_id*}

  Note The *wlan_id* and *guest_lan_id* parameters are optional and constrain the list to the anchors in a particular WLAN or guest LAN. To see all of the mobility anchors on your system, enter the **show mobility anchor** command.

  Information similar to the following appears:

```
Mobility Anchor Export List
WLAN ID    IP Address     Status
    1      10.50.234.2    UP
    1      10.50.234.6    UP
    2      10.50.234.2    UP
    2      10.50.234.3    CNTRL_DATA_PATH_DOWN

GLAN ID    IP Address     Status
    1      10.20.100.2    UP
    2      10.20.100.3    UP
```

  The Status text box shows one of these values:

  - UP—The controller is reachable and able to pass data.
  - CNTRL_PATH_DOWN—The mpings failed. The controller cannot be reached through the control path and is considered failed.
  - DATA_PATH_DOWN—The epings failed. The controller cannot be reached and is considered failed.
  - CNTRL_DATA_PATH_DOWN—Both the mpings and epings failed. The controller cannot be reached and is considered failed.

- See the status of all mobility group members by entering this command:

  show mobility summary

  Information similar to the following appears:

```
Mobility Keepalive interval..................... 10
Mobility Keepalive count........................ 3
Mobility Group members configured............... 3

Controllers configured in the mobility group
MAC Address        IP Address     Group Name     Status
00:0b:85:32:b1:80  10.10.1.1      local          Up
00:0b:85:33:a1:70  10.1.1.2       local          Data Path Down
00:0b:85:23:b2:30  10.20.1.2      local          Up
```

- Troubleshoot mobility issues by entering these commands:
  - **debug mobility handoff** {**enable** | **disable**}—Debugs mobility handoff issues.

- **debug mobility keep-alive** {**enable** | **disable**} **all**—Dumps the keepalive packets for all mobility anchors.
- **debug mobility keep-alive** {**enable** | **disable**} *IP_address*—Dumps the keepalive packets for a specific mobility anchor.

WLAN Mobility Security Values

For any anchoring or mobility event, the WLAN security policy values on each controller must match. These values can be validated in the controller debugs. Table 14-4 lists the WLAN mobility security values and their corresponding security policy.

Table 14-4 WLAN Mobility Security Values

Security Hexadecimal Value	Security Policy
0x00000000	Security_None
0x00000001	Security_WEP
0x00000002	Security_802_1X
0x00000004	Security_IPSec*
0x00000008	Security_IPSec_Passthrough*
0x00000010	Security_Web
0x00000020	Security_PPTP*
0x00000040	Security_DHCP_Required
0x00000080	Security_WPA_NotUsed
0x00000100	Security_Cranite_Passthrough*
0x00000200	Security_Fortress_Passthrough*
0x00000400	Security_L2TP_IPSec*
0x00000800	Security_802_11i_NotUsed*
0x00001000	Security_Web_Passthrough

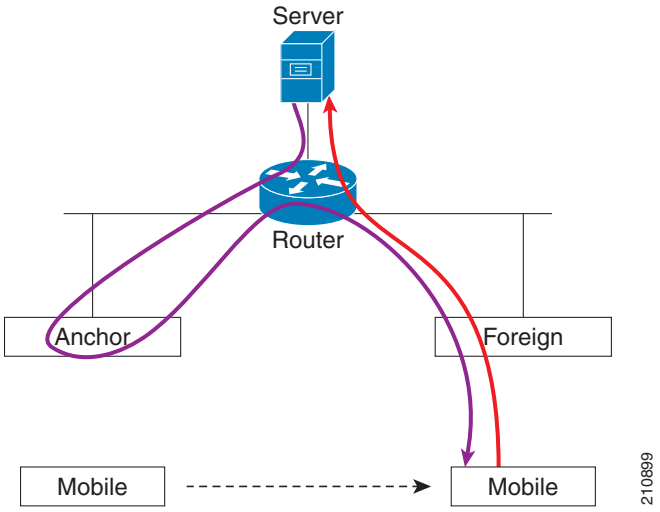
*Controllers running software release 6.0 or later releases do not support this security policy.

Using Symmetric Mobility Tunneling

Controller software releases 4.1 through 5.1 support both asymmetric and symmetric mobility tunneling. Controller software release 5.2 or later releases support only symmetric mobility tunneling, which is now always enabled by default.

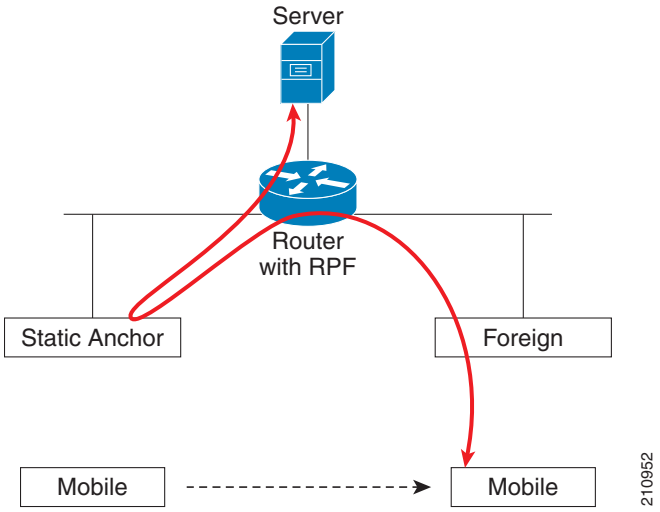
In asymmetric tunneling, client traffic to the wired network is routed directly through the foreign controller, as shown in Figure 14-16.

Figure 14-16 Asymmetric Tunneling or Uni-Directional Tunneling



Asymmetric tunneling breaks when an upstream router has reverse path filtering (RPF) enabled. In this case, the client traffic is dropped at the router because the RPF check ensures that the path back to the source address matches the path from which the packet is coming. When symmetric mobility tunneling is enabled, all client traffic is sent to the anchor controller and can then successfully pass the RPF check, as shown in Figure 14-17.

Figure 14-17 Symmetric Mobility Tunneling or Bi-Directional Tunneling



Symmetric mobility tunneling is also useful in the following situations:

- If a firewall installation in the client packet path drops packets because the source IP address does not match the subnet on which the packets are received.
- If the access-point group VLAN on the anchor controller is different than the WLAN interface VLAN on the foreign controller. In this case, client traffic could be sent on an incorrect VLAN during mobility events.

Note Although a Cisco 2100 Series Controller cannot be designated as an anchor for a WLAN when you are using auto-anchor mobility, it can serve as an anchor in symmetric mobility tunneling to process and forward the upstream client data traffic tunneled from the foreign controller.

Both the controller GUI and CLI show that symmetric mobility tunneling is enabled on the controller:

- To use the controller GUI to verify that symmetric mobility tunneling is enabled, choose **Controller > Mobility Management > Mobility Anchor Config** to open the Mobility Anchor Config page (see Figure 14-18). The Symmetric Mobility Tunneling Mode text box shows Enabled.

Figure 14-18 Mobility Anchor Config Page

- To use the controller CLI to verify that symmetric mobility tunneling is enabled, enter this command:

  show mobility summary

  Information similar to the following appears:

```
Symmetric Mobility Tunneling (current) .......... Enabled
Symmetric Mobility Tunneling (after reboot) ..... Enabled
Mobility Protocol Port........................... 16666
Mobility Security Mode........................... Disabled
Default Mobility Domain.......................... User1
Mobility Keepalive interval...................... 10
Mobility Keepalive count......................... 3
Mobility Group members configured................ 7

Controllers configured in the Mobility Group
MAC Address         IP Address    Group Name      Status
00:0b:85:32:b0:80    10.28.8.30       User1        Up
00:0b:85:47:f6:00    10.28.16.10      User1        Up
00:16:9d:ca:d8:e0    10.28.32.10      User1        Up
00:18:73:34:a9:60    10.28.24.10      <local>      Up
00:18:73:36:55:00    10.28.8.10       User1        Up
00:1a:a1:c1:7c:e0    10.28.32.30      User1        Up
00:d0:2b:fc:90:20   10.28.32.61     User1        Control and Data Path Down
```

Running Mobility Ping Tests

Controllers in a mobility list communicate with each other by controlling information over a well-known UDP port and exchanging data traffic through an Ethernet-over-IP (EoIP) tunnel. Because UDP and EoIP are not reliable transport mechanisms, there is no guarantee that a mobility control packet or data packet will be delivered to a mobility peer. Mobility packets may be lost in transit due to a firewall filtering the UDP port or EoIP packets or due to routing issues.

Controller software release 4.0 or later releases enable you to test the mobility communication environment by performing mobility ping tests. These tests may be used to validate connectivity between members of a mobility group (including guest controllers). Two ping tests are available:

- Mobility ping over UDP—This test runs over mobility UDP port 16666. It tests whether the mobility control packet can be reached over the management interface.
- Mobility ping over EoIP—This test runs over EoIP. It tests the mobility data traffic over the management interface.

Only one mobility ping test per controller can be run at a given time.

Note These ping tests are not Internet Control Message Protocol (ICMP) based. The term “ping” is used to indicate an echo request and an echo reply message.

Note Any ICMP packet greater than 1280 bytes will always be responded with a packet that is truncated to 1280 bytes. For example, a ping with a packet that is greater than 1280 bytes from a host to the management interface is always responded with a packet that is truncated to 1280 bytes.

Use these commands to run mobility ping tests using the controller CLI:

- To test the mobility UDP control packet communication between two controllers, enter this command:

  mping *mobility_peer_IP_address*

  The *mobility_peer_IP_address* parameter must be the IP address of a controller that belongs to the mobility list.

- To test the mobility EoIP data packet communication between two controllers, enter this command:

  eping *mobility_peer_IP_address*

  The *mobility_peer_IP_address* parameter must be the IP address of a controller that belongs to the mobility list.

- To troubleshoot your controller for mobility ping, enter these commands:

  config logging buffered debugging

  show logging

  To troubleshoot your controller for mobility ping over UDP, enter this command to display the mobility control packet:

  debug mobility handoff enable

  Note We recommend using an ethereal trace capture when troubleshooting.

Configuring Dynamic Anchoring for Clients with Static IP Addresses

At times you may want to configure static IP addresses for wireless clients. When these wireless clients move about in a network, they could try associating with other controllers. If the clients try to associate with a controller that does not support the same subnet as the static IP, the clients fail to connect to the network. You can now enable dynamic tunneling of clients with static IP addresses.

Dynamic anchoring of static IP clients with static IP addresses can be associated with other controllers where the client's subnet is supported by tunneling the traffic to another controller in the same mobility group. This feature enables you to configure your WLAN so that the network is serviced even though the clients use static IP addresses.

How Dynamic Anchoring of Static IP Clients Works

The following sequence of steps occur when a client with a static IP address tries to associate with a controller:

1. When a client associates with a controller, for example, WLC-1, it performs a mobility announcement. If a controller in the mobility group responds (for example WLC-2), the client traffic is tunneled to the controller WLC-2. As a result, the controller WLC 1 becomes the foreign controller and WLC-2 becomes the anchor controller.
2. If none of the controllers respond, the client is treated as a local client and authentication is performed. The IP address for the client is updated either through an orphan packet handling or an ARP request processing. If the client's IP subnet is not supported in the controller (WLC-1), WLC-1 sends another static IP mobile announce and if a controller (for example WLC-3) which supports the clients subnet responds to that announce, the client traffic is tunneled to that controller WLC-3. As a result, the controller WLC 1 becomes the export foreign controller and WLC-2 becomes the export anchor controller.
3. Once the acknowledgement is received, the client traffic is tunneled between the anchor and the controller (WLC-1).

Note If you configure WLAN with an interface group and any of the interfaces in the interface group supports the static IP client subnet, the client is assigned to that interface. This situation occurs in local or remote (static IP Anchor) controller.

Note A security level 2 authentication is performed only in the local (static IP foreign) controller, which is also known as the exported foreign controller.

Note Do not configure overridden interfaces when you perform AAA for static IP tunneling, this is because traffic can get blocked for the client if the overridden interface does not support the client's subnet. This can be possible in extreme cases where the overriding interface group supports the client's subnet.

Note The local controller must be configured with the correct AAA server where this client entry is present.

The following restrictions apply when configuring static IP tunneling with other features on the same WLAN:

- Auto anchoring mobility (guest tunneling) cannot be configured for the same WLAN.
- Hybrid-REAP local authentication cannot be configured for the same WLAN.
- The DHCP required option cannot be configured for the same WLAN.

Note You cannot configure dynamic anchoring of static IP clients with hybrid REAP local switching.

Using the GUI to Configure Dynamic Anchoring of Static IP Clients

To configure dynamic anchoring of static IP clients using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the WLAN on which you want to enable dynamic anchoring of IP clients. The WLANs > Edit page is displayed.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page.

Step 4 Enable dynamic anchoring of static IP clients by selecting the **Static IP Tunneling** check box.

Step 5 Click **Apply** to commit your changes.

Using the CLI to Configure Dynamic Anchoring of Static IP Clients

To configure dynamic anchoring of Static IP clients using the controller CLI, use the following commands:

config wlan static-ip tunneling {enable | disable} *wlan_id*— Enables or disables the dynamic anchoring of static IP clients on a given WLAN.

To monitor and troubleshoot your controller for clients with static IP, use the following commands:

- **show wlan** *wlan_id*—Enables you to see the status of the static IP clients feature.

```
.............
Static IP client tunneling..... Enabled
.............
```

- **debug client** *client-mac*
- **debug dot11 mobile** enable
- **debug mobility handoff** enable

Configuring Foreign Mappings

Auto-Anchor mobility, also known as Foreign Mapping, allows you to configure users that are on different foreign controllers to obtain IP addresses from a subnet or group of subnets.

Using the GUI to Configure Foreign MAC Mapping

To configure a foreign mapping using the controller GUI, follow these steps:

Step 1 Choose the WLANs tab.

The WLANs page appears listing the available WLANs.

Step 2 Click the Blue drop down arrow for the desired WLAN and choose **Foreign-Maps**.

The foreign mappings page appears. This page also lists the MAC addresses of the foreign controllers that are in the mobility group and interfaces/interface groups.

Step 3 Choose the desired foreign controller MAC and the interface or interface group to which it must be mapped and click on **Add Mapping**.

Using the CLI to Configure Foreign Controller MAC Mapping

To configure foreign controller MAC mapping, use this command:

config wlan mobility foreign-map add *wlan-id foreign_ctlr_mac interface/interface_grp name*

To configure a foreign mappings, use this command:

config wlan mobility foreign-map add *wlan_id interface*

CHAPTER 15

Configuring Hybrid REAP

This chapter describes hybrid REAP and explains how to configure this feature on controllers and access points. It contains these sections:

Overview of Hybrid REAP

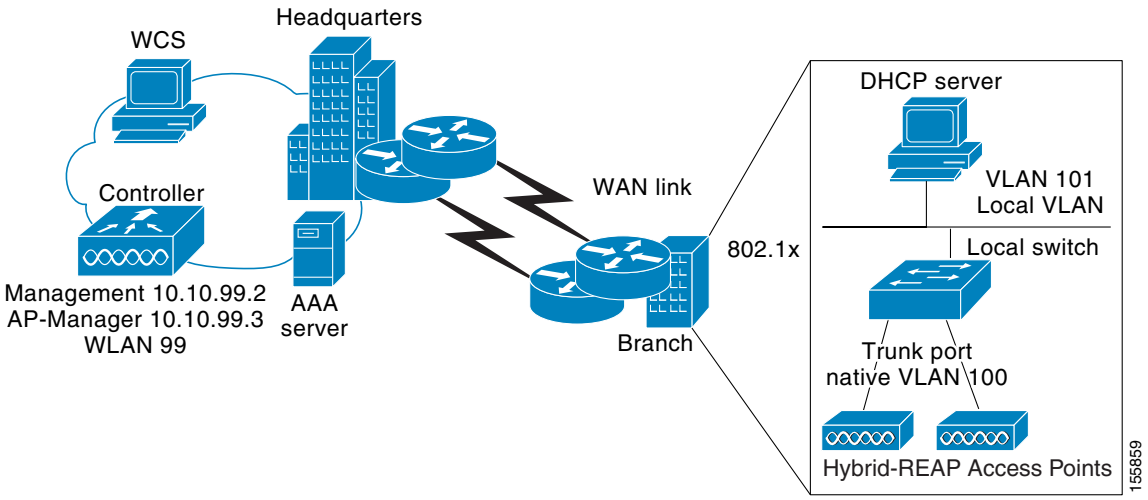
Hybrid REAP is a wireless solution for branch office and remote office deployments. It enables customers to configure and control access points in a branch or remote office from the corporate office through a wide area network (WAN) link without deploying a controller in each office. The hybrid-REAP access points can switch client data traffic locally and perform client authentication locally when their connection to the controller is lost. When they are connected to the controller, they can also send traffic back to the controller. In connected mode, the hybrid REAP access point can also perform local authentication.

Hybrid REAP is supported only on the 1130AG, 1140, 1240, 1250, 1260, AP801, AP802, and AP3550 access points on the Cisco WiSM, Cisco 5500, 4400, 2100, 2500, and Flex 7500 Series Controllers, the Catalyst 3750G Integrated Wireless LAN Controller Switch; the Controller Network Module for Integrated Services Routers. Figure 15-1 shows a typical hybrid-REAP deployment.

Note Do not connect hybrid REAP access points directly to any physical port on Cisco 2100 or 2500 Series Controller platform.

Note A newly connected access point cannot be booted in hybrid REAP mode.

Figure 15-1 Hybrid-REAP Deployment



There is no deployment restriction on the number of hybrid-REAP access points per location. However, the minimum bandwidth restriction remains 128 kbps with the roundtrip latency no greater than 300 ms and the maximum transmission unit (MTU) no smaller than 500 bytes.

Hybrid-REAP Authentication Process

When an access point boots up, it looks for a controller. If it finds one, it joins the controller, downloads the latest software image and configuration from the controller, and initializes the radio. It saves the downloaded configuration in nonvolatile memory for use in standalone mode.

Note Once the access point is rebooted after downloading the latest controller software, it must be converted to the hybrid REAP mode. This can done using the GUI or CLI.

A hybrid-REAP access point can learn the controller IP address in one of these ways:

- If the access point has been assigned an IP address from a DHCP server, it can discover a controller through the regular CAPWAP or LWAPP discovery process.

  Note OTAP is no longer supported on the controllers with 6.0.196 code and above.

- If the access point has been assigned a static IP address, it can discover a controller through any of the discovery process methods except DHCP option 43. If the access point cannot discover a controller through Layer 3 broadcast, we recommend DNS resolution. With DNS, any access point with a static IP address that knows of a DNS server can find at least one controller.
- If you want the access point to discover a controller from a remote network where CAPWAP or LWAPP discovery mechanisms are not available, you can use priming. This method enables you to specify (through the access point CLI) the controller to which the access point is to connect.

Note See Chapter 8, "Controlling Lightweight Access Points," or the controller deployment guide at this URL for more information on how access points find controllers: http://www.cisco.com/en/US/docs/wireless/technology/controller/deployment/guide/dep.html

When a hybrid-REAP access point can reach the controller (referred to as *connected mode*), the controller assists in client authentication. When a hybrid-REAP access point cannot access the controller, the access point enters standalone mode and authenticates clients by itself.

Note The LEDs on the access point change as the device enters different hybrid-REAP modes. See the hardware installation guide for your access point for information on LED patterns.

When a client associates to a hybrid-REAP access point, the access point sends all authentication messages to the controller and either switches the client data packets locally (locally switched) or sends them to the controller (centrally switched), depending on the WLAN configuration. With respect to client authentication (open, shared, EAP, web authentication, and NAC) and data packets, the WLAN can be in any one of the following states depending on the configuration and state of controller connectivity:

- central authentication, central switching—In this state, the controller handles client authentication, and all client data is tunneled back to the controller. This state is valid only in connected mode.
- central authentication, local switching—In this state, the controller handles client authentication, and the hybrid-REAP access point switches data packets locally. After the client authenticates successfully, the controller sends a configuration command with a new payload to instruct the hybrid-REAP access point to start switching data packets locally. This message is sent per client. This state is applicable only in connected mode.
- local authentication, local switching—In this state, the hybrid-REAP access point handles client authentication and switches client data packets locally. This state is valid in standalone mode and connected mode.

  In connected mode, the access point provides minimal information about the locally authenticated client to the controller. The following information is not available to the controller:

  - Policy type
  - Access VLAN
  - VLAN name
  - Supported rates
  - Encryption cipher

  Local authentication is useful where you cannot maintain a remote office setup of a minimum bandwidth of 128 kbps with the round-trip latency no greater than 100 ms and the maximum transmission unit (MTU) no smaller than 500 bytes. In local authentication, the authentication capabilities are present in the access point itself. Local authentication reduces the latency requirements of the branch office.

Note Local authentication can only be enabled on the WLAN of a hybrid-REAP access point that is in local switching mode.

Notes about local authentication are as follows:

- Guest authentication cannot be done on a hybrid-REAP local authentication-enabled WLAN.

  - Local RADIUS on the controller is not supported.
  - Once the client has been authenticated, roaming is only supported after the controller and the other hybrid REAP access points in the group are updated with the client information.
  - Local authentication in connected mode requires a WLAN configuration.

Note When locally switched clients that are connected to a hybrid REAP access point renew the IP addresses, on joining back, the client continues to stay in the run state. These clients are not reauthenticated by the controller.

- authentication down, switch down—In this state, the WLAN disassociates existing clients and stops sending beacon and probe requests. This state is valid in both standalone mode and connected mode.
- authentication down, local switching—In this state, the WLAN rejects any new clients trying to authenticate, but it continues sending beacon and probe responses to keep existing clients alive. This state is valid only in standalone mode.

When a hybrid-REAP access point enters standalone mode, WLANs that are configured for open, shared, WPA-PSK, or WPA2-PSK authentication enter the "local authentication, local switching" state and continue new client authentications. In controller software release 4.2 or later releases, this configuration is also correct for WLANs that are configured for 802.1X, WPA-802.1X, WPA2-802.1X, or CCKM, but these authentication types require that an external RADIUS server be configured. You can also configure a local RADIUS server on a HREAP access point to support 802.1X in a standalone mode or with local authentication.

Other WLANs enter either the "authentication down, switching down" state (if the WLAN was configured for central switching) or the "authentication down, local switching" state (if the WLAN was configured for local switching).

When hybrid-REAP access points are connected to the controller (rather than in standalone mode), the controller uses its primary RADIUS servers and accesses them in the order specified on the RADIUS Authentication Servers page or in the **config radius auth add** CLI command (unless the server order is overridden for a particular WLAN). However, to support 802.1X EAP authentication, hybrid-REAP access points in standalone mode need to have their own backup RADIUS server to authenticate clients.

Note A controller does not use a backup RADIUS server. The controller uses the backup RADIUS server in local authentication mode.

You can configure a backup RADIUS server for individual hybrid-REAP access points in standalone mode by using the controller CLI or for groups of hybrid-REAP access points in standalone mode by using either the GUI or CLI. A backup server configured for an individual access point overrides the backup RADIUS server configuration for a hybrid-REAP.

When a hybrid-REAP access point enters standalone mode, it disassociates all clients that are on centrally switched WLANs. For web-authentication WLANs, existing clients are not disassociated, but the hybrid-REAP access point stops sending beacons when the number of associated clients reaches zero (0). It also sends disassociation messages to new clients associating to web-authentication WLANs. Controller-dependent activities, such as network access control (NAC) and web authentication (guest access), are disabled, and the access point does not send any intrusion detection system (IDS) reports to the controller. Most radio resource management (RRM) features (such as neighbor discovery; noise, interference, load, and coverage measurements; use of the neighbor list; and rogue containment and detection) are disabled. However, a hybrid-REAP access point supports dynamic frequency selection in standalone mode.

Note If your controller is configured for NAC, clients can associate only when the access point is in connected mode. When NAC is enabled, you need to create an unhealthy (or quarantined) VLAN so that the data traffic of any client that is assigned to this VLAN passes through the controller, even if the WLAN is configured for local switching. After a client is assigned to a quarantined VLAN, all of its data packets are centrally switched. See the "Configuring Dynamic Interfaces" section on page 3-18 for information on creating quarantined VLANs and the "Configuring NAC Out-of-Band Integration" section on page 7-68 for information on configuring NAC out-of-band support.

When a hybrid-REAP access point enters into a standalone mode, the following occurs:

- The access point checks whether it is able to reach the default gateway via ARP. If so, it will continue to try and reach the controller.

If the access point fails to establish the ARP, the following will occur.

- The access point attempts to discover for five times and if it still cannot find the controller, it tries to renew the DHCP on the ethernet interface to get a new DHCP IP.
- The access point will retry for five times, and if that fails, the access point will renew the IP address of the interface again, this will happen for three attempts.
- If the three attempts fail, the access point will fall back to the static IP and will reboot (only if the access point is configured with a static IP).
- Reboot is done to remove the possibility of any unknown error the access point configuration.

Once the access point reestablishes a connection with the controller, it disassociates all clients, applies new configuration information from the controller, and reallows client connectivity.

Starting release 7.0.116.0 and later releases, the controller software release has added a more robust fault tolerance methodology to hybrid REAP access points. In previous releases, whenever a hybrid REAP access point disassociates from a controller, it moves to the standalone mode. The clients that are centrally switched are disassociated. However, the hybrid REAP access point continues to serve locally switched clients. When the hybrid REAP access point rejoins the controller (or a standby controller), all clients are disconnected and are authenticated again. In the controller software 7.0.116.0 and later releases, this functionality has been enhanced and the connection between the clients and the hybrid REAP access points are maintained intact and the clients experience seameless connectivity.

Note This feature can be used only when both the access point and the controller have the same configuration.

Note Clients that are centrally authenticated are reauthenticated.

Note Client connections are restored only for locally switched clients that are in the RUN state when the access point moves from the standalone mode to the connected mode. After the access point moves from the standalone mode to the connected mode, the access point's radio is also reset.

Note The configuration on the controller must be the same between the time the access point went into standalone mode and the time the access point came back to connected mode. Similarly, if the access point is falling back to a secondary or backup controller, the configuration between the primary and secondary or backup controller must be the same.

Session timeout and reauthentication is performed when the access point establishes a connected to the controller.

After the client connection has been established, the controller does not restore the original attributes of the client. The client username, current rate and supported rates, and listen interval values are reset to the default values only after the session timer expires.

Hybrid-REAP Guidelines

Follow these guidelines when using hybrid REAP:

- You can deploy a hybrid-REAP access point with either a static IP address or a DHCP address. In the case of DHCP, a DHCP server must be available locally and must be able to provide the IP address for the access point at bootup.
- Hybrid REAP supports up to four fragmented packets or a minimum 500-byte maximum transmission unit (MTU) WAN link.
- Round-trip latency must not exceed 300 milliseconds (ms) between the access point and the controller, and CAPWAP control packets must be prioritized over all other traffic. In cases where you cannot achieve the 300 milliseconds round-trip latency, you can configure the access point to perform local authentication. See the "Hybrid-REAP Authentication Process" section on page 15-2 to know more about hybrid-REAP local authentication using local authentication and local switching.
- The controller can send multicast packets in the form of unicast or multicast packets to the access point. In hybrid-REAP mode, the access point can receive multicast packets only in unicast form.
- To use CCKM fast roaming with hybrid-REAP access points, you must configure hybrid-REAP Groups. See the "Configuring Hybrid-REAP Groups" section on page 15-18 for more information.
- Hybrid-REAP access points support a 1-1 network address translation (NAT) configuration. They also support port address translation (PAT) for all features except true multicast. Multicast is supported across NAT boundaries when configured using the Unicast option. Hybrid-REAP access points also support a many-to-one NAT/PAT boundary, except when you want true multicast to operate for all centrally switched WLANs.

  Note Although NAT and PAT are supported for hybrid-REAP access points, they are not supported on the corresponding controller. Cisco does not support configurations in which the controller is behind a NAT/PAT boundary.

- VPN and PPTP are supported for locally switched traffic if these security types are accessible locally at the access point.
- Hybrid-REAP access points support multiple SSIDs. See the "Using the CLI to Create WLANs" section on page 7-6 for more information.
- NAC out-of-band integration is supported only on WLANs configured for hybrid-REAP central switching. It is not supported for use on WLANs configured for hybrid-REAP local switching. See the "Configuring NAC Out-of-Band Integration" section on page 7-68 for more information.
- The primary and secondary controllers for a hybrid-REAP access point must have the same configuration. Otherwise, the access point might lose its configuration, and certain features (such as WLAN override, VLANs, static channel number, and so on) might not operate correctly. In addition, make sure to duplicate the SSID of the hybrid-REAP access point and its index number on both controllers.

- The QoS profile per-user bandwidth contracts are not supported for H-REAP locally switched WLANs. The QoS per-user bandwidth contracts are only supported for centrally switched WLANs and APs in the local mode.

Note If you configure a hybrid REAP access point with a syslog server configured on the access point, after the access point is reloaded and the native VLAN other than 1, at time of initialization, few syslog packets from the access point are tagged with VLAN ID 1. This is a known issue.

Configuring Hybrid REAP

To configure hybrid REAP, you must follow the instructions in these sections in the order provided:

- Configuring the Switch at the Remote Site, page 15-7
- Configuring the Controller for Hybrid REAP, page 15-8
- Configuring an Access Point for Hybrid REAP, page 15-13
- Connecting Client Devices to the WLANs, page 15-18

Configuring the Switch at the Remote Site

To prepare the switch at the remote site, follow these steps:

Step 1 Attach the access point that will be enabled for hybrid REAP to a trunk or access port on the switch.

Note The sample configuration in this procedure shows the hybrid-REAP access point connected to a trunk port on the switch.

Step 2 See the sample configuration in this procedure to configure the switch to support the hybrid-REAP access point.

In this sample configuration, the hybrid-REAP access point is connected to trunk interface FastEthernet 1/0/2 with native VLAN 100. The access point needs IP connectivity on the native VLAN. The remote site has local servers/resources on VLAN 101. A DHCP pool is created in the local switch for both VLANs in the switch. The first DHCP pool (NATIVE) is used by the hybrid-REAP access point, and the second DHCP pool (LOCAL-SWITCH) is used by the clients when they associate to a WLAN that is locally switched. The bolded text in the sample configuration shows these settings.

Note The addresses in this sample configuration are for illustration purposes only. The addresses that you use must fit into your upstream network.

A sample local switch configuration is as follows:

```
ip dhcp pool NATIVE
   network 10.10.100.0 255.255.255.0
   default-router 10.10.100.1
!
ip dhcp pool LOCAL-SWITCH
   network 10.10.101.0 255.255.255.0
   default-router 10.10.101.1
```

```
!
interface FastEthernet1/0/1
 description Uplink port
 no switchport
 ip address 10.10.98.2 255.255.255.0
 spanning-tree portfast
!
interface FastEthernet1/0/2
 description the Access Point port
 switchport trunk encapsulation dot1q
 switchport trunk native vlan 100
 switchport trunk allowed vlan 100,101
 switchport mode trunk
 spanning-tree portfast
!
interface Vlan100
 ip address 10.10.100.1 255.255.255.0
 ip helper-address 10.10.100.1
!
interface Vlan101
 ip address 10.10.101.1 255.255.255.0
 ip helper-address 10.10.101.1
end
!
```

Configuring the Controller for Hybrid REAP

This section describes how to configure the controller for hybrid REAP using either the controller GUI or the CLI.

Using the GUI to Configure the Controller for Hybrid REAP

The controller configuration for hybrid REAP consists of creating centrally switched and locally switched WLANs. Table 15-1 shows the three WLANs as an example.

Table 15-1 WANs Example

WLAN	Security	Authentication	Switching	Interface Mapping (VLAN)
employee	WPA1+WPA2	Central	Central	management (centrally switched VLAN)
employee-local	WPA1+WPA2 (PSK)	Local	Local	101 (locally switched VLAN)
guest-central	Web authentication	Central	Central	management (centrally switched VLAN)
employee-local-auth	WPA1+WPA2	Local	Local	101 (locally switched VLAN)

Note See the "Using the CLI to Configure the Controller for Hybrid REAP" section on page 15-12 if you would prefer to configure the controller for hybrid REAP using the CLI.

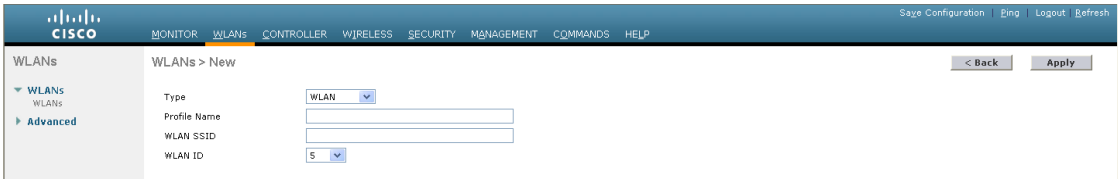
To configure the controller for these WLANs, follow these steps:

Step 1 Create a centrally switched WLAN (in our example, this is the first WLAN (employee)) as follows:

a. Choose **WLANs** to open the WLANs page.

b. From the drop-down list, choose **Create New** and click **Go** to open the WLANs > New page (see Figure 15-2).

Figure 15-2 WLANs > New Page



c. From the Type drop-down list, choose **WLAN**.

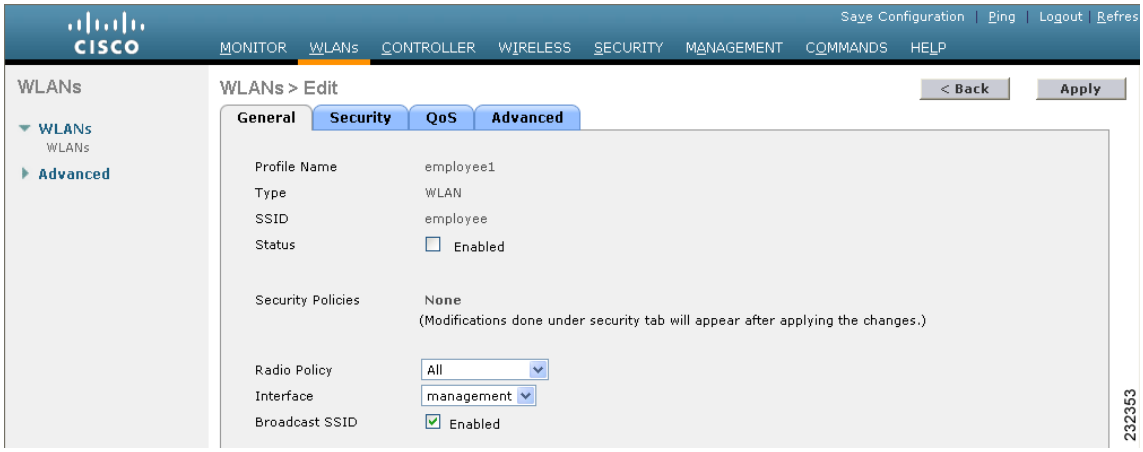
d. In the Profile Name text box, enter a unique profile name for the WLAN.

e. In the WLAN SSID text box, enter a name for the WLAN.

f. From the WLAN ID drop-down list, choose the ID number for this WLAN.

g. Click **Apply** to commit your changes. The WLANs > Edit page appears (see Figure 15-3).

Figure 15-3 WLANs > Edit Page



h. Modify the configuration parameters for this WLAN using the various WLANs > Edit tabs. In our employee WLAN example, you would need to choose **WPA+WPA2** for Layer 2 Security from the Security > Layer 2 tabs and then set the WPA+WPA2 parameters.

Note Be sure to enable this WLAN by selecting the **Status** check box on the General tab.

Note If NAC is enabled and you created a quarantined VLAN and want to use it for this WLAN, be sure to select it from the Interface drop-down list on the General tab.

i. Click **Apply** to commit your changes.

j. Click **Save Configuration** to save your changes.

Step 2 Create a locally switched WLAN (in our example, this is the second WLAN [employee-local]) as follows:

a. Follow the substeps in Step 1 to create a new WLAN. In our example, this WLAN is named "employee-local."

b. When the WLANs > Edit page appears, modify the configuration parameters for this WLAN. In our employee WLAN example, you would need to choose **WPA+WPA2** for Layer 2 Security from the Security > Layer 2 tabs and then set the WPA+WPA2 parameters.

Note Be sure to enable this WLAN by selecting the **Status** check box on the General tab. Also, be sure to enable local switching by selecting the **H-REAP Local Switching** check box on the Advanced tab. When you enable local switching, any hybrid-REAP access point that advertises this WLAN is able to locally switch data packets (instead of tunneling them to the controller).

Note When you enable hybrid-REAP local switching, the Learn Client IP Address check box is enabled by default. However, if the client is configured with Fortress Layer 2 encryption, the controller cannot learn the client IP address, and the controller periodically drops the client. Disable this option so that the controller maintains the client connection without waiting to learn the client IP address. The ability to disable this option is supported only with hybrid-REAP local switching; it is not supported with hybrid-REAP central switching.

Note For hybrid-REAP access points, the interface mapping at the controller for WLANs that is configured for H-REAP Local Switching is inherited at the access point as the default VLAN tagging. This mapping can be easily changed per SSID, per hybrid-REAP access point. Nonhybrid-REAP access points tunnel all traffic back to the controller, and VLAN tagging is dictated by each WLAN's interface mapping.

c. Click **Apply** to commit your changes.

d. Click **Save Configuration** to save your changes.

Step 3 Follow these steps if you also want to create a centrally switched WLAN that is used for guest access. In our example, this is the third WLAN (guest-central). You might want to tunnel guest traffic to the controller so you can exercise your corporate data policies for unprotected guest traffic from a central site.

Note Chapter 11, "Managing User Accounts," provides additional information on creating guest user accounts.

a. Follow the substeps in Step 1 to create a new WLAN. In our example, this WLAN is named "guest-central."

b. When the WLANs > Edit page appears, modify the configuration parameters for this WLAN. In our employee WLAN example, you would need to choose **None** for both Layer 2 Security and Layer 3 Security on the Security > Layer 2 and Security > Layer 3 tabs and select the **Web Policy** check box and make sure **Authentication** is selected on the Layer 3 tab.

Note If you are using an external web server, you must configure a preauthentication access control list (ACL) on the WLAN for the server and then choose this ACL as the WLAN preauthentication ACL on the Layer 3 tab. See Chapter 6, "Configuring Security Solutions" for more information on ACLs.

Note Make sure to enable this WLAN by selecting the **Status** check box on the General tab.

c. Click **Apply** to commit your changes.

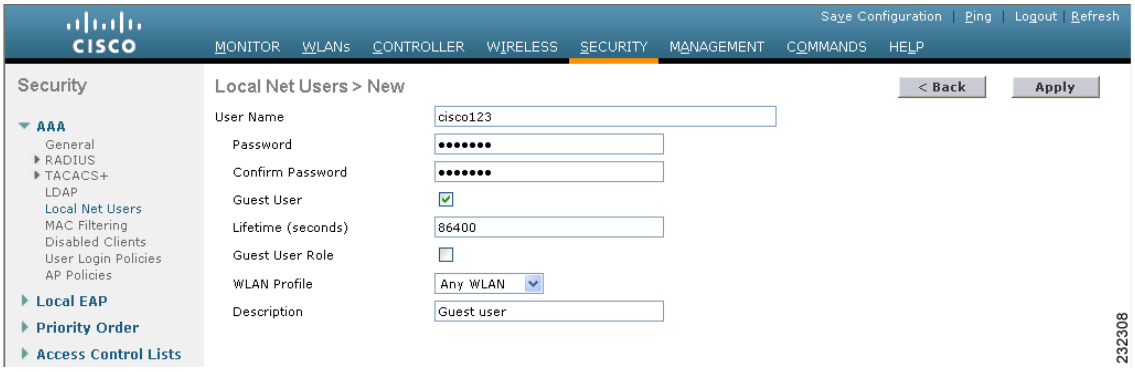
d. Click **Save Configuration** to save your changes.

e. If you want to customize the content and appearance of the login page that guest users will see the first time they access this WLAN, follow the instructions in Chapter 6, "Configuring Security Solutions."

f. To add a local user to this WLAN, choose **Security > AAA > Local Net Users**.

g. When the Local Net Users page appears, click **New**. The Local Net Users > New page appears (see Figure 15-4).

Figure 15-4 Local Net Users > New Page



h. In the User Name and Password text boxes, enter a username and password for the local user.

i. In the Confirm Password text box, reenter the password.

j. Select the **Guest User** check box to enable this local user account.

k. In the Lifetime text box, enter the amount of time (in seconds) for this user account to remain active.

l. If you are adding a new user, you selected the Guest User check box, and you want to assign a QoS role to this guest user, select the **Guest User Role** check box. The default setting is unselected.

Note If you do not assign a QoS role to a guest user, the bandwidth contracts for this user are defined in the QoS profile for the WLAN.

Note Guest user configuration is not supported with hybrid REAP local switching.

m. If you are adding a new user and you selected the Guest User Role check box, choose the QoS role that you want to assign to this guest user from the Role drop-down list. If you want to create a new QoS role, see the "Configuring Quality of Service" section on page 4-68 for instructions.

n. From the WLAN Profile drop-down list, choose the name of the WLAN that is to be accessed by the local user. If you choose **Any WLAN**, which is the default setting, the user can access any of the configured WLANs.

o. In the Description text box, enter a descriptive title for the local user (such as "Guest user").

p. Click **Apply** to commit your changes.

q. Click **Save Configuration** to save your changes.

Step 4 See to the "Configuring an Access Point for Hybrid REAP" section on page 15-13 to configure up to six access points for hybrid-REAP.

Using the CLI to Configure the Controller for Hybrid REAP

Use these commands to configure the controller for hybrid REAP:

- **config wlan h-reap local-switching** *wlan_id* **enable**—Configures the WLAN for local switching.

Note When you enable hybrid-REAP local switching, the controller waits to learn the client IP address by default. However, if the client is configured with Fortress Layer 2 encryption, the controller cannot learn the client IP address, and the controller periodically drops the client. Use the **config wlan h-reap learn-ipaddr** *wlan_id* **disable** command to disable the client IP address learning feature so that the controller maintains the client connection without waiting to learn the client IP address. The ability to disable this feature is supported only with hybrid-REAP local switching; it is not supported with hybrid-REAP central switching. If you later want to re-enable this feature, enter the **config wlan h-reap learn-ipaddr** *wlan_id* **enable** command.

- **config wlan h-reap local-switching** *wlan_id* **disable**—Configures the WLAN for central switching. This is the default value.

Note See the "Configuring an Access Point for Hybrid REAP" section on page 15-13 to configure up to six access points for hybrid REAP.

Use these commands to obtain hybrid-REAP information:

- **show ap config general** *Cisco_AP*—Shows VLAN configurations.
- **show wlan wlan_id**—Shows whether the WLAN is locally or centrally switched.
- **show client detail** *client_mac*—Shows whether the client is locally or centrally switched.

Use these commands to obtain debug information:

- **debug hreap aaa** {**event** | **error**} {**enable** | **disable**}—Enables or disables debugging of hybrid-REAP backup RADIUS server events or errors.
- **debug hreap cckm** {**enable** | **disable**}—Enables or disables debugging of hybrid-REAP CCKM.
- **debug hreap** {**enable** | **disable**}—Enables or disables debugging of hybrid-REAP Groups.
- **debug pem state** {**enable** | **disable**}—Enables or disables debugging of the policy manager state machine.
- **debug pem events** {**enable** | **disable**}—Enables or disables debugging of policy manager events.

Configuring an Access Point for Hybrid REAP

This section describes how to configure an access point for hybrid REAP using either the controller GUI or CLI.

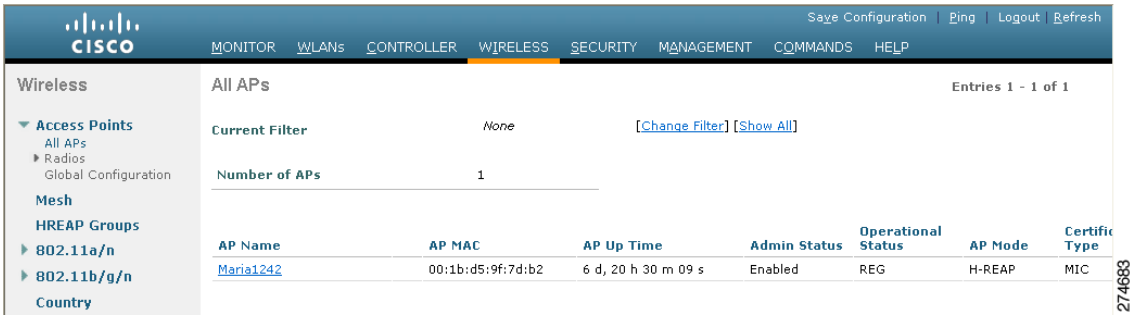
Using the GUI to Configure an Access Point for Hybrid REAP

To configure an access point for hybrid REAP using the controller GUI, follow these steps:

Step 1 Make sure that the access point has been physically added to your network.

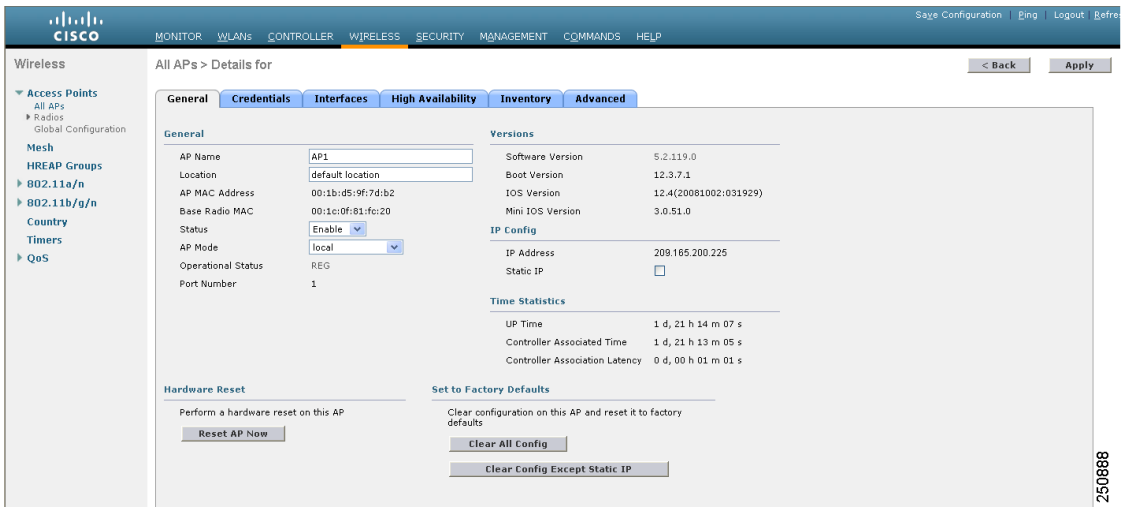
Step 2 Choose **Wireless** to open the All APs page (see Figure 15-5).

Figure 15-5 All APs Page



Step 3 Click the name of the desired access point. The All APs > Details (General) page appears (see Figure 15-6).

Figure 15-6 All APs > Details for (General) Page



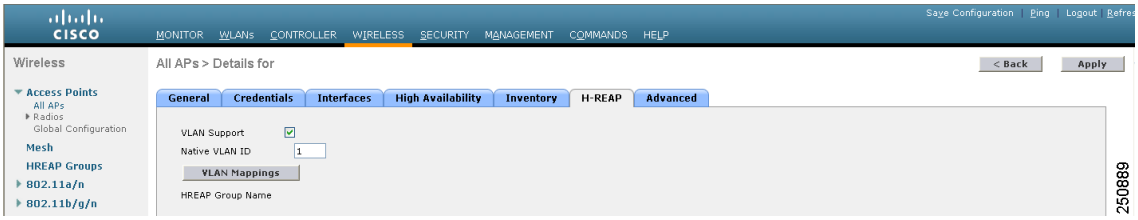
Step 4 Choose **H-REAP** from the AP Mode drop-down list to enable hybrid REAP for this access point.

Note The last parameter on the inventory tab indicates whether the access point can be configured for hybrid REA

Step 5 Click **Apply** to commit your changes and to cause the access point to reboot.

Step 6 Choose the **H-REAP** tab to open the All APs > Details for (H-REAP) page (see Figure 15-7).

Figure 15-7 All APs > Details for (H-REAP) Page



If the access point belongs to a hybrid-REAP group, the name of the group appears in the HREAP Name text box.

Step 7 Select the **VLAN Support** check box and enter the number of the native VLAN on the remote network (such as 100) in the **Native VLAN ID** text box.

Note By default, a VLAN is not enabled on the hybrid-REAP access point. Once hybrid REAP is enabled, the access point inherits the VLAN ID associated to the WLAN. This configuration is saved in the access point and received after the successful join response. By default, the native VLAN is 1. One native VLAN must be configured per hybrid-REAP access point in a VLAN-enabled domain. Otherwise, the access point cannot send and receive packets to and from the controller.

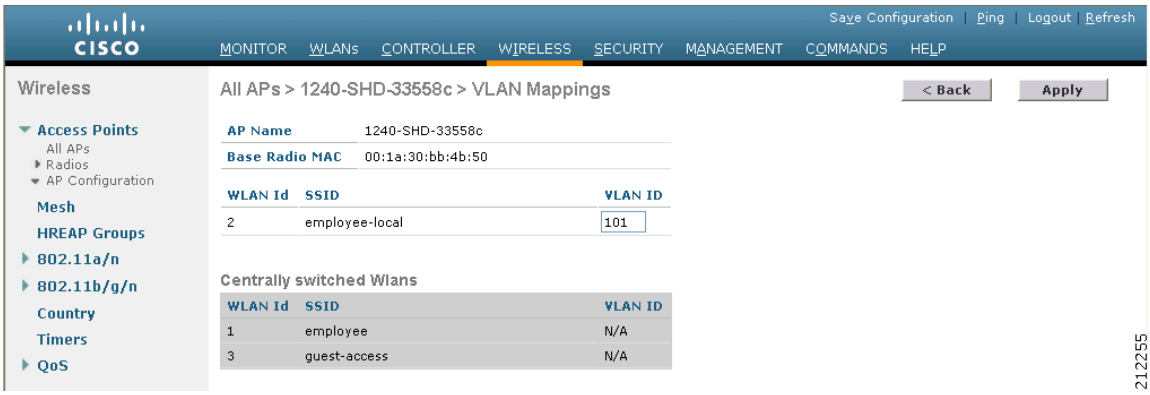
Note To preserve the VLAN mappings in the access point after an upgrade or downgrade, it is necessary that the access point join is restricted to the controller for which it is primed. That is, no other discoverable controller with a different configuration should be available by other means. Similarly, at the time the access point joins, if it moves across controllers which have different VLAN mappings, the VLAN mappings at the access point may get mismatched.

Step 8 Click **Apply** to commit your changes. The access point temporarily loses its connection to the controller while its Ethernet port is reset.

Step 9 Click the name of the same access point and then choose the **H-REAP** tab.

Step 10 Click **VLAN Mappings** to open the All APs > *Access Point Name* > VLAN Mappings page (see Figure 15-8).

Figure 15-8 All APs > Access Point Name > VLAN Mappings Page



Step 11 Enter the number of the VLAN from which the clients will get an IP address when doing local switching (VLAN 101, in this example) in the VLAN ID text box.

Step 12 Click **Apply** to commit your changes.

Step 13 Click **Save Configuration** to save your changes.

Step 14 Repeat this procedure for any additional access points that need to be configured for hybrid REAP at the remote site.

Using the CLI to Configure an Access Point for Hybrid REAP

Use these commands on the controller to configure an access point for hybrid REAP:

- **config ap mode h-reap** *Cisco_AP*—Enables hybrid REAP for this access point.
- **config ap h-reap radius auth set** {**primary** | **secondary**} *ip_address auth_port secret Cisco_AP*—Configures a primary or secondary RADIUS server for a specific hybrid-REAP access point.

Note Only the Session Timeout RADIUS attribute is supported in standalone mode. All other attributes as well as RADIUS accounting are not supported.

Note To delete a RADIUS server that is configured for a hybrid-REAP access point, enter the **config ap h-reap radius auth delete** {**primary** | **secondary**} *Cisco_AP* command.

- **config ap h-reap vlan wlan** *wlan_id vlan-id Cisco_AP***—**Enables you to assign a VLAN ID to this hybrid-REAP access point. By default, the access point inherits the VLAN ID associated to the WLAN.
- **config ap h-reap vlan** {**enable** | **disable**} *Cisco_AP*—Enables or disables VLAN tagging for this hybrid-REAP access point. By default, VLAN tagging is not enabled. Once VLAN tagging is enabled on the hybrid-REAP access point, WLANs enabled for local switching inherit the VLAN assigned at the controller.
- **config ap h-reap vlan native** *vlan-id Cisco_AP*—Enables you to configure a native VLAN for this hybrid-REAP access point. By default, no VLAN is set as the native VLAN. One native VLAN must be configured per hybrid-REAP access point (when VLAN tagging is enabled). Make sure the switchport to which the access point is connected has a corresponding native VLAN configured as well. If the hybrid-REAP access point's native VLAN setting and the upstream switchport native VLAN do not match, the access point cannot transmit packets to and from the controller.

Note To preserve the VLAN mappings in the access point after an upgrade or downgrade, it is necessary that the access point join is restricted to the controller for which it is primed. That is, no other discoverable controller with a different configuration should be available by other means. Similarly, at the time the access point joins, if it moves across controllers which have different VLAN mappings, the VLAN mappings at the access point may get mismatched.

Use these commands on the hybrid-REAP access point to obtain status information:

- **show capwap reap status**—Shows the status of the hybrid-REAP access point (connected or standalone).
- **show capwap reap association**—Shows the list of clients associated to this access point and their SSIDs.

Use these commands on the hybrid-REAP access point to obtain debug information:

- **debug capwap reap**—Shows general hybrid-REAP activities.
- **debug capwap reap mgmt**—Shows client authentication and association messages.
- **debug capwap reap load**—Shows payload activities, which is useful when the hybrid-REAP access point boots up in standalone mode.
- **debug dot11 mgmt interface**—Shows 802.11 management interface events.
- **debug dot11 mgmt msg**—Shows 802.11 management messages.
- **debug dot11 mgmt ssid**—Shows SSID management events.
- **debug dot11 mgmt state-machine**—Shows the 802.11 state machine.
- **debug dot11 mgmt station**—Shows client events.

Using the GUI to Configure an Access Point for Local Authentication on a WLAN

To configure an access point to enable an access point for local authentication on a WLAN using the controller GUI, follow these steps:

Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Click the ID number of the desired WLAN. The WLANs > Edit page appears.

Step 3 Choose the **Advanced** tab to open the WLANs > Edit (Advanced) page.

Step 4 Enable H-REAP local switching by selecting the **H-reap Local Switching** check box under the H-REAP section.

Step 5 Enable H-REAP local authentication by selecting the **H-REAP Local Auth** check box.

Note Do not connect access points in HREAP mode directly to a Cisco 2100 and 2500 Series Controllers.

Step 6 Click **Apply** to commit your changes.

Using the CLI to Configure an Access Point for Local Authentication on a WLAN

Use the following commands to configure an access point for local authentication on a WLAN:

Note You must enable local switching on the WLAN where you want to enable local authentication for an access point. See the "Using the CLI to Configure the Controller for Hybrid REAP" section on page 15-12 for more information.

- **config wlan h-reap ap-auth** *wlan_id* **{enable | disable}**—Configures the access point to enable or disable local authentication on a WLAN.

Note Do not connect the access points in HREAP mode directly to Cisco 2100 and 2500 Series Controllers.

- **show wlan** *wlan-id* —Displays the configuration for the WLAN. If local authentication is enabled, the following information appears.

```
. . .
. . .
Web Based Authentication..................... Disabled
   Web-Passthrough........................... Disabled
   Conditional Web Redirect.................. Disabled
   Splash-Page Web Redirect.................. Disabled
   Auto Anchor............................... Disabled
   H-REAP Local Switching.................... Enabled
   H-REAP Local Authentication............... Enabled
   H-REAP Learn IP Address................... Enabled
   Client MFP................................ Optional
   Tkip MIC Countermeasure Hold-down Timer..... 60
Call Snooping................................ Disabled
Roamed Call Re-Anchor Policy................. Disabled
. . .
. . .
```

See the "Using the CLI to Configure the Controller for Hybrid REAP" section on page 15-12 for more information on viewing and debugging.

Connecting Client Devices to the WLANs

Follow the instructions for your client device to create profiles to connect to the WLANs you created in the "Configuring the Controller for Hybrid REAP" section on page 15-8.

In our example, you would create three profiles on the client:

1. To connect to the "employee" WLAN, you would create a client profile that uses WPA/WPA2 with PEAP-MSCHAPV2 authentication. Once the client becomes authenticated, it should get an IP address from the management VLAN of the controller.
2. To connect to the "local-employee" WLAN, you would create a client profile that uses WPA/WPA2 authentication. Once the client becomes authenticated, it should get an IP address from VLAN 101 on the local switch.
3. To connect to the "guest-central" WLAN, you would create a client profile that uses open authentication. Once the client becomes authenticated, it should get an IP address from VLAN 101 on the network local to the access point. Once the client connects, the local user can type any http address in the web browser. The user is automatically directed to the controller to complete the web-authentication process. When the web login page appears, the user enters his or her username and password.

To see if a client's data traffic is being locally or centrally switched, choose **Monitor** > **Clients** on the controller GUI, click the **Detail** link for the desired client, and look at the Data Switching parameter under AP Properties.

Configuring Hybrid-REAP Groups

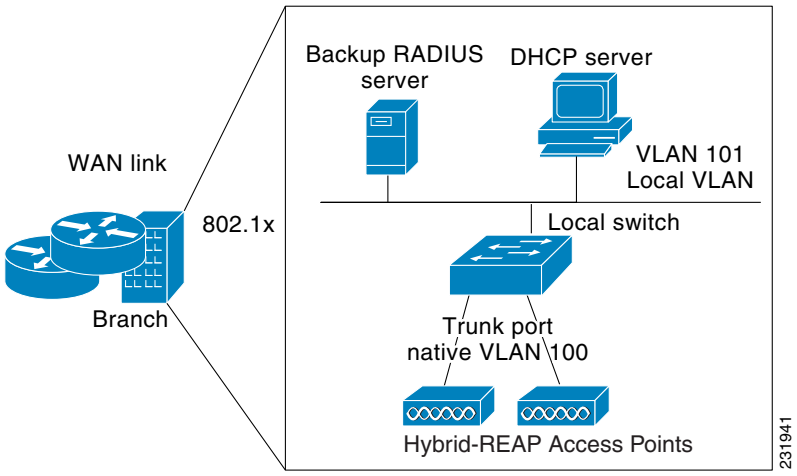
In order to better organize and manage your hybrid-REAP access points, you can create hybrid-REAP Groups and assign specific access points to them.

The number of hybrid-REAP groups and access point support depends on the platform that you are using. You can configure the following:

- Up to 100 hybrid-REAP groups for a Cisco 5500 Series Controller
- Up to 500 hybrid-REAP groups for a Cisco Flex 7500 Series Controller. The Cisco Flex 7500 Series Controller can accommodate up to 50 access points per hybrid REAP group.
- Up to 20 hybrid-REAP groups with up to 25 access points per group for the remaining controller platforms.

All of the hybrid-REAP access points in a group share the same backup RADIUS server, CCKM, and local authentication configuration information. This feature is helpful if you have multiple hybrid-REAP access points in a remote office or on the floor of a building and you want to configure them all at once. For example, you can configure a backup RADIUS server for a hybrid-REAP rather than having to configure the same server on each access point. Figure 15-9 shows a typical hybrid-REAP deployment with a backup RADIUS server in the branch office.

Figure 15-9 Hybrid-REAP Group Deployment



Hybrid-REAP Groups and Backup RADIUS Servers

You can configure the controller to allow a hybrid-REAP access point in standalone mode to perform full 802.1X authentication to a backup RADIUS server. You can configure a primary backup RADIUS server or both a primary and secondary backup RADIUS server. These servers can be used when the hybrid-REAP access point is in of these two modes: standalone or connected.

Hybrid-REAP Groups and CCKM

Hybrid-REAP Groups are required for CCKM fast roaming to work with hybrid-REAP access points. CCKM fast roaming is achieved by caching a derivative of the master key from a full EAP authentication so that a simple and secure key exchange can occur when a wireless client roams to a different access point. This feature prevents the need to perform a full RADIUS EAP authentication as the client roams from one access point to another. The hybrid-REAP access points need to obtain the CCKM cache information for all the clients that might associate so they can process it quickly instead of sending it back to the controller. If, for example, you have a controller with 300 access points and 100 clients that might associate, sending the CCKM cache for all 100 clients is not practical. If you create a hybrid-REAP that includes a limited number of access points (for example, you create a group for four access points in a remote office), the clients roam only among those four access points, and the CCKM cache is distributed among those four access points only when the clients associate to one of them.

Note CCKM fast roaming among hybrid-REAP and non-hybrid-REAP access points is not supported. See the "WPA1 and WPA2" section on page 7-25 for information on configuring CCKM.

Hybrid-REAP Groups and OKC

Startingin the 7.0.116.0 release, hybrid-REAP groups enable Opportunistic Key Caching (OKC) to enable fast roaming of clients. OKC facilitates fast roaming by using PMK caching in access points that are in the same Hybrid- REAP group.

This feature prevents the need to perform a full authentication as the client roams from one access point to another. Whenever a client roams from one hybrid-REAP access point to another, the hybrid-REAP group access point calculates the PMKID using the cached PMK.

To see the PMK cache entries at the hybrid-REAP access point, use the **show capwap reap pmk** command. This feature is supported on Cisco hybrid-REAP access points.

Note The hybrid-REAP access point must be in connected mode when the PMK is derived during WPA2/802.1x authentication.

Hybrid-REAP Groups and Local Authentication

You can configure the controller to allow a hybrid-REAP access point in standalone mode to perform LEAP or EAP-FAST authentication for up to 100 statically configured users. The controller sends the static list of usernames and passwords to each hybrid-REAP access point when it joins the controller. Each access point in the group authenticates only its own associated clients.

This feature is ideal for customers who are migrating from an autonomous access point network to a lightweight hybrid-REAP access point network and are not interested in maintaining a large user database or adding another hardware device to replace the RADIUS server functionality available in the autonomous access point.

Note This feature can be used with the hybrid-REAP backup RADIUS server feature. If a hybrid-REAP is configured with both a backup RADIUS server and local authentication, the hybrid-REAP access point always attempts to authenticate clients using the primary backup RADIUS server first, followed by the secondary backup RADIUS server (if the primary is not reachable), and finally the hybrid-REAP access point itself (if the primary and secondary are not reachable).

The number of hybrid-REAP groups and access point support depends on the platform that you are using. You can configure the following:

- Up to 100 hybrid-REAP groups for a Cisco 5500 Series Controller
- Up to 500 hybrid-REAP groups for a Cisco Flex 7500 Series Controller. The Cisco Flex 7500 Series Controller can accommodate up to 50 access points per hybrid REAP group.
- Up to 20 hybrid-REAP groups with up to 25 access points per group for the remaining platforms.

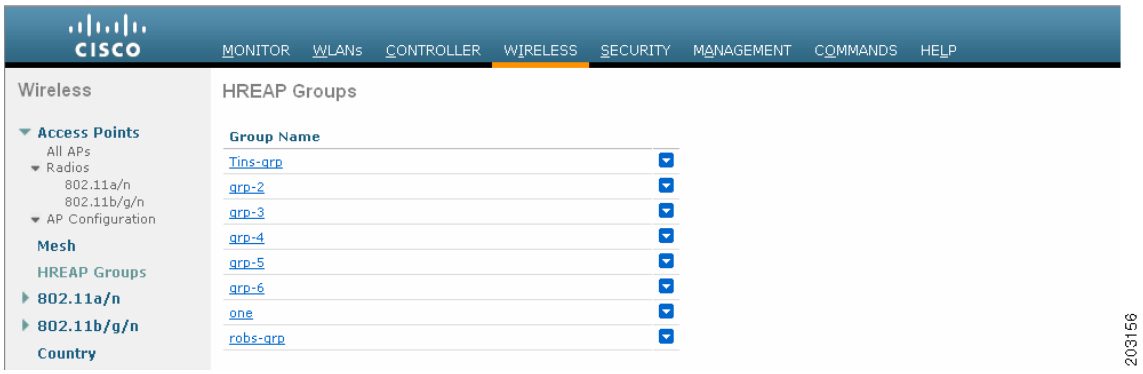
Follow the instructions in this section to configure hybrid-REAPs using the controller GUI or CLI.

Using the GUI to Configure Hybrid-REAP Groups

To configure hybrid-REAP groups using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **HREAP Groups** to open the HREAP Groups page (see Figure 15-10).

Figure 15-10 Hybrid REAP Groups Page



This page lists any hybrid-REAP groups that have already been created.

Note If you want to delete an existing group, hover your cursor over the blue drop-down arrow for that group and choose **Remove**.

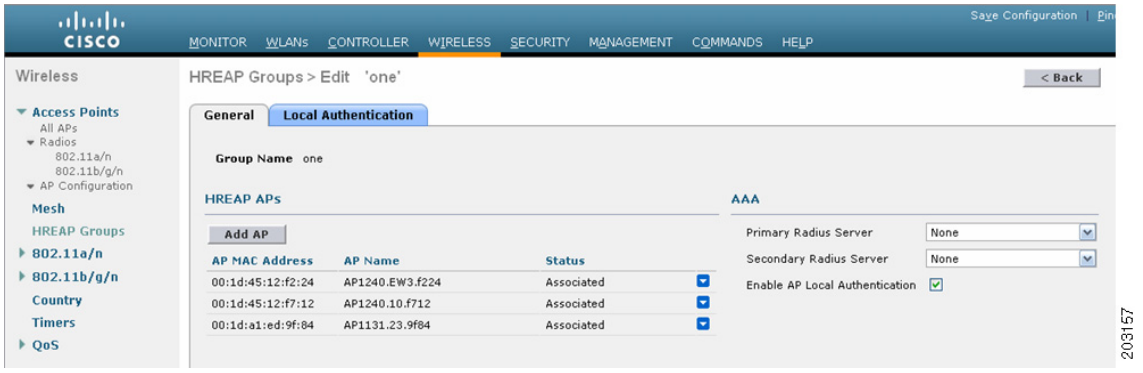
Step 2 To create a new hybrid REAP Group, click **New**.

Step 3 When the HREAP Groups > New page appears, enter the name of the new group in the Group Name text Box. You can enter up to 32 alphanumeric characters.

Step 4 Click **Apply** to commit your changes. The new group appears on the HREAP Groups page.

Step 5 To edit the properties of a group, click the name of the desired group. The HREAP Groups > Edit (General) page appears (see Figure 15-11).

Figure 15-11 Hybrid REAPs > Edit (General) Page



Step 6 If you want to configure a primary RADIUS server for this group (for example, the access points are using 802.1X authentication), choose the desired server from the Primary RADIUS Server drop-down list. Otherwise, leave the text box set to the default value of None.

Step 7 If you want to configure a secondary RADIUS server for this group, choose the server from the Secondary RADIUS Server drop-down list. Otherwise, leave the field set to the default value of None.

Step 8 To add an access point to the group, click **Add AP**. Additional fields appear on the page under "Add AP".

Step 9 Perform one of the following:

- To choose an access point that is connected to this controller, select the **Select APs from Current Controller** check box and choose the name of the access point from the AP Name drop-down list.

  Note If you choose an access point on this controller, the MAC address of the access point is automatically entered in the Ethernet MAC text box to prevent any mismatches from occurring.

- To choose an access point that is connected to a different controller, leave the **Select APs from Current Controller** check box unselected and enter its MAC address in the Ethernet MAC text box.

  Note If the hybrid-REAP access points within a group are connected to different controllers, all of the controllers must belong to the same mobility group.

Step 10 Click **Add** to add the access point to this hybrid-REAP group. The access point's MAC address, name, and status appear at the bottom of the page.

Note If you want to delete an access point, hover your cursor over the blue drop-down arrow for that access point and choose **Remove**.

Step 11 Click **Apply** to commit your changes.

Step 12 Repeat Step 9 through Step 11 if you want to add more access points to this hybrid-REAP Group.

Step 13 Enable local authentication for a hybrid-REAP Group as follows:

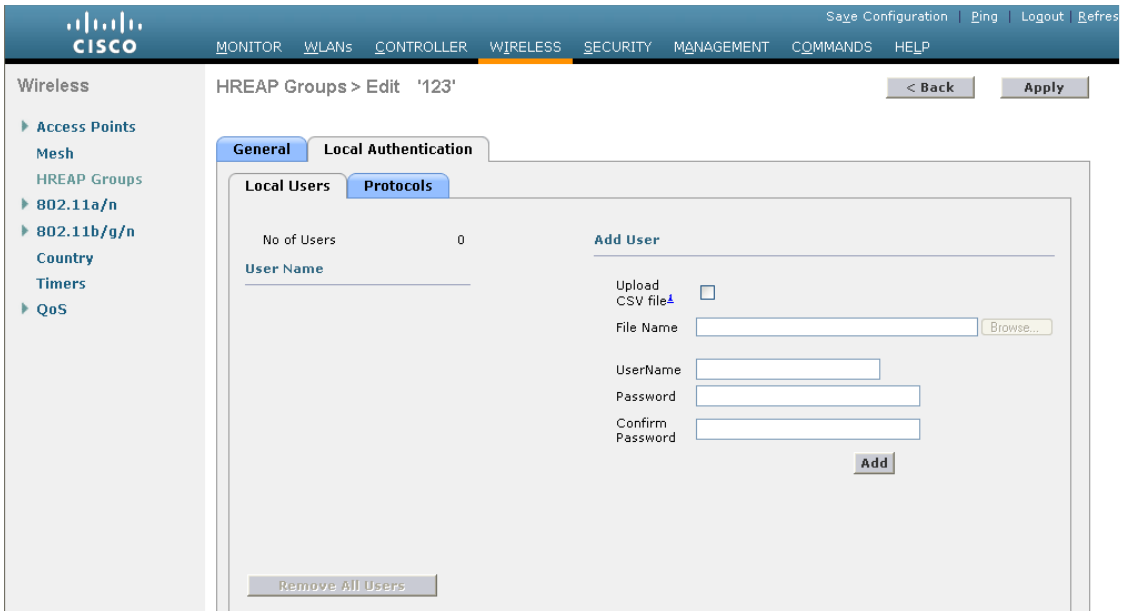
a. Make sure that the Primary RADIUS Server and Secondary RADIUS Server parameters are set to **None**.

b. Select the **Enable AP Local Authentication** check box to enable local authentication for this hybrid-REAP Group. The default value is unselected.

c. Click **Apply** to commit your changes.

d. Choose the **Local Authentication** tab to open the Hybrid REAPs > Edit (Local Authentication > Local Users) page (see Figure 15-12).

Figure 15-12 Hybrid REAP > Edit (Local Authentication > Local Users) Page



e. To add clients that you want to be able to authenticate using LEAP or EAP-FAST, perform one of the following:

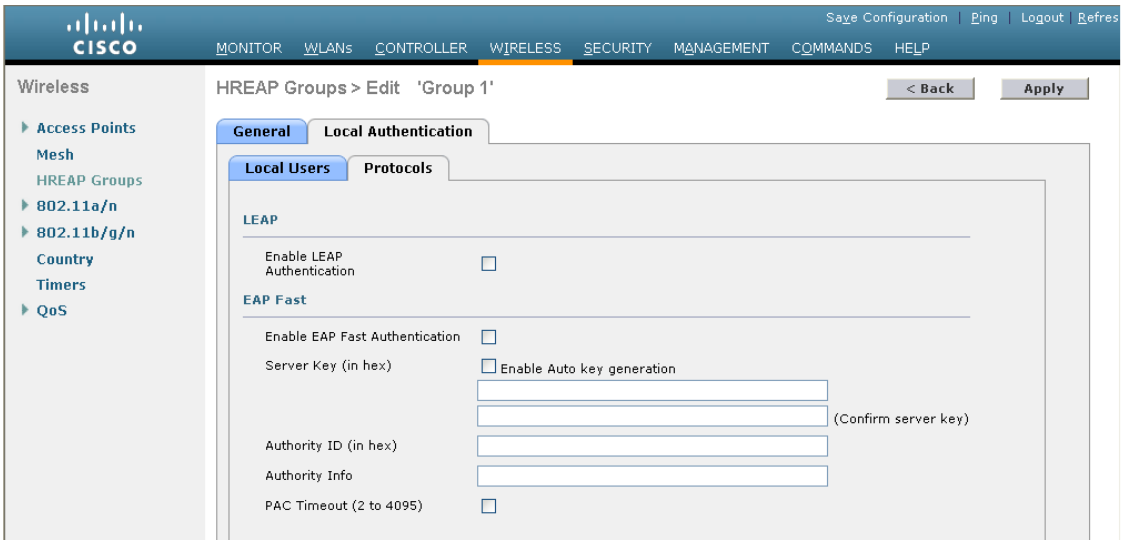
- Upload a comma-separated values (CSV) file by selecting the **Upload CSV File** check box, clicking the **Browse** button to browse to an CSV file that contains usernames and passwords (each line of the file needs to be in the following format: username, password), and clicking **Add** to upload the CSV file. The clients' names appear on the left side of the page under the "User Name" heading.
- Add clients individually by entering the client's username in the User Name text box and a password for the client in the Password and Confirm Password text boxes, and clicking **Add** to add this client to the list of supported local users. The client name appears on the left side of the page under the "User Name" heading.

Note You can add up to 100 clients.

f. Click **Apply** to commit your changes.

g. Choose the **Protocols** tab to open the Hybrid REAPs > Edit (Local Authentication > Protocols) page (see Figure 15-13).

Figure 15-13 HREAP Groups > Edit (Local Authentication > Protocols) Page



h. To allow a hybrid-REAP access point to authenticate clients using LEAP, select the **Enable LEAP Authentication** check box and then go to Step n.

i. To allow a hybrid-REAP access point to authenticate clients using EAP-FAST, select the **Enable EAP-FAST Authentication** check box and then go to the next step. The default value is unselected.

j. Perform one of the following, depending on how you want protected access credentials (PACs) to be provisioned:

- To use manual PAC provisioning, enter the server key used to encrypt and decrypt PACs in the Server Key and Confirm Server Key text boxes. The key must be 32 hexadecimal characters.
- To allow PACs to be sent automatically to clients that do not have one during PAC provisioning, select the **Enable Auto Key Generation** check box.

k. In the Authority ID text box, enter the authority identifier of the EAP-FAST server. The identifier must be 32 hexadecimal characters.

l. In the Authority Info text box, enter the authority identifier of the EAP-FAST server in text format. You can enter up to 32 hexadecimal characters.

m. To specify a PAC timeout value, select the **PAC Timeout** check box and enter the number of seconds for the PAC to remain viable in the text box. The default value is unselected, and the valid range is 2 to 4095 seconds when enabled.

n. Click **Apply** to commit your changes.

Step 14 Click **Save Configuration** to save your changes.

Step 15 Repeat this procedure if you want to add more hybrid-REAPs.

Note To see if an individual access point belongs to a hybrid-REAP Group, you can choose **Wireless > Access Points > All APs >** the name of the desired access point > the **H-REAP** tab. If the access point belongs to a hybrid-REAP, the name of the group appears in the Hybrid REAP Name text box.

Using the CLI to Configure Hybrid-REAP Groups

To configure hybrid-REAP Groups using the controller CLI, follow these steps:

Step 1 Add or delete a hybrid-REAP Group by entering this command:

config hreap *group_name* {**add** | **delete**}

Step 2 Configure a primary or secondary RADIUS server for the hybrid-REAP Group by entering this command:

config hreap *group_name* **radius server** {**add** | **delete**} {**primary** | **secondary**} *server_index*

Step 3 Add an access point to the hybrid-REAP Group by entering this command:

config hreap *group_name* **ap** {**add** | **delete**} *ap_mac*

Step 4 Configure local authentication for a hybrid-REAP group as follows:

a. Make sure that a primary and secondary RADIUS server are not configured for the hybrid-REAP Group.

b. To enable or disable local authentication for this hybrid-REAP group, enter this command:

config hreap *group_name* **radius ap** {**enable** | **disable**}

c. To enter the username and password of a client that you want to be able to authenticate using LEAP or EAP-FAST, enter this command:

config hreap *group_name* **radius ap user add** *username* **password** *password*

Note You can add up to 100 clients.

d. To allow a hybrid-REAP access point to authenticate clients using LEAP or to disable this behavior, enter this command:

config hreap *group_name* **radius ap leap** {**enable** | **disable**}

e. To allow a hybrid-REAP access point to authenticate clients using EAP-FAST or to disable this behavior, enter this command:

config hreap *group_name* **radius ap eap-fast** {**enable** | **disable**}

f. Enter one of the following commands, depending on how you want PACs to be provisioned:

- **config hreap** *group_name* **radius ap server-key** *key*—Specifies the server key used to encrypt and decrypt PACs. The key must be 32 hexadecimal characters.
- **config hreap** *group_name* **radius ap server-key auto**—Allows PACs to be sent automatically to clients that do not have one during PAC provisioning.

g. To specify the authority identifier of the EAP-FAST server, enter this command:

config hreap *group_name* **radius ap authority id** *id*

where *id* is 32 hexadecimal characters.

h. To specify the authority identifier of the EAP-FAST server in text format, enter this command:

config hreap *group_name* **radius ap authority info** *info*

where *info* is up to 32 hexadecimal characters.

i. To specify the number of seconds for the PAC to remain viable, enter this command:

config hreap *group_name* **radius ap pac-timeout** *timeout*

where *timeout* is a value between 2 and 4095 seconds (inclusive) or 0. A value of 0, which the default value, disables the PAC timeout.

Step 5 Save your changes by entering this command:

save config

Step 6 See the current list of hybrid-REAP Groups by entering this command:

show hreap summary

Information similar to the following appears:

```
Hreap Summary: Count 2

Group Name      # Aps
Group 1         1
Group 2         1
```

Step 7 See the details for a specific hybrid-REAP Groups by entering this command:

show hreap detail *group_name*

Information similar to the following appears:

```
Number of Ap's in Group: 3

00:1d:45:12:f2:24    AP1240.EW3.f224  Joined
00:1d:45:12:f7:12    AP1240.10.f712     Joined
00:1d:a1:ed:9f:84    AP1131.23.9f84     Joined


Group Radius Servers Settings:
 Primary Server Index.......................... Disabled
 Secondary Server Index........................ Disabled

Group Radius AP Settings:
AP RADIUS server............ Enabled
EAP-FAST Auth............... Enabled
LEAP Auth................... Enabled
Server Key Auto Generated... No
Server Key..................     <hidden>
Authority ID................ 436973636f000000000000000000000000
Authority Info.............. Cisco A_ID
PAC Timeout................. 0
Number of User's in Group: 20

                  1cisco                    2cisco
                  3cisco                    4cisco
                   cisco                     test1
                  test10                    test11
                  test12                    test13
                  test14                    test15
                   test2                     test3
                   test4                     test5
                   test6                     test7
                  test8                   test9
```

APPENDIX A

Safety Considerations and Translated Safety Warnings

This appendix lists safety considerations and translations of the safety warnings that apply to the Cisco Inified Wireless Network (UWN) solution products. The following safety considerations and safety warnings appear in this appendix:

Safety Considerations

Follow these guidelines when installing Cisco UWN solution products:

- The Cisco lightweight access points with or without external antenna ports are only intended for installation in Environment A as defined in IEEE 802.3af. All interconnected equipment must be contained within the same building including the interconnected equipment's associated LAN connections.
- For lightweight access points provided with optional external antenna ports, make sure that all external antennas and their associated wiring are located entirely indoors. These lightweight access points and their optional external antennas are not suitable for outdoor use.
- Make sure that plenum-mounted lightweight access points are powered using Power over Ethernet (PoE) to comply with safety regulations.
- For all controllers, verify that the ambient temperature remains between 0 and 40°C (32 and 104°F), taking into account the elevated temperatures that occur when they are installed in a rack.
- When multiple controllers are mounted in an equipment rack, be sure that the power source is sufficiently rated to safely run all of the equipment in the rack.
- Verify the integrity of the ground before installing controllers in an equipment rack.

- Lightweight access points are suitable for use in environmental air space in accordance with Section 300.22.C of the National Electrical Code, and Sections 2-128, 12-010(3) and 12-100 of the Canadian Electrical Code, Part 1, C22.1.

Warning Definition

Warning **IMPORTANT SAFETY INSTRUCTIONS**

This warning symbol means danger. You are in a situation that could cause bodily injury. Before you work on any equipment, be aware of the hazards involved with electrical circuitry and be familiar with standard practices for preventing accidents. Use the statement number provided at the end of each warning to locate its translation in the translated safety warnings that accompanied this device. Statement 1071

SAVE THESE INSTRUCTIONS

Waarschuwing **BELANGRIJKE VEILIGHEIDSINSTRUCTIES**

Dit waarschuwingssymbool betekent gevaar. U verkeert in een situatie die lichamelijk letsel kan veroorzaken. Voordat u aan enige apparatuur gaat werken, dient u zich bewust te zijn van de bij elektrische schakelingen betrokken risico's en dient u op de hoogte te zijn van de standaard praktijken om ongelukken te voorkomen. Gebruik het nummer van de verklaring onderaan de waarschuwing als u een vertaling van de waarschuwing die bij het apparaat wordt geleverd, wilt raadplegen.

BEWAAR DEZE INSTRUCTIES

Varoitus **TÄRKEITÄ TURVALLISUUSOHJEITA**

Tämä varoitusmerkki merkitsee vaaraa. Tilanne voi aiheuttaa ruumiillisia vammoja. Ennen kuin käsittelet laitteistoa, huomioi sähköpiirien käsittelemiseen liittyvät riskit ja tutustu onnettomuuksien yleisiin ehkäisytapoihin. Turvallisuusvaroitusten käännökset löytyvät laitteen mukana toimitettujen käännettyjen turvallisuusvaroitusten joukosta varoitusten lopussa näkyvien lausuntonumeroiden avulla.

SÄILYTÄ NÄMÄ OHJEET

Attention **IMPORTANTES INFORMATIONS DE SÉCURITÉ**

Ce symbole d'avertissement indique un danger. Vous vous trouvez dans une situation pouvant entraîner des blessures ou des dommages corporels. Avant de travailler sur un équipement, soyez conscient des dangers liés aux circuits électriques et familiarisez-vous avec les procédures couramment utilisées pour éviter les accidents. Pour prendre connaissance des traductions des avertissements figurant dans les consignes de sécurité traduites qui accompagnent cet appareil, référez-vous au numéro de l'instruction situé à la fin de chaque avertissement.

CONSERVEZ CES INFORMATIONS

Warnung **WICHTIGE SICHERHEITSHINWEISE**

Dieses Warnsymbol bedeutet Gefahr. Sie befinden sich in einer Situation, die zu Verletzungen führen kann. Machen Sie sich vor der Arbeit mit Geräten mit den Gefahren elektrischer Schaltungen und den üblichen Verfahren zur Vorbeugung vor Unfällen vertraut. Suchen Sie mit der am Ende jeder Warnung angegebenen Anweisungsnummer nach der jeweiligen Übersetzung in den übersetzten Sicherheitshinweisen, die zusammen mit diesem Gerät ausgeliefert wurden.

BEWAHREN SIE DIESE HINWEISE GUT AUF.

Avvertenza **IMPORTANTI ISTRUZIONI SULLA SICUREZZA**

Questo simbolo di avvertenza indica un pericolo. La situazione potrebbe causare infortuni alle persone. Prima di intervenire su qualsiasi apparecchiatura, occorre essere al corrente dei pericoli relativi ai circuiti elettrici e conoscere le procedure standard per la prevenzione di incidenti. Utilizzare il numero di istruzione presente alla fine di ciascuna avvertenza per individuare le traduzioni delle avvertenze riportate in questo documento.

CONSERVARE QUESTE ISTRUZIONI

Advarsel **VIKTIGE SIKKERHETSINSTRUKSJONER**

Dette advarselssymbolet betyr fare. Du er i en situasjon som kan føre til skade på person. Før du begynner å arbeide med noe av utstyret, må du være oppmerksom på farene forbundet med elektriske kretser, og kjenne til standardprosedyrer for å forhindre ulykker. Bruk nummeret i slutten av hver advarsel for å finne oversettelsen i de oversatte sikkerhetsadvarslene som fulgte med denne enheten.

TA VARE PÅ DISSE INSTRUKSJONENE

Aviso **INSTRUÇÕES IMPORTANTES DE SEGURANÇA**

Este símbolo de aviso significa perigo. Você está em uma situação que poderá ser causadora de lesões corporais. Antes de iniciar a utilização de qualquer equipamento, tenha conhecimento dos perigos envolvidos no manuseio de circuitos elétricos e familiarize-se com as práticas habituais de prevenção de acidentes. Utilize o número da instrução fornecido ao final de cada aviso para localizar sua tradução nos avisos de segurança traduzidos que acompanham este dispositivo.

GUARDE ESTAS INSTRUÇÕES

¡Advertencia! **INSTRUCCIONES IMPORTANTES DE SEGURIDAD**

Este símbolo de aviso indica peligro. Existe riesgo para su integridad física. Antes de manipular cualquier equipo, considere los riesgos de la corriente eléctrica y familiarícese con los procedimientos estándar de prevención de accidentes. Al final de cada advertencia encontrará el número que le ayudará a encontrar el texto traducido en el apartado de traducciones que acompaña a este dispositivo.

GUARDE ESTAS INSTRUCCIONES

Varning! **VIKTIGA SÄKERHETSANVISNINGAR**

Denna varningssignal signalerar fara. Du befinner dig i en situation som kan leda till personskada. Innan du utför arbete på någon utrustning måste du vara medveten om farorna med elkretsar och känna till vanliga förfaranden för att förebygga olyckor. Använd det nummer som finns i slutet av varje varning för att hitta dess översättning i de översatta säkerhetsvarningar som medföljer denna anordning.

SPARA DESSA ANVISNINGAR

FONTOS BIZTONSÁGI ELOÍRÁSOK

Ez a figyelmezeto jel veszélyre utal. Sérülésveszélyt rejto helyzetben van. Mielott bármely berendezésen munkát végezte, legyen figyelemmel az elektromos áramkörök okozta kockázatokra, és ismerkedjen meg a szokásos balesetvédelmi eljárásokkal. A kiadványban szereplo figyelmeztetések fordítása a készülékhez mellékelt biztonsági figyelmeztetések között található; a fordítás az egyes figyelmeztetések végén látható szám alapján keresheto meg.

ORIZZE MEG EZEKET AZ UTASÍTÁSOKAT!

Предупреждение **ВАЖНЫЕ ИНСТРУКЦИИ ПО СОБЛЮДЕНИЮ ТЕХНИКИ БЕЗОПАСНОСТИ**

Этот символ предупреждения обозначает опасность. То есть имеет место ситуация, в которой следует опасаться телесных повреждений. Перед эксплуатацией оборудования выясните, каким опасностям может подвергаться пользователь при использовании электрических цепей, и ознакомьтесь с правилами техники безопасности для предотвращения возможных несчастных случаев. Воспользуйтесь номером заявления, приведенным в конце каждого предупреждения, чтобы найти его переведенный вариант в переводе предупреждений по безопасности, прилагаемом к данному устройству.

СОХРАНИТЕ ЭТИ ИНСТРУКЦИИ

警告 重要的安全性说明

此警告符号代表危险。您正处于可能受到严重伤害的工作环境中。在您使用设备开始工作之前，必须充分意识到触电的危险，并熟练掌握防止事故发生的标准工作程序。请根据每项警告结尾提供的声明号码来找到此设备的安全性警告说明的翻译文本。

请保存这些安全性说明

警告 安全上の重要な注意事項

「危険」の意味です。人身事故を予防するための注意事項が記述されています。装置の取り扱い作業を行うときは、電気回路の危険性に注意し、一般的な事故防止策に留意してください。警告の各国語版は、各注意事項の番号を基に、装置に付属の「Translated Safety Warnings」を参照してください。

これらの注意事項を保管しておいてください。

Class 1 Laser Product Warning

Note The 1000BASE-SX and 1000BASE-LX SFP modules contain Class 1 Lasers (Laser Klasse 1) according to EN 60825-1+A1+A2.

Warning **Class 1 laser product.** Statement 1008

Waarschuwing **Klasse-1 laser produkt.**

Varoitus **Luokan 1 lasertuote.**

Attention **Produit laser de classe 1.**

Warnung **Laserprodukt der Klasse 1.**

Avvertenza **Prodotto laser di Classe 1.**

Advarsel **Laserprodukt av klasse 1.**

Aviso **Produto laser de classe 1.**

¡Advertencia! **Producto láser Clase I.**

Varning! **Laserprodukt av klass 1.**

Class 1 besorolású lézeres termék.

Предупреждение Лазерное устройство класса 1.

警告 这是 1 类激光产品。

警告 クラス1レーザー製品です。

Aviso **Produto a laser de classe 1.**

Advarsel **Klasse 1 laserprodukt.**

تحذير **Class 1 Laser ١ منتج**

Upozorenje **Laserski proizvod klase 1**

Upozornění **Laserový výrobek třídy 1.**

Προειδοποίηση Προϊόν λέιζερ κατηγορίας 1.

אזהרה .Class 1 מוצר לייזר

Opomena Ласерски производ од класа 1.

Ostrzeżenie **Produkt laserowy klasy 1.**

Upozornenie **Laserový výrobok triedy 1.**

Class 1 besorolású lézeres termék.

Предупреждение Лазерное устройство класса 1.

警告 这是 1 类激光产品。

警告 クラス1レーザー製品です。

주의 클래스 1 레이저 제품.

تحذير **Class 1 Laser ١ منتج**

Upozorenje **Laserski proizvod klase 1**

Upozornění **Laserový výrobek třídy 1.**

Προειδοποίηση Προϊόν λέιζερ κατηγορίας 1.

אזהרה .Class 1 מוצר לייזר

Opomena Ласерски производ од класа 1.

Ostrzeżenie **Produkt laserowy klasy 1.**

Upozornenie **Laserový výrobok triedy 1.**

Ground Conductor Warning

Warning **This equipment must be grounded. Never defeat the ground conductor or operate the equipment in the absence of a suitably installed ground conductor. Contact the appropriate electrical inspection authority or an electrician if you are uncertain that suitable grounding is available.** Statement 1024

Waarschuwing **Deze apparatuur dient geaard te zijn. De aardingsleiding mag nooit buiten werking worden gesteld en de apparatuur mag nooit bediend worden zonder dat er een op de juiste wijze geïnstalleerde aardingsleiding aanwezig is. Neem contact op met de bevoegde instantie voor elektrische inspecties of met een elektricien als u er niet zeker van bent dat er voor passende aarding gezorgd is.**

Varoitus **Laitteiden on oltava maadoitettuja. Älä koskaan ohita maajohdinta tai käytä laitteita ilman oikein asennettua maajohdinta. Ota yhteys sähkötarkastusviranomaiseen tai sähköasentajaan, jos olet epävarma maadoituksen sopivuudesta.**

Attention **Cet équipement doit être mis à la masse. Ne jamais rendre inopérant le conducteur de masse ni utiliser l'équipement sans un conducteur de masse adéquatement installé. En cas de doute sur la mise à la masse appropriée disponible, s'adresser à l'organisme responsable de la sécurité électrique ou à un électricien.**

Warnung **Dieses Gerät muss geerdet sein. Auf keinen Fall den Erdungsleiter unwirksam machen oder das Gerät ohne einen sachgerecht installierten Erdungsleiter verwenden. Wenn Sie sich nicht sicher sind, ob eine sachgerechte Erdung vorhanden ist, wenden Sie sich an die zuständige Inspektionsbehörde oder einen Elektriker.**

Avvertenza **Questa apparecchiatura deve essere dotata di messa a terra. Non escludere mai il conduttore di protezione né usare l'apparecchiatura in assenza di un conduttore di protezione installato in modo corretto. Se non si è certi della disponibilità di un adeguato collegamento di messa a terra, richiedere un controllo elettrico presso le autorità competenti o rivolgersi a un elettricista.**

Advarsel **Dette utstyret må jordes. Omgå aldri jordingslederen og bruk aldri utstyret uten riktig montert jordingsleder. Ta kontakt med fagfolk innen elektrisk inspeksjon eller med en elektriker hvis du er usikker på om det finnes velegnet jordning.**

Aviso **Este equipamento deve ser aterrado. Nunca anule o fio terra nem opere o equipamento sem um aterramento adequadamente instalado. Em caso de dúvida com relação ao sistema de aterramento disponível, entre em contato com os serviços locais de inspeção elétrica ou um eletricista qualificado.**

¡Advertencia! **Este equipo debe estar conectado a tierra. No inhabilite el conductor de tierra ni haga funcionar el equipo si no hay un conductor de tierra instalado correctamente. Póngase en contacto con la autoridad correspondiente de inspección eléctrica o con un electricista si no está seguro de que haya una conexión a tierra adecuada.**

Varning! **Denna utrustning måste jordas. Koppla aldrig från jordledningen och använd aldrig utrustningen utan en på lämpligt sätt installerad jordledning. Om det föreligger osäkerhet huruvida lämplig jordning finns skall elektrisk besiktningsauktoritet eller elektriker kontaktas.**

A berendezés csak megfelelő védőföldeléssel működtethető. Ne iktassa ki a földelés csatlakozóját, és ne üzemeltesse a berendezést szabályosan felszerelt földelő vezeték nélkül! Ha nem biztos benne, hogy megfelelő földelés áll rendelkezésbe, forduljon a helyi elektromos hatóságokhoz vagy egy villanyszerelőhöz.

Предупреждение Данное устройство должно быть заземлено. Никогда не отключайте провод заземления и не пользуйтесь оборудованием при отсутствии правильно подключенного провода заземления. За сведениями об имеющихся возможностях заземления обратитесь к соответствующим контролирующим организациям по энергоснабжению или к инженеру-электрику.

警告 此设备必须接地。切勿使接地导体失效，或者在没有正确安装接地导体的情况下操作该设备。如果您不能肯定接地导体是否正常发挥作用，请咨询有关电路检测方面的权威人士或电工。

警告 この装置はアース接続する必要があります。アース導体を破損しないよう注意し、アース導体を正しく取り付けないまま装置を稼働させないでください。アース接続が適正であるかどうか分からない場合には、電気検査機関または電気技術者に相談してください。

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Chassis Warning for Rack-Mounting and Servicing

Warning **To prevent bodily injury when mounting or servicing this unit in a rack, you must take special precautions to ensure that the system remains stable. The following guidelines are provided to ensure your safety:**

- **This unit should be mounted at the bottom of the rack if it is the only unit in the rack.**
- **When mounting this unit in a partially filled rack, load the rack from the bottom to the top with the heaviest component at the bottom of the rack.**
- **If the rack is provided with stabilizing devices, install the stabilizers before mounting or servicing the unit in the rack.** Statement 1006

Waarschuwing **Om lichamelijk letsel te voorkomen wanneer u dit toestel in een rek monteert of het daar een servicebeurt geeft, moet u speciale voorzorgsmaatregelen nemen om ervoor te zorgen dat het toestel stabiel blijft. De onderstaande richtlijnen worden verstrekt om uw veiligheid te verzekeren:**

- **Dit toestel dient onderaan in het rek gemonteerd te worden als het toestel het enige in het rek is.**
- **Wanneer u dit toestel in een gedeeltelijk gevuld rek monteert, dient u het rek van onderen naar boven te laden met het zwaarste onderdeel onderaan in het rek.**
- **Als het rek voorzien is van stabiliseringshulpmiddelen, dient u de stabilisatoren te monteren voordat u het toestel in het rek monteert of het daar een servicebeurt geeft.**

Varoitus **Kun laite asetetaan telineeseen tai huolletaan sen ollessa telineessä, on noudatettava erityisiä varotoimia järjestelmän vakavuuden säilyttämiseksi, jotta vältytään loukkaantumiselta. Noudata seuraavia turvallisuusohjeita:**

- **Jos telineessä ei ole muita laitteita, aseta laite telineen alaosaan.**
- **Jos laite asetetaan osaksi täytettyyn telineeseen, aloita kuormittaminen sen alaosasta kaikkein raskaimmalla esineellä ja siirry sitten sen yläosaan.**
- **Jos telinettä varten on vakaimet, asenna ne ennen laitteen asettamista telineeseen tai sen huoltamista siinä.**

Attention **Pour éviter toute blessure corporelle pendant les opérations de montage ou de réparation de cette unité en casier, il convient de prendre des précautions spéciales afin de maintenir la stabilité du système. Les directives ci-dessous sont destinées à assurer la protection du personnelþ:**

- **Si cette unité constitue la seule unité montée en casier, elle doit être placée dans le bas.**
- **Si cette unité est montée dans un casier partiellement rempli, charger le casier de bas en haut en plaçant l'élément le plus lourd dans le bas.**
- **Si le casier est équipé de dispositifs stabilisateurs, installer les stabilisateurs avant de monter ou de réparer l'unité en casier.**

Warnung **Zur Vermeidung von Körperverletzung beim Anbringen oder Warten dieser Einheit in einem Gestell müssen Sie besondere Vorkehrungen treffen, um sicherzustellen, daß das System stabil bleibt. Die folgenden Richtlinien sollen zur Gewährleistung Ihrer Sicherheit dienen:**

- **Wenn diese Einheit die einzige im Gestell ist, sollte sie unten im Gestell angebracht werden.**
- **Bei Anbringung dieser Einheit in einem zum Teil gefüllten Gestell ist das Gestell von unten nach oben zu laden, wobei das schwerste Bauteil unten im Gestell anzubringen ist.**
- **Wird das Gestell mit Stabilisierungszubehör geliefert, sind zuerst die Stabilisatoren zu installieren, bevor Sie die Einheit im Gestell anbringen oder sie warten.**

Avvertenza **Per evitare infortuni fisici durante il montaggio o la manutenzione di questa unità in un supporto, occorre osservare speciali precauzioni per garantire che il sistema rimanga stabile. Le seguenti direttive vengono fornite per garantire la sicurezza personale:**

- **Questa unità deve venire montata sul fondo del supporto, se si tratta dell'unica unità da montare nel supporto.**
- **Quando questa unità viene montata in un supporto parzialmente pieno, caricare il supporto dal basso all'alto, con il componente più pesante sistemato sul fondo del supporto.**
- **Se il supporto è dotato di dispositivi stabilizzanti, installare tali dispositivi prima di montare o di procedere alla manutenzione dell'unità nel supporto.**

Advarsel **Unngå fysiske skader under montering eller reparasjonsarbeid på denne enheten når den befinner seg i et kabinett. Vær nøye med at systemet er stabilt. Følgende retningslinjer er gitt for å verne om sikkerheten:**

- **Denne enheten bør monteres nederst i kabinettet hvis dette er den eneste enheten i kabinettet.**
- **Ved montering av denne enheten i et kabinett som er delvis fylt, skal kabinettet lastes fra bunnen og opp med den tyngste komponenten nederst i kabinettet.**
- **Hvis kabinettet er utstyrt med stabiliseringsutstyr, skal stabilisatorene installeres før montering eller utføring av reparasjonsarbeid på enheten i kabinettet.**

Aviso **Para se prevenir contra danos corporais ao montar ou reparar esta unidade numa estante, deverá tomar precauções especiais para se certificar de que o sistema possui um suporte estável. As seguintes directrizes ajudá-lo-ão a efectuar o seu trabalho com segurança:**

- **Esta unidade deverá ser montada na parte inferior da estante, caso seja esta a única unidade a ser montada.**
- **Ao montar esta unidade numa estante parcialmente ocupada, coloque os itens mais pesados na parte inferior da estante, arrumando-os de baixo para cima.**
- **Se a estante possuir um dispositivo de estabilização, instale-o antes de montar ou reparar a unidade.**

¡Advertencia! **Para evitar lesiones durante el montaje de este equipo sobre un bastidor, o posteriormente durante su mantenimiento, se debe poner mucho cuidado en que el sistema quede bien estable. Para garantizar su seguridad, proceda según las siguientes instrucciones:**

- **Colocar el equipo en la parte inferior del bastidor, cuando sea la única unidad en el mismo.**
- **Cuando este equipo se vaya a instalar en un bastidor parcialmente ocupado, comenzar la instalación desde la parte inferior hacia la superior colocando el equipo más pesado en la parte inferior.**
- **Si el bastidor dispone de dispositivos estabilizadores, instalar éstos antes de montar o proceder al mantenimiento del equipo instalado en el bastidor.**

Varning! **För att undvika kroppsskada när du installerar eller utför underhållsarbete på denna enhet på en ställning måste du vidta särskilda försiktighetsåtgärder för att försäkra dig om att systemet står stadigt. Följande riktlinjer ges för att trygga din säkerhet:**

- **Om denna enhet är den enda enheten på ställningen skall den installeras längst ned på ställningen.**
- **Om denna enhet installeras på en delvis fylld ställning skall ställningen fyllas nedifrån och upp, med de tyngsta enheterna längst ned på ställningen.**
- **Om ställningen är försedd med stabiliseringsdon skall dessa monteras fast innan enheten installeras eller underhålls på ställningen.**

A készülék rackbe történő beszerelése és karbantartása során bekövetkező sérülések elkerülése végett speciális óvintézkedésekkel meg kell őrizni a rendszer stabilitását. A személyes biztonsága érdekében tartsa be a következő szabályokat:

- **Ha a rackben csak ez az egy készülék található, a rack aljába kell beszerelni.**
- **Ha nincs teljesen tele az a rack, amelybe beszerelik a készüléket, alulról fölfelé haladva töltse fel a racket úgy, hogy a legnehezebb készülék kerüljön a rack aljába.**
- **Ha stabilizáló eszközök is tartoznak a rackhez, szerelje fel a stabilizátorokat, mielőtt beszerelné az egységet a rackbe, vagy karbantartást végezne rajta.**

Предупреждение Во избежание травм при монтаже и обслуживании устройства в стойке следует принять особые меры предосторожности, чтобы убедиться в устойчивости оборудования.
Для обеспечения безопасности работ необходимо соблюдать следующие правила.

- Если в стойке находится одно устройство, оно должно быть установлено в нижней части.
- При монтаже устройств в частично заполненную стойку устанавливайте оборудование снизу вверх, размещая наиболее тяжелые устройства в нижней части.
- Если стойка снабжена приспособлениями для стабилизации, их необходимо установить до начала монтажа или обслуживания оборудования.

警告 为避免在机架中安装或维修该部件时使身体受伤，您必须采取特殊的预防措施确保系统固定。以下是确保安全的原则：

- 如果此部件是机架中唯一的部件，应将其安装在机架的底部。
- 如果在部分装满的机架中安装此部件，请按从下往上的顺序安装各个部件，并且最重的组件应安装在机架的底部。
- 如果机架配有固定装置，请先装好固定装置，然后再在机架中安装或维修部件。

警告 この装置をラックに設置したり保守作業を行ったりするときは、人身事故を防ぐため、システムが安定しているかどうかを十分に確認する必要があります。次の注意事項に従ってください。

- ラックにこの装置を単独で設置する場合は、ラックの一番下に設置します。
- ラックに別の装置がすでに設置されている場合は、最も重量のある装置を一番下にして、重い順に下から上へ設置します。
- ラックに安定器具が付属している場合は、その安定器具を取り付けてから、装置をラックに設置するか、またはラック内の装置の保守作業を行ってください。

주의 이 장치를 랙에 장착하거나 서비스할 때 신체 부상을 방지하려면, 시스템이 안정된 상태를 유지하도록 특별히 주의해야 합니다. 사용자의 안전을 위해 다음 지침 사항을 준수하십시오.

- 이 장치가 랙에 장착되는 유일한 것일 경우, 랙의 맨 아래 부분에 장착되어야 합니다.
- 부분적으로 차 있는 랙에 이 장치를 장착할 경우, 가장 무거운 장치를 랙의 맨 아래 부분부터 차례로 장착하십시오.
- 안정기가 랙과 함께 제공되는 경우, 이 안정기를 설치한 후 이 장치를 랙에 장착하거나 서비스하십시오

Aviso **Para evitar lesões corporais ao montar ou dar manutenção a esta unidade em um rack, é necessário tomar todas as precauções para garantir a estabilidade do sistema. As seguintes orientações são fornecidas para garantir a sua segurança:**

- **Se esta for a única unidade, ela deverá ser montada na parte inferior do rack.**
- **Ao montar esta unidade em um rack parcialmente preenchido, carregue-o de baixo para cima com o componente mais pesado em sua parte inferior.**
- **Se o rack contiver dispositivos estabilizadores, instale-os antes de montar ou dar manutenção à unidade existente.**

Advarsel **For at forhindre legemesbeskadigelse ved montering eller service af denne enhed i et rack, skal du sikre at systemet står stabilt. Følgende retningslinjer er også for din sikkerheds skyld:**

- **Enheden skal monteres i bunden af dit rack, hvis det er den eneste enhed i racket.**
- **Ved montering af denne enhed i et delvist fyldt rack, skal enhederne installeres fra bunden og opad med den tungeste enhed nederst.**
- **Hvis racket leveres med stabiliseringsenheder, skal disse installeres for enheden monteres eller serviceres i racket.**

تحذير **لتجنب حدوث أي إصابات عند تركيب هذه الوحدة، يجب اتباع بعض الاحتياطات لضمان عمل النظام بشكل سليم.**
يتم ذكر الإرشادات التالية لضمان الأمان.
يجب تركيب هذه الوحدة في الجزء السفلي من الدولاب المتضمن قضبان إذا كانت هذه الوحدة هي الوحدة الوحيدة في الدولاب الذي يحتوي على قضبان.
عند تركيب هذه الوحدة في دولاب شبه ممتلئ، قم برفع الدولاب من الجزء السفلي لأعلى بحيث يكون الجزء الأثقل وزناً أسفل الدولاب.
إذا كان الدولاب المتضمن قضباناً يحتوي على أجهزة حفظ التوازن، قم بتثبيت هذه الأجهزة قبل تركيب الوحدة في الدولاب.

Upozorenje **Kako ne bi došlo do tjelesnih ozljeda kod postavljanja ili servisiranja uređaja na polici, potrebno je poduzeti mjere predostrožnosti kako bi sustav uvijek bio stabilan. Sigurnost se može osigurati poštivanjem sljedećih smjernica:**
- **Ovaj uređaj treba ugraditi na dno police, ukoliko je to jedini uređaj na polici.**
- **Kod ugradnje uređaja u policu na kojoj se već nalaze drugi uređaji, policu treba opremati počevši od dna, te tako da se na dno stave najteži dijelovi.**
- **Ukoliko su na polici ugrađeni stabilizatori, njih montirajte prije ugradnje ili servisiranja uređaja na polici.**

Upozornění **Abyste předešli poranění osob při montáži nebo opravě zařízení v montážním rámu, musíte dodržovat zvláštní preventivní opatření pro zajištění udržení stability systému. Pro zajištění bezpečnosti obsluhy jsou určeny následující zásady:**
- **Pokud je toto zařízení jedinou jednotkou v montážním rámu, musí být namontováno na nejnižší místo rámu.**
- **Pokud je toto zařízení montováno do částečně obsazeného montážního rámu, obsazujte montážní rám ve směru zdola nahoru tak, aby byla nejtěžší součást nejníže.**
- **Pokud je montážní rám vybaven stabilizačními zařízeními, nainstalujte stabilizátory ještě před montáží nebo opravou zařízení v montážním rámu.**

Προειδοποίηση Για να αποφύγετε τον τραυματισμό κατά την τοποθέτηση ή τη συντήρηση αυτής της συσκευής σε αρθρωτό σύστημα, πρέπει να λάβετε ειδικές προφυλάξεις για να διασφαλίσετε τη σταθερότητα του συστήματος. Οι παρακάτω οδηγίες παρέχονται για να εξασφαλίσουν την ασφάλειά σας:
- Αυτή η συσκευή πρέπει να τοποθετείται στο κάτω μέρος του αρθρωτού συστήματος αν είναι η μοναδική συσκευή σε αυτό.
- Όταν τοποθετείτε αυτήν τη συσκευή σε εν μέρει γεμάτο αρθρωτό σύστημα, τοποθετήστε συσκευές στο αρθρωτό σύστημα από κάτω προς τα επάνω, με τη βαρύτερη συσκευή στο κάτω μέρος του συστήματος.
- Εάν το αρθρωτό σύστημα διαθέτει διατάξεις σταθεροποίησης, τοποθετήστε τους σταθεροποιητές πριν τοποθετήσετε ή συντηρήσετε τη συσκευή στο αρθρωτό σύστημα.

אזהרה כדי למנוע פציעה בעת הרכבת יחידה זו במעמד או טיפול בה, עליך לנקוט אמצעי זהירות מיוחדים כדי להבטיח את יציבות המערכת. הקווים המנחים הבאים ניתנים על מנת להבטיח את ביטחונך:
- אם יחידה זו היא יחידה בודדת במעמד, יש להרכיב את היחידה בחלקו התחתון של המעמד.
- בעת הרכבת יחידה זו במעמד המלא בחלקו, טען את המעמד החל בחלק התחתון וכלפי מעלה כאשר הרכיב הכבד ביותר נמצא בחלקו התחתון של המעמד.
- אם המעמד מסופק עם התקני ייצוב, התקן את המייצבים לפני הרכבה היחידה במעמד או טיפול בה.

Opomena За да се не повредите кога го монтирате или го сервисирате уредот на полица, мора да бидете особено претпазливи за да ја обезбедите стабилноста на системот. Следите напатствија се дадени за да ја осигураат Вашата безбедност:
- Уредот треба да се монтира најдолу на полицата ако е единствен уред на полицата.
- Кога го монтирате уредот на делумно пополнета полица, полнете ја полицата од дното кон врвот со најтешката компонента на дното на полицата.
- Ако полицата има стабилизаторски делови, наместете ги стабилизаторите пред да го монтирате или сервисирате уредот на полицата.

Ostrzeżenie **Aby zapobiec urazom podczas montażu lub serwisowania tego urządzenia w stojaku, należy zastosować szczególne środki ostrożności w celu zapewnienia stabilności układu. Poniżej przedstawiono wskazówki, których przestrzeganie zapewni bezpieczeństwo:**

- **Jeśli urządzenie to jest jedynym urządzeniem w stojaku, powinno być zamontowane na dole.**
- **W przypadku montażu urządzenia w częściowo zapełnionym stojaku należy instalować kolejne urządzenia od najniższego do najwyższego, przy czym element najcięższy powinien być zamontowany najniżej w stojaku.**
- **Jeśli stojak jest wyposażony w elementy stabilizujące, należy zamontować stabilizatory przed przystąpieniem do montażu lub serwisowania urządzeń w stojaku.**

Upozornenie **Aby ste predišli poraneniu osôb pri montáži alebo oprave zariadenia v montážnom ráme, musíte dodržiavať zvláštne preventívne opatrenia na zaistenie udržania stability systému. Na zaistenie bezpečnosti obsluhy sú určené nasledujúce zásady:**

- **Pokiaľ je toto zariadenie jedinou jednotkou v montážnom ráme, musí byť namontované na najnižšie miesto v ráme.**
- **Pokiaľ je toto zariadenie montované do čiastočne obsadeného montážneho rámu, obsadzujte montážny rám v smere zdola nahor tak, aby bola najťažšia súčasť najnižšie.**
- **Pokiaľ je montážny rám vybavený stabilizačnými zariadeniami, nainštalujte stabilizátory ešte pred montážou alebo opravou zariadenia v montážnom ráme.**

A készülék rackbe történő beszerelése és karbantartása során bekövetkező sérülések elkerülése végett speciális óvintézkedésekkel meg kell őrizni a rendszer stabilitását. A személyes biztonsága érdekében tartsa be a következő szabályokat:

- **Ha a rackben csak ez az egy készülék található, a rack aljába kell beszerelni.**
- **Ha nincs teljesen tele az a rack, amelybe beszerelik a készüléket, alulról fölfelé haladva töltse fel a racket úgy, hogy a legnehezebb készülék kerüljön a rack aljába.**
- **Ha stabilizáló eszközök is tartoznak a rackhez, szerelje fel a stabilizátorokat, mielőtt beszerelné az egységet a rackbe, vagy karbantartást végezne rajta.**

Предупреждение Во избежание травм при монтаже и обслуживании устройства в стойке следует принять особые меры предосторожности, чтобы убедиться в устойчивости оборудования. Для обеспечения безопасности работ необходимо соблюдать следующие правила.

- Если в стойке находится одно устройство, оно должно быть установлено в нижней части.
- При монтаже устройств в частично заполненную стойку устанавливайте оборудование снизу вверх, размещая наиболее тяжелые устройства в нижней части.
- Если стойка снабжена приспособлениями для стабилизации, их необходимо установить до начала монтажа или обслуживания оборудования.

警告 为避免在机架中安装或维修该部件时使身体受伤，您必须采取特殊的预防措施确保系统固定。以下是确保安全的原则：

- 如果此部件是机架中唯一的部件，应将其安装在机架的底部。
- 如果在部分装满的机架中安装此部件，请按从下往上的顺序安装各个部件，并且最重的组件应安装在机架的底部。
- 如果机架配有固定装置，请先装好固定装置，然后再在机架中安装或维修部件。

警告 この装置をラックに設置したり保守作業を行ったりするときは、人身事故を防ぐため、システムが安定しているかどうかを十分に確認する必要があります。次の注意事項に従ってください。

- ラックにこの装置を単独で設置する場合は、ラックの一番下に設置します。
- ラックに別の装置がすでに設置されている場合は、最も重量のある装置を一番下にして、重い順に下から上へ設置します。
- ラックに安定器具が付属している場合は、その安定器具を取り付けてから、装置をラックに設置するか、またはラック内の装置の保守作業を行ってください。

주의 이 장치를 랙에 장착하거나 서비스할 때 신체 부상을 방지하려면, 시스템이 안정된 상태를 유지하도록 특별히 주의해야 합니다. 사용자의 안전을 위해 다음 지침 사항을 준수하십시오.

- 이 장치가 랙에 장착되는 유일한 것일 경우, 랙의 맨 아래 부분에 장착되어야 합니다.
- 부분적으로 차 있는 랙에 이 장치를 장착할 경우, 가장 무거운 장치를 랙의 맨 아래 부분부터 차례로 장착하십시오.
- 안정기가 랙과 함께 제공되는 경우, 이 안정기를 설치한 후 이 장치를 랙에 장착하거나 서비스하십시오

تحذير **لتجنب حدوث أي إصابات عند تركيب هذه الوحدة، يجب اتباع بعض الاحتياطات لضمان عمل النظام بشكل سليم. يتم ذكر الإرشادات التالية لضمان الأمان.**

يجب تركيب هذه الوحدة في الجزء السفلي من الدولاب المتضمن قضبان إذا كانت هذه الوحدة هي الوحدة الوحيدة في الدولاب الذي يحتوي على قضبان.

عند تركيب هذه الوحدة في دولاب شبه ممتلئ، قم برفع الدولاب من الجزء السفلي لأعلى بحيث يكون الجزء الأثقل وزناً أسفل الدولاب.

إذا كان الدولاب المتضمن قضباناً يحتوي على أجهزة حفظ التوازن، قم بتثبيت هذه الأجهزة قبل تركيب الوحدة في الدولاب.

Upozorenje Kako ne bi došlo do tjelesnih ozljeda kod postavljanja ili servisiranja uređaja na polici, potrebno je poduzeti mjere predostrožnosti kako bi sustav uvijek bio stabilan. Sigurnost se može osigurati poštivanjem sljedećih smjernica:

- **Ovaj uređaj treba ugraditi na dno police, ukoliko je to jedini uređaj na polici.**
- **Kod ugradnje uređaja u policu na kojoj se već nalaze drugi uređaji, policu treba opremati počevši od dna, te tako da se na dno stave najteži dijelovi.**
- **Ukoliko su na polici ugrađeni stabilizatori, njih montirajte prije ugradnje ili servisiranja uređaja na polici.**

Upozornění Abyste předešli poranění osob při montáži nebo opravě zařízení v montážním rámu, musíte dodržovat zvláštní preventivní opatření pro zajištění udržení stability systému. Pro zajištění bezpečnosti obsluhy jsou určeny následující zásady:

- **Pokud je toto zařízení jedinou jednotkou v montážním rámu, musí být namontováno na nejnižší místo rámu.**
- **Pokud je toto zařízení montováno do částečně obsazeného montážního rámu, obsazujte montážní rám ve směru zdola nahoru tak, aby byla nejtěžší součást nejníže.**
- **Pokud je montážní rám vybaven stabilizačními zařízeními, nainstalujte stabilizátory ještě před montáží nebo opravou zařízení v montážním rámu.**

Προειδοποίηση

Για να αποφύγετε τον τραυματισμό κατά την τοποθέτηση ή τη συντήρηση αυτής της συσκευής σε αρθρωτό σύστημα, πρέπει να λάβετε ειδικές προφυλάξεις για να διασφαλίσετε τη σταθερότητα του συστήματος. Οι παρακάτω οδηγίες παρέχονται για να εξασφαλίσουν την ασφάλειά σας:

- Αυτή η συσκευή πρέπει να τοποθετείται στο κάτω μέρος του αρθρωτού συστήματος αν είναι η μοναδική συσκευή σε αυτό.
- Όταν τοποθετείτε αυτήν τη συσκευή σε εν μέρει γεμάτο αρθρωτό σύστημα, τοποθετήστε συσκευές στο αρθρωτό σύστημα από κάτω προς τα επάνω, με τη βαρύτερη συσκευή στο κάτω μέρος του συστήματος.
- Εάν το αρθρωτό σύστημα διαθέτει διατάξεις σταθεροποίησης, τοποθετήστε τους σταθεροποιητές πριν τοποθετήσετε ή συντηρήσετε τη συσκευή στο αρθρωτό σύστημα.

אזהרה

כדי למנוע פציעה בעת הרכבת יחידה זו במעמד או טיפול בה, עליך לנקוט אמצעי זהירות מיוחדים כדי להבטיח את יציבות המערכת. הקווים המנחים הבאים ניתנים על מנת להבטיח את ביטחונך:

- אם יחידה זו היא יחידה בודדת במעמד, יש להרכיב את היחידה בחלקו התחתון של המעמד.
- בעת הרכבת יחידה זו במעמד המלא בחלקו, טען את המעמד החל בחלק התחתון וכלפי מעלה כאשר הרכיב הכבד ביותר נמצא בחלקו התחתון של המעמד.
- אם המעמד מסופק עם התקני ייצוב, התקן את המייצבים לפני הרכבה היחידה במעמד או טיפול בה.

Opomena

За да се не повредите кога го монтирате или го сервисирате уредот на полица, мора да бидете особено претпазливи за да ја обезбедите стабилноста на системот. Следите напатствија се дадени за да ја осигураат Вашата безбедност:

- Уредот треба да се монтира најдолу на полицата ако е единствен уред на полицата.
- Кога го монтирате уредот на делумно пополнета полица, полнете ја полицата од дното кон врвот со најтешката компонента на дното на полицата.
- Ако полицата има стабилизаторски делови, наместете ги стабилизаторите пред да го монтирате или сервисирате уредот на полицата.

Ostrzeżenie **Aby zapobiec urazom podczas montażu lub serwisowania tego urządzenia w stojaku, należy zastosować szczególne środki ostrożności w celu zapewnienia stabilności układu. Poniżej przedstawiono wskazówki, których przestrzeganie zapewni bezpieczeństwo:**
- **Jeśli urządzenie to jest jedynym urządzeniem w stojaku, powinno być zamontowane na dole.**
- **W przypadku montażu urządzenia w częściowo zapełnionym stojaku należy instalować kolejne urządzenia od najniższego do najwyższego, przy czym element najcięższy powinien być zamontowany najniżej w stojaku.**
- **Jeśli stojak jest wyposażony w elementy stabilizujące, należy zamontować stabilizatory przed przystąpieniem do montażu lub serwisowania urządzeń w stojaku.**

Upozornenie **Aby ste predišli poraneniu osôb pri montáži alebo oprave zariadenia v montážnom ráme, musíte dodržiavať zvláštne preventívne opatrenia na zaistenie udržania stability systému. Na zaistenie bezpečnosti obsluhy sú určené nasledujúce zásady:**
- **Pokiaľ je toto zariadenie jedinou jednotkou v montážnom ráme, musí byť namontované na najnižšie miesto v ráme.**
- **Pokiaľ je toto zariadenie montované do čiastočne obsadeného montážneho rámu, obsadzujte montážny rám v smere zdola nahor tak, aby bola najťažšia súčasť najnižšie.**
- **Pokiaľ je montážny rám vybavený stabilizačnými zariadeniami, nainštalujte stabilizátory ešte pred montážou alebo opravou zariadenia v montážnom ráme.**

Battery Handling Warning

Warning **There is the danger of explosion if the controller battery is replaced incorrectly. Replace the battery only with the same or equivalent type recommended by the manufacturer. Dispose of used batteries according to the manufacturer's instructions.** Statement 1015

Waarschuwing **Er is ontploffingsgevaar als de batterij verkeerd vervangen wordt. Vervang de batterij slechts met hetzelfde of een equivalent type dat door de fabrikant aanbevolen is. Gebruikte batterijen dienen overeenkomstig fabrieksvoorschriften weggeworpen te worden.**

Varoitus **Räjähdyksen vaara, jos akku on vaihdettu väärään akkuun. Käytä vaihtamiseen ainoastaan samantai vastaavantyyppistä akkua, joka on valmistajan suosittelema. Hävitä käytetyt akut valmistajan ohjeiden mukaan.**

Attention **Danger d'explosion si la pile n'est pas remplacée correctement. Ne la remplacer que par une pile de type semblable ou équivalent, recommandée par le fabricant. Jeter les piles usagées conformément aux instructions du fabricant.**

Warnung **Bei Einsetzen einer falschen Batterie besteht Explosionsgefahr. Ersetzen Sie die Batterie nur durch den gleichen oder vom Hersteller empfohlenen Batterietyp. Entsorgen Sie die benutzten Batterien nach den Anweisungen des Herstellers.**

Avvertenza **Pericolo di esplosione se la batteria non è installata correttamente. Sostituire solo con una di tipo uguale o equivalente, consigliata dal produttore. Eliminare le batterie usate secondo le istruzioni del produttore.**

Advarsel **Det kan være fare for eksplosjon hvis batteriet skiftes på feil måte. Skift kun med samme eller tilsvarende type som er anbefalt av produsenten. Kasser brukte batterier i henhold til produsentens instruksjoner.**

Aviso **Existe perigo de explosão se a bateria for substituída incorrectamente. Substitua a bateria por uma bateria igual ou de um tipo equivalente recomendado pelo fabricante. Destrua as baterias usadas conforme as instruções do fabricante.**

¡Advertencia! **Existe peligro de explosión si la batería se reemplaza de manera incorrecta. Reemplazar la batería exclusivamente con el mismo tipo o el equivalente recomendado por el fabricante. Desechar las baterías gastadas según las instrucciones del fabricante.**

Varning! **Explosionsfara vid felaktigt batteribyte. Ersätt endast batteriet med samma batterityp som rekommenderas av tillverkaren eller motsvarande. Följ tillverkarens anvisningar vid kassering av använda batterier.**

Robbanásveszélyt idézhet elő, ha helytelenül cserélik ki az akkumulátort. Csak a gyártó által javasolttal megegyező vagy azzal egyenértékű típusúra cserélje ki az akkumulátort! A használt akkumulátorok kidobásakor tartsa be a gyártó előírásait!

Предупреждение При неправильной замене батареи возможен взрыв. Для замены следует использовать батарею того же или аналогичного типа, рекомендованного изготовителем. Утилизацию батареи необходимо производить в соответствии с указаниями изготовителя.

警告 电池更换不当会有爆炸危险。请只用同类电池或制造商推荐的功能相当的电池更换原有电池。请按制造商的说明处理废旧电池。

警告 不適切なバッテリに交換すると、爆発の危険性があります。製造元が推奨するものと同じまたは同等のバッテリだけを使用してください。使用済みのバッテリは、製造元が指示する方法に従って処分してください。

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Equipment Installation Warning

Warning **Only trained and qualified personnel should be allowed to install, replace, or service this equipment.** Statement 1030

Waarschuwing **Deze apparatuur mag alleen worden geïnstalleerd, vervangen of hersteld door bevoegd geschoold personeel.**

Varoitus **Tämän laitteen saa asentaa, vaihtaa tai huoltaa ainoastaan koulutettu ja laitteen tunteva henkilökunta.**

Attention **Il est vivement recommandé de confier l'installation, le remplacement et la maintenance de ces équipements à des personnels qualifiés et expérimentés.**

Warnung **Das Installieren, Ersetzen oder Bedienen dieser Ausrüstung sollte nur geschultem, qualifiziertem Personal gestattet werden.**

Avvertenza **Questo apparato può essere installato, sostituito o mantenuto unicamente da un personale competente.**

Advarsel **Bare opplært og kvalifisert personell skal foreta installasjoner, utskiftninger eller service på dette utstyret.**

Aviso **Apenas pessoal treinado e qualificado deve ser autorizado a instalar, substituir ou fazer a revisão deste equipamento.**

¡Advertencia! **Solamente el personal calificado debe instalar, reemplazar o utilizar este equipo.**

Varning! **Endast utbildad och kvalificerad personal bör få tillåtelse att installera, byta ut eller reparera denna utrustning.**

A berendezést csak szakképzett személyek helyezhetik üzembe, cserélhetik és tarthatják karban.

Предупреждение Установку, замену и обслуживание этого оборудования может осуществлять только специально обученный квалифицированный персонал.

警告 只有经过培训且具有资格的人员才能进行此设备的安装、更换和维修。

警告 この装置の設置、交換、保守は、訓練を受けた相応の資格のある人が行ってください。

주의 교육을 받고 자격을 갖춘 사람만 이 장비를 설치, 교체, 또는 서비스를 수행해야 합니다.

Aviso **Somente uma equipe treinada e qualificada tem permissão para instalar, substituir ou dar manutenção a este equipamento.**

Advarsel **Kun uddannede personer må installere, udskifte komponenter i eller servicere dette udstyr.**

تحذير **يسمح للفنيين المتخصصين فقط بتركيب المعدة أو استبدالها أو إجراء الصيانة عليها.**

Upozorenje **Uređaj smije ugrađivati, mijenjati i servisirati samo za to obučeno i osposobljeno servisno osoblje.**

Upozornění **Instalaci, výměnu nebo opravu tohoto zařízení smějí provádět pouze proškolené a kvalifikované osoby.**

Προειδοποίηση Η τοποθέτηση, η αντικατάσταση και η συντήρηση του εξοπλισμού επιτρέπεται να γίνονται μόνο από καταρτισμένο προσωπικό με τα κατάλληλα προσόντα.

אזהרה רק עובדים מיומנים ומוסמכים רשאים להתקין, להחליף, או לטפל בציד זה.

Opomena Местењето, заменувањето и сервисирањето на оваа опрема треба да му биде дозволено само на обучен и квалификуван персонал.

Ostrzeżenie **Do instalacji, wymiany i serwisowania tych urządzeń mogą być dopuszczone wyłącznie osoby wykwalifikowane i przeszkolone.**

Upozornenie **Inštaláciu, výmenu alebo opravu tohto zariadenia smú vykonávať iba vyškolené a kvalifikované osoby.**

A berendezést csak szakképzett személyek helyezhetik üzembe, cserélhetik és tarthatják karban.

Предупреждение Установку, замену и обслуживание этого оборудования может осуществлять только специально обученный квалифицированный персонал.

警告 只有经过培训且具有资格的人员才能进行此设备的安装、更换和维修。

警告 この装置の設置、交換、保守は、訓練を受けた相応の資格のある人が行ってください。

주의 교육을 받고 자격을 갖춘 사람만 이 장비를 설치, 교체, 또는 서비스를 수행해야 합니다.

تحذير **يسمح للفنيين المتخصصين فقط بتركيب المعدة أو استبدالها أو إجراء الصيانة عليها.**

Upozorenje **Uređaj smije ugrađivati, mijenjati i servisirati samo za to obučeno i osposobljeno servisno osoblje.**

Upozornění **Instalaci, výměnu nebo opravu tohoto zařízení smějí provádět pouze proškolené a kvalifikované osoby.**

Προειδοποίηση Η τοποθέτηση, η αντικατάσταση και η συντήρηση του εξοπλισμού επιτρέπεται να γίνονται μόνο από καταρτισμένο προσωπικό με τα κατάλληλα προσόντα.

אזהרה רק עובדים מיומנים ומוסמכים רשאים להתקין, להחליף, או לטפל בציד זה.

Opomena Местењето, заменувањето и сервисирањето на оваа опрема треба да му биде дозволено само на обучен и квалификуван персонал.

Ostrzeżenie **Do instalacji, wymiany i serwisowania tych urządzeń mogą być dopuszczone wyłącznie osoby wykwalifikowane i przeszkolone.**

Upozornenie **Inštaláciu, výmenu alebo opravu tohto zariadenia smú vykonávať iba vyškolené a kvalifikované osoby.**

More Than One Power Supply Warning for Cisco 5500 and 4400 Series Controllers

Warning **The wireless lan controller might have more than one power supply connection. All connections must be removed to de-energize the unit.** Statement 1028

Waarschuwing **Deze eenheid kan meer dan één stroomtoevoeraansluiting bevatten. Alle aansluitingen dienen ontkoppeld te worden om de eenheid te ontkrachten.**

Varoitus **Tässä laitteessa voi olla useampia kuin yksi virtakytkentä. Kaikki liitännät on irrotettava, jotta jännite poistetaan laitteesta.**

Attention **Cette unité peut avoir plus d'une connexion d'alimentation. Pour supprimer toute tension et tout courant électrique de l'unité, toutes les connexions d'alimentation doivent être débranchées.**

Warnung **Dieses Gerät kann mehr als eine Stromzufuhr haben. Um sicherzustellen, dass der Einheit kein Strom zugeführt wird, müssen alle Verbindungen entfernt werden.**

Avvertenza **Questa unità può avere più di una connessione all'alimentazione elettrica. Tutte le connessioni devono essere staccate per togliere la corrente dall'unità.**

Advarsel **Denne enheten kan ha mer enn én strømtilførselskobling. Alle koblinger må fjernes fra enheten for å utkoble all strøm.**

Aviso **Esta unidade poderá ter mais de uma conexão de fonte de energia. Todas as conexões devem ser removidas para desligar a unidade.**

¡Advertencia! **Puede que esta unidad tenga más de una conexión para fuentes de alimentación. Para cortar por completo el suministro de energía, deben desconectarse todas las conexiones.**

Varning! **Denna enhet har eventuellt mer än en strömförsörjningsanslutning. Alla anslutningar måste tas bort för att göra enheten strömlös.**

Előfordulhat, hogy a készülék többszörösen van csatlakoztatva az áramforráshoz. A készülék áramtalanításához mindegyik csatlakozást meg kell szüntetni.

Предупреждение В данном устройстве может использоваться несколько подключений к электросети. Чтобы обесточить устройство, необходимо отключить все эти подключения.

警告 此部件连接的电源可能不止一个。必须将所有电源断开才能停止给该部件供电。

警告 この装置には、複数の電源が接続されている場合があります。装置の電源を完全にオフにするには、すべての電源を切断する必要があります。

주의 본 장치에는 2개 이상의 전원 공급 연결 단자가 있을 수 있습니다. 이 장치의 전원을 차단하려면 모든 연결 단자를 제거해야 합니다.

Aviso **Esta unidade pode ter mais de uma conexão de fonte de alimentação. Todas as conexões devem ser removidas para interromper a alimentação da unidade.**

Advarsel **Denne enhed har muligvis mere end en strømforsyningstilslutning. Alle tilslutninger skal fjernes for at aflade strømmen fra enheden.**

تحذير **قد تتضمن هذه الوحدة أكثر من اتصال بمورد الطاقة. يجب فصل كافة التوصيلات حتى يمكن إفراغ طاقة الوحدة.**

Upozorenje **Uređaj može imati više priključaka za izvore napajanja. Za potpuno isključivanje napajanja potrebno je iskopčati sve priključke.**

Upozornění **Toto zařízení může být připojeno k více než jednomu zdroji napájení. Aby se zařízení zcela odpojilo od proudu, musí být odpojeno od všech zdrojů napájení.**

Προειδοποίηση Αυτή η συσκευή ίσως να έχει περισσότερες συνδέσεις τροφοδοσίας.
Για να απενεργοποιηθεί η συσκευή, πρέπει να αφαιρεθούν όλες οι συνδέσεις.

אזהרה ייתכן שביחידה זו קיים יותר מחיבור אחד לספק כוח. יש להסיר את כל החיבורים כדי להפסיק את אספקת המתח ליחידה.

Opomena Уредот може да има повеќе од еден приклучок за напојување. Сите приклучоци мора да се извадат за да се прекине доводот на енергија во уредот.

Ostrzeżenie **To urządzenie może mieć podłączone więcej niż jedno źródło zasilania. Aby całkowicie odciąć dopływ energii do urządzenia, należy odłączyć wszystkie źródła zasilania.**

Upozornenie **Toto zariadenie môže byť pripojené k viac ako jednému zdroju napájania. Aby sa zariadenie odpojilo od prúdu, musí byť odpojené od všetkých zdrojov.**

Előfordulhat, hogy a készülék többszörösen van csatlakoztatva az áramforráshoz. A készülék áramtalanításához mindegyik csatlakozást meg kell szüntetni.

Предупреждение В данном устройстве может использоваться несколько подключений к электросети. Чтобы обесточить устройство, необходимо отключить все эти подключения.

警告 此部件连接的电源可能不止一个。必须将所有电源断开才能停止给该部件供电。

警告 この装置には、複数の電源が接続されている場合があります。装置の電源を完全にオフにするには、すべての電源を切断する必要があります。

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تحذير **قد تتضمن هذه الوحدة أكثر من اتصال بمورد الطاقة. يجب فصل كافة التوصيلات حتى يمكن إفراغ طاقة الوحدة.**

Upozorenje **Uređaj može imati više priključaka za izvore napajanja. Za potpuno isključivanje napajanja potrebno je iskopčati sve priključke.**

Upozornění **Toto zařízení může být připojeno k více než jednomu zdroji napájení. Aby se zařízení zcela odpojilo od proudu, musí být odpojeno od všech zdrojů napájení.**

Προειδοποίηση Αυτή η συσκευή ίσως να έχει περισσότερες συνδέσεις τροφοδοσίας. Για να απενεργοποιηθεί η συσκευή, πρέπει να αφαιρεθούν όλες οι συνδέσεις.

אזהרה יתכן שביחידה זו קיים יותר מחיבור אחד לספק כוח. יש להסיר את כל החיבורים כדי להפסיק את אספקת המתח ליחידה.

Opomena Уредот може да има повеќе од еден приклучок за напојување. Сите приклучоци мора да се извадат за да се прекине доводот на енергија во уредот.

Ostrzeżenie **To urządzenie może mieć podłączone więcej niż jedno źródło zasilania. Aby całkowicie odciąć dopływ energii do urządzenia, należy odłączyć wszystkie źródła zasilania.**

Upozornenie **Toto zariadenie môže byť pripojené k viac ako jednému zdroju napájania. Aby sa zariadenie odpojilo od prúdu, musí byť odpojené od všetkých zdrojov.**

APPENDIX B

Declarations of Conformity and Regulatory Information

This appendix provides declarations of conformity and regulatory information for the products in the Cisco UWN solution.

This appendix contains these sections:

Guidelines for Operating Controllers in Japan

This section provides guidelines for avoiding interference when operating Cisco Aironet 5500, 4400, and Cisco 2100 Series Controller in Japan. These guidelines are provided in both Japanese and English.

VCCI Class A Warning for Cisco 5500 Series Controllers and 4400 Series Controllers in Japan

Warning **This is a Class A product based on the standard of the Voluntary Control Council for Interference by Information Technology Equipment (VCCI). If this equipment is used in a domestic environment, radio disturbance may arise. When such trouble occurs, the user may be required to take corrective actions.**

警告

VCCI 準拠クラスA機器（日本）
この装置は、情報処理装置等電波障害自主規制協議会（VCCI）の基準に基づくクラスA情報技術装置です。この装置を家庭環境で使用すると電波妨害を引き起こすことがあります。この場合には使用者が適切な対策を講ずるよう要求されることがあります。

VCCI Class B Warning for Cisco 2100 Series Controller in Japan

Warning **This is a Class B product based on the standard of the Voluntary Control Council for Interference from Information Technology Equipment (VCCI). If this is used near a radio or television receiver in a domestic environment, it may cause radio interference. Install and use the equipment according to the instruction manual.**

警告

この装置は、クラスＢ情報技術装置です。この装置は、家庭環境で使用することを目的としていますが、この装置がラジオやテレビジョン受信機に近接して使用されると、受信障害を引き起こすことがあります。
取扱説明書に従って正しい取り扱いをして下さい。

ＶＣＣＩ－Ｂ

Power Cable and AC Adapter Warning for Japan

Warning **When installing the product, please use the provided or designated connection cables/power cables/AC adaptors. Using any other cables/adaptors could cause a malfunction or a fire. Electrical Appliance and Material Safety Law prohibits the use of UL-certified cables (that have the "UL" shown on the code) for any other electrical devices than products designated by CISCO. The use of cables that are certified by Electrical Appliance and Material Safety Law (that have "PSE" shown on the code) is not limited to CISCO-designated products.**

警告

接続ケーブル、電源コード、ACアダプタなどの部品は、必ず添付品または指定品をご使用ください。添付品・指定品以外の部品をご使用になると故障や動作不良、火災の原因となります。また、電気用品安全法により、当該法の認定（PSEとコードに表記）でなくUL認定（ULまたはCSAマークがコードに表記）の電源ケーブルは弊社が指定する製品以外の電気機器には使用できないためご注意ください。

Declaration of Conformity Statements

All the Declaration of Conformity statements related to this product can be found at the following URL:

http://www.ciscofax.com

FCC Statement for Cisco 5500 Series Wireless LAN Controllers

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case users will be required to correct the interference at their own expense.

FCC Statement for Cisco 4400 Series Wireless LAN Controllers

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Statement for Cisco 2100 Series Wireless LAN Controllers

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help. [cfr reference 15.105]

APPENDIX C

End User License and Warranty

This appendix describes the end user license and warranty that apply to the Cisco UWN Solution products:

- Cisco 2100 Series Wireless LAN Controllers
- Cisco 4400 Series Wireless LAN Controllers
- Cisco 5500 Series Wireless LAN Controllers
- Cisco Wireless Services Modules

This appendix contains these sections:

End User License Agreement

IMPORTANT: PLEASE READ THIS END USER LICENSE AGREEMENT CAREFULLY. DOWNLOADING, INSTALLING OR USING CISCO OR CISCO-SUPPLIED SOFTWARE CONSTITUTES ACCEPTANCE OF THIS AGREEMENT.

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Term and Termination. This Agreement and the license granted herein shall remain effective until terminated. Customer may terminate this Agreement and the license at any time by destroying all copies of Software and any Documentation. Customer's rights under this Agreement will terminate immediately without notice from Cisco if Customer fails to comply with any provision of this Agreement. Cisco and its suppliers are further entitled to obtain injunctive relief if Customer's use of the Software is in violation of any license restrictions. Upon termination, Customer shall destroy all copies of Software and Documentation in its possession or control. All confidentiality obligations of Customer and all limitations of liability and disclaimers and restrictions of warranty shall survive termination of this Agreement. In addition, the provisions of the sections titled "U.S. Government End User Purchasers" and "General Terms Applicable to the Limited Warranty Statement and End User License" shall survive termination of this Agreement.

Customer Records. Customer grants to Cisco and its independent accountants the right to examine Customer's books, records and accounts during Customer's normal business hours to verify compliance with this Agreement. In the event such audit discloses non-compliance with this Agreement, Customer shall promptly pay to Cisco the appropriate license fees, plus the reasonable cost of conducting the audit.

Export. Software and Documentation, including technical data, may be subject to U.S. export control laws, including the U.S. Export Administration Act and its associated regulations, and may be subject to export or import regulations in other countries. Customer agrees to comply strictly with all such regulations and acknowledges that it has the responsibility to obtain licenses to export, re-export, or import Software and Documentation. Customer's failure to comply with such restrictions shall constitute a material breach of the Agreement.

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Limited Warranty

Hardware for Cisco 2100 Series Wireless LAN Controllers, Cisco 4400 Series Wireless LAN Controllers, Cisco 5500 Series Wireless LAN Controllers, and Cisco Wireless Services Modules. Cisco Systems, Inc., or the Cisco Systems, Inc. subsidiary selling the Product ("Cisco") warrants that commencing from the date of shipment to Customer (and in case of resale by a Cisco reseller, commencing not more than ninety (90) days after original shipment by Cisco), and continuing for a period of ninety (90) days, the Hardware will be free from defects in material and workmanship under normal use. The date of shipment of a Product by Cisco is set forth on the packaging material in which the Product is shipped. This limited warranty extends only to the original user of the Product. Customer's sole and exclusive remedy and the entire liability of Cisco and its suppliers under this limited warranty will be, at Cisco's or its service center's option, shipment of a replacement within the warranty period and according to the replacement process described in the Warranty Card (if any), or if no Warranty Card, as described at http://www.cisco.com/en/US/products/prod_warranties_listing.html or a refund of the purchase price if the Hardware is returned to the party supplying it to Customer, freight and insurance prepaid. Cisco replacement parts used in Hardware replacement may be new or equivalent to new. Cisco's obligations hereunder are conditioned upon the return of affected Hardware in accordance with Cisco's or its service center's then-current Return Material Authorization (RMA) procedures.

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APPENDIX D

Troubleshooting

This appendix lists system messages that can appear on the Cisco UWN solution interfaces, describes the LED patterns on controllers and lightweight access points, and provides CLI commands that can be used to troubleshoot problems on the controller. It contains these sections:

Interpreting LEDs

This section describes how to interpret controller LEDs and lightweight access point LEDs.

Interpreting Controller LEDs

See the quick start guide for your specific controller for a description of the LED patterns. You can find the guides at this URL:

http://www.cisco.com/en/US/products/hw/wireless/index.html

Interpreting Lightweight Access Point LEDs

See the quick start guide or hardware installation guide for your specific access point for a description of the LED patterns. You can find the guides at this URL:

http://www.cisco.com/en/US/products/hw/wireless/index.html

System Messages

Table D-1 lists some common system messages and their descriptions. For a complete list of system messages, see the *Cisco Wireless LAN Controller System Message Guide, Release 7.0*.

Table D-1 System Messages and Descriptions

Error Message	Description
apf_utils.c 680: Received a CIF field without the protected bit set from mobile xx:xx:xx:xx:xx:xx	A client is sending an association request on a security-enabled WLAN with the protected bit set to 0 (in the Capability field of the association request). As designed, the controller rejects the association request, and the client sees an association failure.
dtl_arp.c 480: Got an idle-timeout message from an unknown client xx:xx:xx:xx:xx:xx	The controller's network processing unit (NPU) sends a timeout message to the central processing unit (CPU) indicating that a particular client has timed out or aged out. This situation typically occurs when the CPU has removed a wireless client from its internal database but has not notified the NPU. Because the client remains in the NPU database, it ages out on the network processor and notifies the CPU. The CPU finds the client that is not present in its database and then sends this message.
STATION_DISASSOCIATE	The client may have intentionally terminated usage or may have experienced a service disruption.
STATION_DEAUTHENTICATE	The client may have intentionally terminated usage or this message could indicate an authentication issue.
STATION_AUTHENTICATION_FAIL	Check disable, key mismatch, or other configuration issues.
STATION_ASSOCIATE_FAIL	Check load on the Cisco radio or signal quality issues.
LRAD_ASSOCIATED	The associated lightweight access point is now managed by this controller.
LRAD_DISASSOCIATED	The lightweight access point may have associated to a different controller or may have become completely unreachable.

Table D-1 System Messages and Descriptions (continued)

Error Message	Description
LRAD_UP	The lightweight access point is operational; no action required.
LRAD_DOWN	The lightweight access point may have a problem or is administratively disabled.
LRADIF_UP	The Cisco radio is UP.
LRADIF_DOWN	The Cisco radio may have a problem or is administratively disabled.
LRADIF_LOAD_PROFILE_FAILED	The client density may have exceeded system capacity.
LRADIF_NOISE_PROFILE_FAILED	The non-802.11 noise has exceeded the configured threshold.
LRADIF_INTERFERENCE_PROFILE_FAILED	802.11 interference has exceeded threshold on channel; check channel assignments.
LRADIF_COVERAGE_PROFILE_FAILED	A possible coverage hole has been detected. Check the lightweight access point history to see if it is a common problem and add lightweight access points if necessary.
LRADIF_LOAD_PROFILE_PASSED	The load is now within threshold limits.
LRADIF_NOISE_PROFILE_PASSED	The detected noise is now less than threshold.
LRADIF_INTERFERENCE_PROFILE_PASSED	The detected interference is now less than threshold.
LRADIF_COVERAGE_PROFILE_PASSED	The number of clients receiving a poor signal are within threshold.
LRADIF_CURRENT_TXPOWER_CHANGED	Informational message.
LRADIF_CURRENT_CHANNEL_CHANGED	Informational message.
LRADIF_RTS_THRESHOLD_CHANGED	Informational message.
LRADIF_ED_THRESHOLD_CHANGED	Informational message.
LRADIF_FRAGMENTATION_THRESHOLD_CHANGED	Informational message.
RRM_DOT11_A_GROUPING_DONE	Informational message.
RRM_DOT11_B_GROUPING_DONE	Informational message.
ROGUE_AP_DETECTED	May be a security issue. Use maps and trends to investigate.
ROGUE_AP_REMOVED	A detected rogue access point has timed out. The unit might have shut down or moved out of the coverage area.
AP_MAX_ROGUE_COUNT_EXCEEDED	The current number of active rogue access points has exceeded system threshold.
LINK_UP	Positive confirmation message.
LINK_DOWN	A port may have a problem or is administratively disabled.

Table D-1 System Messages and Descriptions (continued)

Error Message	Description
LINK_FAILURE	A port may have a problem or is administratively disabled.
AUTHENTICATION_FAILURE	An attempted security breech has occurred. Investigate.
STP_NEWROOT	Informational message.
STP_TOPOLOGY_CHANGE	Informational message.
IPSEC_ESP_AUTH_FAILURE	Check WLAN IPsec configuration.
IPSEC_ESP_REPLAY_FAILURE	Check for an attempt to spoof an IP address.
IPSEC_ESP_POLICY_FAILURE	Check for a IPsec configuration mismatch between WLAN and client.
IPSEC_ESP_INVALID_SPI	Informational message.
IPSEC_OTHER_POLICY_FAILURE	Check for a IPsec configuration mismatch between WLAN and client.
IPSEC_IKE_NEG_FAILURE	Check for a IPsec IKE configuration mismatch between WLAN and client.
IPSEC_SUITE_NEG_FAILURE	Check for a IPsec IKE configuration mismatch between WLAN and client.
IPSEC_INVALID_COOKIE	Informational message.
RADIOS_EXCEEDED	The maximum number of supported Cisco radios has been exceeded. Check for a controller failure in the same Layer 2 network or add another controller.
SENSED_TEMPERATURE_HIGH	Check fan, air conditioning, and/or other cooling arrangements.
SENSED_TEMPERATURE_LOW	Check room temperature and/or other reasons for low temperature.
TEMPERATURE_SENSOR_FAILURE	Replace temperature sensor as soon as possible.
TEMPERATURE_SENSOR_CLEAR	The temperature sensor is operational.
POE_CONTROLLER_FAILURE	Check ports; a possible serious failure has been detected.
MAX_ROGUE_COUNT_EXCEEDED	The current number of active rogue access points has exceeded system threshold.
SWITCH_UP	The controller is responding to SNMP polls.
SWITCH_DOWN	The controller is not responding to SNMP polls; check controller and SNMP settings.
RADIUS_SERVERS_FAILED	Check network connectivity between RADIUS and the controller.
CONFIG_SAVED	The running configuration has been saved to flash; it will be active after a reboot.
MULTIPLE_USERS	Another user with the same username has logged in.

Table D-1 System Messages and Descriptions (continued)

Error Message	Description
FAN_FAILURE	Monitor controller temperature to avoid overheating.
POWER_SUPPLY_CHANGE	Check for a power-supply malfunction.
COLD_START	The controller may have been rebooted.
WARM_START	The controller may have been rebooted.

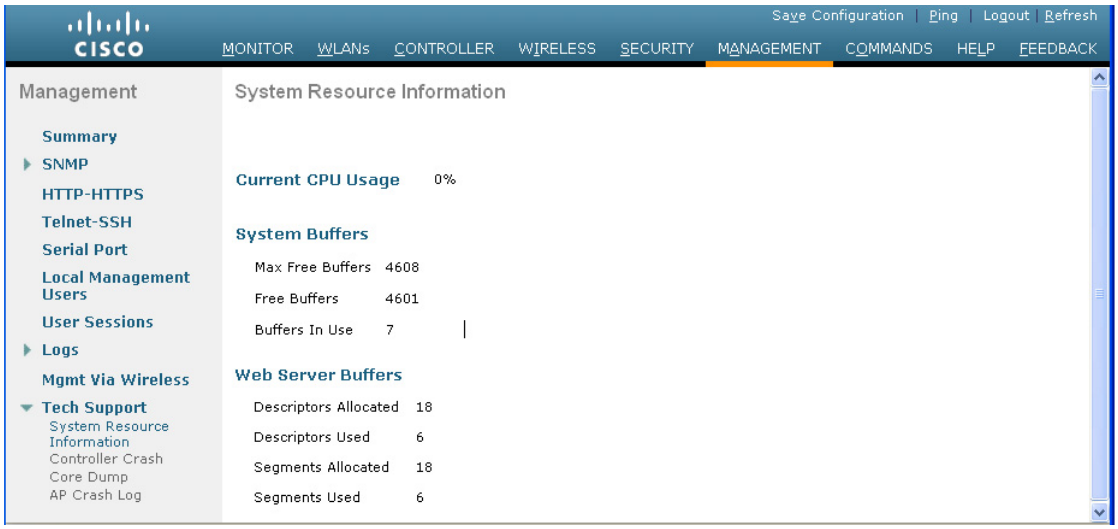
Viewing System Resources

You can use the GUI or CLI to determine the amount of system resources being used by the controller. Specifically, you can view the current controller CPU usage, system buffers, and web server buffers.

Note The Cisco 5500 Series Controllers have multiple CPUs, so you can view individual CPU usage. For each CPU, you can see the percentage of the CPU in use and the percentage of the CPU time spent at the interrupt level (for example, 0%/3%).

On the controller GUI, choose **Management > Tech Support > System Resource Information**. The System Resource Information page appears (see Figure D-1).

Figure D-1 System Resource Information Page



On the controller CLI, enter these commands:

- show cpu

  Information similar to the following appears:

```
Current CPU(s) load: 0%
ndividual CPU load: 0%/0%, 0%/0%, 0%/1%, 0%/0%, 0%/0%, 0%/0%, 0%/0%, 0%/0%, 0%/0%,
0%/0%
```

Where the first number is the CPU percentage that the controller spent on the user application and the second number is the CPU percentage that the controller spent on the OS services.

- show tech-support

  Information similar to the following appears:

```
System Information
Manufacturer's Name.............................. Cisco Systems Inc.
Product Name..................................... Cisco Controller
Product Version.................................. 6.0.165.0
...
---------------Show cpu---------------
Current CPU(s) Load.............................. 0%
Individual CPU Load.............................. 0%/3%, 0%/1%, 0%/1%, 0%/1%, 0%/0%,
0%/1%

---------------Show system buffers---------------

System Buffers
   Max Free Buffers.............................. 4608
   Free Buffers.................................. 4596
   Buffers In Use................................ 12

Web Server Resources
   Descriptors Allocated......................... 259
   Descriptors Used.............................. 4
   Segments Allocated............................ 259
   Segments Used................................. 4

System Resources
   Uptime........................................ 595748 Secs
   Total Ram..................................... 907872 Kbytes
...
```

Using the CLI to Troubleshoot Problems

If you experience any problems with your controller, you can use the commands in this section to gather information and debug issues.

1. **show process cpu**—Shows how various tasks in the system are using the CPU at that instant in time. This command is helpful in understanding if any single task is monopolizing the CPU and preventing other tasks from being performed.

   Information similar to the following appears:

```
Name               Priority      CPU Use      Reaper
 reaperWatcher      ( 3/124)     0 %         (  0/  0)%   I
 osapiReaper         (10/121)    0 %         (  0/  0)%   I
 TempStatus         (255/  1)    0 %         (  0/  0)%   I
 emWeb              (255/  1)    0 %         (  0/  0)%   T 300
 cliWebTask         (255/  1)    0 %         (  0/  0)%   I
 UtilTask           (255/  1)    0 %         (  0/  0)%   T 300
```

   In the example above, the following fields provide information:

   - The Name field shows the tasks that the CPU is to perform.
   - The Priority field shows two values: 1) the original priority of the task that was created by the actual function call and 2) the priority of the task divided by a range of system priorities.
   - The CPU Use field shows the CPU usage of a particular task.

- The Reaper field shows three values: 1) the amount of time for which the task is scheduled in user mode operation, 2) the amount of time for which the task is scheduled in system mode operation, and 3) whether the task is being watched by the reaper task monitor (indicated by a "T"). If the task is being watched by the reaper task monitor, this field also shows the timeout value (in seconds) before which the task needs to alert the task monitor.

Note If you want to see the total CPU usage as a percentage, enter the **show cpu** command.

2. **show process memory**—Shows the allocation and deallocation of memory from various processes in the system at that instant in time.

   Information similar to the following appears:

```
Name                Priority     BytesInUse  BlocksInUse  Reaper
 reaperWatcher       ( 3/124)     0           0           (  0/  0)%   I
 osapiReaper          (10/121)    0           0           (  0/  0)%   I
 TempStatus          (255/  1)    308         1           (  0/  0)%   I
 emWeb               (255/  1)    294440      4910        (  0/  0)%  T 300
 cliWebTask          (255/  1)    738         2           (  0/  0)%   I
 UtilTask            (255/  1)    308         1           (  0/  0)%  T 300
```

   In the example above, the following fields provide information:

   - The Name field shows the tasks that the CPU is to perform.
   - The Priority field shows two values: 1) the original priority of the task that was created by the actual function call and 2) the priority of the task divided by a range of system priorities.
   - The BytesInUse field shows the actual number of bytes used by dynamic memory allocation for a particular task.
   - The BlocksInUse field shows the chunks of memory that are assigned to perform a particular task.
   - The Reaper field shows three values: 1) the amount of time for which the task is scheduled in user mode operation, 2) the amount of time for which the task is scheduled in system mode operation, and 3) whether the task is being watched by the reaper task monitor (indicated by a "T"). If the task is being watched by the reaper task monitor, this field also shows the timeout value (in seconds) before which the task needs to alert the task monitor.

3. **show tech-support**—Shows an array of information related to the state of the system, including the current configuration, last crash file, CPU utilization, and memory utilization.
4. show run-config**—Shows the complete configuration of the controller. To exclude access point configuration settings, use the** show run-config no-ap **command.**

Note If you want to see the passwords in clear text, enter the **config passwd-cleartext enable command**. To execute this command, you must enter an admin password. This command is valid only for this particular session. It is not saved following a reboot.

5. **show run-config commands**—Shows the list of configured commands on the controller. This command shows only values configured by the user. It does not show system-configured default values.

Configuring System and Message Logging

System logging allows controllers to log their system events to up to three remote syslog servers. The controller sends a copy of each syslog message as it is logged to each syslog server configured on the controller. Being able to send the syslog messages to multiple servers ensures that the messages are not lost due to the temporary unavailability of one syslog server. Message logging allows system messages to be logged to the controller buffer or console.

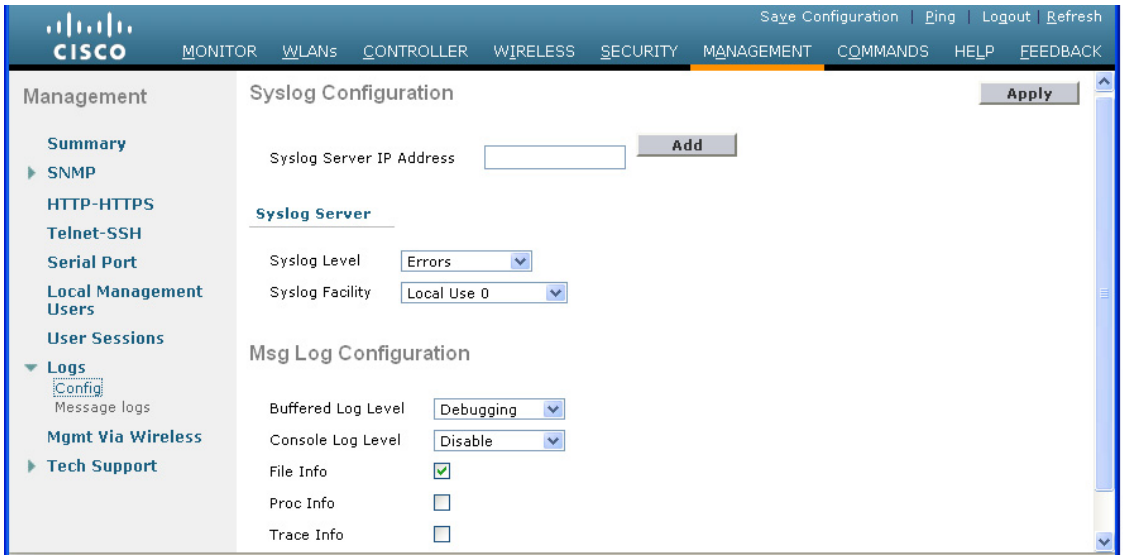
You can use the controller GUI or CLI to configure system and message logging.

Using the GUI to Configure System and Message Logging

To configure system and message logging using the controller GUI, follow these steps:

Step 1 Choose **Management** > **Logs** > **Config**. The Syslog Configuration page appears (see Figure D-2).

Figure D-2 Syslog Configuration Page



Step 2 In the Syslog Server IP Address text box, enter the IP address of the server to which to send the syslog messages and click **Add**. You can add up to three syslog servers to the controller. The list of syslog servers that have already been added to the controller appears below this text box.

Note If you want to remove a syslog server from the controller, click **Remove** to the right of the desired server.

Step 3 To set the severity level for filtering syslog messages to the syslog servers, choose one of the following options from the Syslog Level drop-down list:

- **Emergencies = Severity level 0**
- **Alerts** = Severity level 1 (default value)
- **Critical** = Severity level 2
- **Errors** = Severity level 3

- **Warnings** = Severity level 4
- **Notifications** = Severity level 5
- **Informational** = Severity level 6
- **Debugging** = Severity level 7

If you set a syslog level, only those messages whose severity is equal to or less than that level are sent to the syslog servers. For example, if you set the syslog level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are sent to the syslog servers.

Step 4 To set the facility for outgoing syslog messages to the syslog servers, choose one of the following options from the Syslog Facility drop-down list:

- **Kernel** = Facility level 0
- **User Process** = Facility level 1
- **Mail** = Facility level 2
- **System Daemons** = Facility level 3
- **Authorization** = Facility level 4
- **Syslog** = Facility level 5 (default value)
- **Line Printer** = Facility level 6
- **USENET** = Facility level 7
- **Unix-to-Unix Copy** = Facility level 8
- **Cron** = Facility level 9
- **FTP Daemon** = Facility level 11
- **System Use 1** = Facility level 12
- **System Use 2** = Facility level 13
- **System Use 3** = Facility level 14
- **System Use 4** = Facility level 15
- **Local Use 0** = Facility level 16
- **Local Use 1** = Facility level 17
- **Local Use 2** = Facility level 18
- **Local Use 3** = Facility level 19
- **Local Use 4** = Facility level 20
- **Local Use 5** = Facility level 21
- **Local Use 6** = Facility level 22
- **Local Use 7** = Facility level 23

Step 5 Click **Apply** to commit your changes.

Step 6 To set the severity level for logging messages to the controller buffer and console, choose one of the following options from both the Buffered Log Level and Console Log Level drop-down listes:

- **Emergencies = Severity level 0**
- **Alerts** = Severity level 1
- **Critical** = Severity level 2
- **Errors** = Severity level 3 (default value)

- **Warnings** = Severity level 4
- **Notifications** = Severity level 5
- **Informational** = Severity level 6
- **Debugging** = Severity level 7
- **Disable**— This option is available only for Console Log level. Select this option to disable console logging.

If you set a logging level, only those messages whose severity is equal to or less than that level are logged by the controller. For example, if you set the logging level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are logged.

Step 7 Select the **File Info** check box if you want the message logs to include information about the source file. The default value is enabled.

Step 8 Select the **Trace Info** check box if you want the message logs to include traceback information. The default value is disabled.

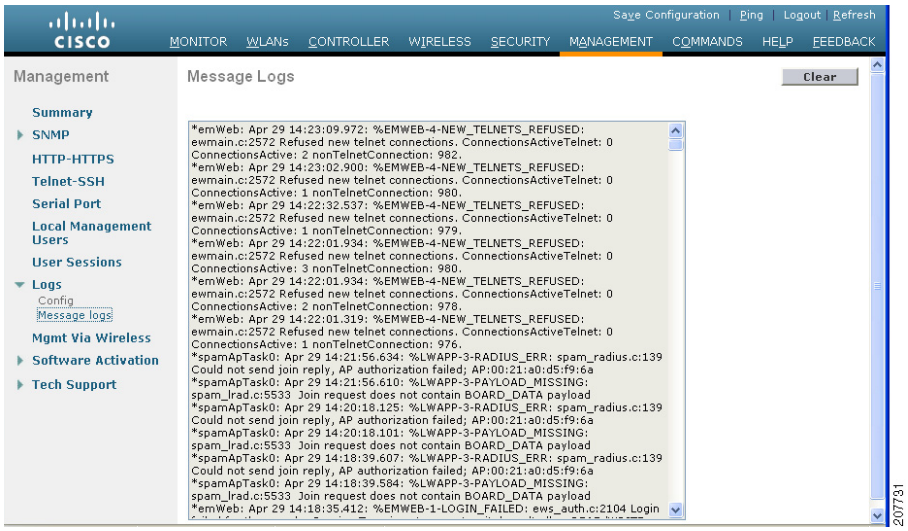
Step 9 Click **Apply** to commit your changes.

Step 10 Click **Save Configuration** to save your changes.

Using the GUI to View Message Logs

To view message logs using the controller GUI, choose **Management** > **Logs** > **Message Logs**. The Message Logs page appears (see Figure D-3).

Figure D-3 Message Logs Page



Note To clear the current message logs from the controller, click **Clear**.

Using the CLI to Configure System and Message Logging

To configure system and message logging using the controller CLI, follow these steps:

Step 1 To enable system logging and set the IP address of the syslog server to which to send the syslog messages, enter this command:

config logging syslog host *server_IP_address*

You can add up to three syslog servers to the controller.

Note To remove a syslog server from the controller, enter this command:
config logging syslog host *server_IP_address* **delete**

Step 2 To set the severity level for filtering syslog messages to the syslog server, enter this command:

config logging syslog level *severity_level*

where *severity_level* is one of the following:

- emergencies = Severity level 0
- alerts = Severity level 1
- critical = Severity level 2
- errors = Severity level 3
- warnings = Severity level 4
- notifications = Severity level 5
- informational = Severity level 6
- debugging = Severity level 7

Note As an alternative, you can enter a number from 0 through 7 for the *severity_level* parameter.

Note If you set a syslog level, only those messages whose severity is equal to or less than that level are sent to the syslog server. For example, if you set the syslog level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are sent to the syslog server.

Step 3 To set the severity level for filtering syslog messages for a particular access point or for all access points, enter this command:

config ap logging syslog level *severity_level {Cisco_AP* | **all***}*

where *severity_level* is one of the following:

- emergencies = Severity level 0
- alerts = Severity level 1
- critical = Severity level 2
- errors = Severity level 3
- warnings = Severity level 4
- notifications = Severity level 5

- informational = Severity level 6
- debugging = Severity level 7

Note If you set a syslog level, only those messages whose severity is equal to or less than that level are sent to the access point. For example, if you set the syslog level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are sent to the access point.

Step 4 To set the facility for outgoing syslog messages to the syslog server, enter this command:

config logging syslog facility *facility_code*

where *facility_code* is one of the following:

- authorization = Authorization system. Facility level = 4.
- auth-private = Authorization system (private). Facility level = 10.
- cron = Cron/at facility. Facility level = 9.
- daemon = System daemons. Facility level = 3.
- ftp = FTP daemon. Facility level = 11.
- kern = Kernel. Facility level = 0.
- local0 = Local use. Facility level = 16.
- local1 = Local use. Facility level = 17.
- local2 = Local use. Facility level = 18.
- local3 = Local use. Facility level = 19.
- local4 = Local use. Facility level = 20.
- local5 = Local use. Facility level = 21.
- local6 = Local use. Facility level = 22.
- local7 = Local use. Facility level = 23.
- lpr = Line printer system. Facility level = 6.
- mail = Mail system. Facility level = 2.
- news = USENET news. Facility level = 7.
- sys12 = System use. Facility level = 12.
- sys13 = System use. Facility level = 13.
- sys14 = System use. Facility level = 14.
- sys15 = System use. Facility level = 15.
- syslog = The syslog itself. Facility level = 5.
- user = User process. Facility level = 1.
- uucp = Unix-to-Unix copy system. Facility level = 8.

Step 5 To set the severity level for logging messages to the controller buffer and console, enter these commands:

- **config logging buffered** *severity_level*
- **config logging console** *severity_level*

where *severity_level* is one of the following:

- emergencies = Severity level 0

- alerts = Severity level 1
- critical = Severity level 2
- errors = Severity level 3
- warnings = Severity level 4
- notifications = Severity level 5
- informational = Severity level 6
- debugging = Severity level 7

Note As an alternative, you can enter a number from 0 through 7 for the *severity_level* parameter.

Note If you set a logging level, only those messages whose severity is equal to or less than that level are logged by the controller. For example, if you set the logging level to Warnings (severity level 4), only those messages whose severity is between 0 and 4 are logged.

Step 6 To save debug messages to the controller buffer, the controller console, or a syslog server, enter these commands:

- **config logging debug buffered** {**enable** | **disable**}
- **config logging debug console** {**enable** | **disable**}
- **config logging debug syslog** {**enable** | **disable**}

By default, the console command is enabled, and the buffered and syslog commands are disabled.

Step 7 To cause the controller to include information about the source file in the message logs or to prevent the controller from displaying this information, enter this command:

config logging fileinfo {**enable** | **disable**}

The default value is enabled.

Step 8 To cause the controller to include process information in the message logs or to prevent the controller from displaying this information, enter this command:

config logging procinfo {**enable** | **disable**}

The default value is disabled.

Step 9 To cause the controller to include traceback information in the message logs or to prevent the controller from displaying this information, enter this command:

config logging traceinfo {**enable** | **disable**}

The default value is disabled.

Step 10 To enable or disable timestamps in log messages and debug messages, enter these commands:

- **config service timestamps log** {**datetime** | **disable**}
- **config service timestamps debug** {**datetime** | **disable**}

  where

  - **datetime** = Messages are timestamped with the standard date and time. This is the default value.
  - **disable** = Messages are not timestamped.

Step 11 To save your changes, enter this command:

save config

Using the CLI to View System and Message Logs

To see the logging parameters and buffer contents, enter this command:

show logging

Information similar to the following appears:

```
Logging to buffer :
- Logging of system messages to buffer :
 - Logging filter level..................... errors
 - Number of system messages logged..... 8716
 - Number of system messages dropped..... 2906
- Logging of debug messages to buffer ..... Disabled
 - Number of debug messages logged..... 0
 - Number of debug messages dropped..... 0
Logging to console :
- Logging of system messages to console :
 - Logging filter level..................... errors
 - Number of system messages logged..... 0
 - Number of system messages dropped..... 11622
- Logging of debug messages to console ..... Enabled
 - Number of debug messages logged..... 0
 - Number of debug messages dropped..... 0
Logging to syslog :
- Syslog facility..... local0
- Logging of system messages to syslog :
 - Logging filter level..... errors
 - Number of system messages logged..... 8716
- Number of debug messages dropped..... 0
- Number of remote syslog hosts..... 0
  - Host 0..... Not Configured
  - Host 1..... Not Configured
  - Host 2..... Not Configured
Logging of traceback..... Disabled
Logging of process information..... Disabled
Logging of source file informational..... Enabled
Timestamping of messages.....
- Timestamping of system messages..... Enabled
 - Timestamp format..... Date and Time
- Timestamping of debug messages..... Enabled
 - Timestamp format..... Date and Time

Logging buffer (8722 logged, 2910 dropped)

*Mar 26 09:23:13.574: %MM-3-INVALID_PKT_RECVD: mm_listen.c:5508 Received an invalid packet
from 1.100.163.144. Source member:0.0.0.0. source member unknown.
*Mar 26 09:23:13.574: %MM-3-INVALID_PKT_RECVD: mm_listen.c:5508 Received an invalid packet
from 1.100.163.144. Source member:0.0.0.0. source member unknown.
Previous message occurred 2 times.
*Mar 26 09:22:44.925: %MM-3-INVALID_PKT_RECVD: mm_listen.c:5508 Received an invalid packet
from 1.100.163.144. Source member:0.0.0.0. source member unknown.
...
```

Viewing Access Point Event Logs

Access points log all system messages (with a severity level greater than or equal to notifications) to the access point event log. The event log can contain up to 1024 lines of messages, with up to 128 characters per line. When the event log becomes filled, the oldest message is removed to accommodate a new event message. The event log is saved in a file on the access point flash, which ensures that it is saved through a reboot cycle. To minimize the number of writes to the access point flash, the contents of the event log are written to the event log file during normal reload and crash scenarios only.

Use these CLI commands to view or clear the access point event log from the controller:

- To see the contents of the event log file for an access point that is joined to the controller, enter this command:

  show ap eventlog *Cisco_AP*

  Information similar to the following appears:

```
AP event log download has been initiated
Waiting for download to complete

AP event log download completed.
 ========================= AP Event log Contents =====================
*Sep 22 11:44:00.573: %CAPWAP-5-CHANGED: CAPWAP changed state to IMAGE
*Sep 22 11:44:01.514: %LINEPROTO-5-UPDOWN: Line protocol on Interface Dot11Radio0,
changed state to down
*Sep 22 11:44:01.519: %LINEPROTO-5-UPDOWN: Line protocol on Interface Dot11Radio1,
changed state to down
*Sep 22 11:44:53.539: *** Access point reloading. Reason: NEW IMAGE DOWNLOAD ***
*Mar 1 00:00:39.078: %CAPWAP-3-ERRORLOG: Did not get log server settings from DHCP.
*Mar 1 00:00:42.142: %CDP_PD-4-POWER_OK: Full power - NEGOTIATED inline power source
*Mar 1 00:00:42.151: %LINK-3-UPDOWN: Interface Dot11Radio1, changed state to up
*Mar 1 00:00:42.158: %LINK-3-UPDOWN: Interface Dot11Radio0, changed state to up
*Mar 1 00:00:43.143: %LINEPROTO-5-UPDOWN: Line protocol on Interface Dot11Radio1,
changed state to up
*Mar 1 00:00:43.151: %LINEPROTO-5-UPDOWN: Line protocol on Interface Dot11Radio0,
changed state to up
*Mar 1 00:00:48.078: %CAPWAP-3-ERRORLOG: Could Not resolve CISCO-CAPWAP-CONTROLLER
*Mar 1 00:01:42.144: %CDP_PD-4-POWER_OK: Full power - NEGOTIATED inline power source
*Mar 1 00:01:48.121: %CAPWAP-3-CLIENTERRORLOG: Set Transport Address: no more AP
manager IP addresses remain
*Mar 1 00:01:48.122: %CAPWAP-5-CHANGED: CAPWAP changed state to JOIN
*Mar 1 00:01:48.122: %LINK-5-CHANGED: Interface Dot11Radio0, changed state to
administratively down
*Mar 1 00:01:48.122: %LINK-5-CHANGED: Interface Dot11Radio1, changed state to
administratively down
```

- To delete the existing event log and create an empty event log file for a specific access point or for all access points joined to the controller, enter this command:

  clear ap-eventlog {**specific** *Cisco_AP* | **all**}

Uploading Logs and Crash Files

Follow the instructions in this section to upload logs and crash files from the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the file upload. Follow these guidelines when setting up a TFTP or FTP server:

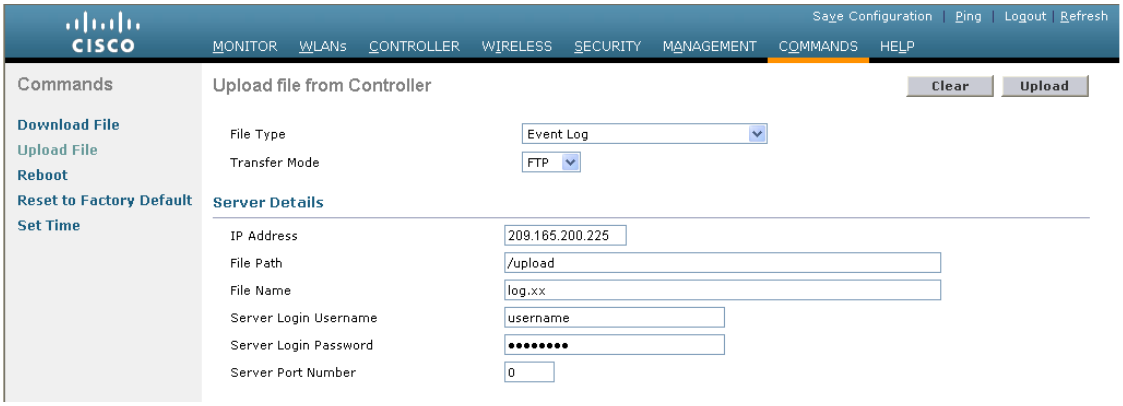
- If you are uploading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are uploading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Using the GUI to Upload Logs and Crash Files

To upload logs and crash files using the controller GUI, follow these steps:

Step 1 Choose **Command > Upload File**. The Upload File from Controller page appears (see Figure D-4).

Figure D-4 Upload File from Controller Page



Step 2 From the File Type drop-down list, choose one of the following:

- **Event Log**
- **Message Log**
- **Trap Log**
- **Crash File**

Step 3 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 4 In the IP Address text box, enter the IP address of the TFTP or FTP server.

Step 5 In the File Path text box, enter the directory path of the log or crash file.

Step 6 In the File Name text box, enter the name of the log or crash file.

Step 7 If you chose FTP as the Transfer Mode, follow these steps:

a. In the Server Login Username text box, enter the FTP server login name.

b. In the Server Login Password text box, enter the FTP server login password.

c. In the Server Port Number text box, enter the port number of the FTP server. The default value for the server port is 21.

Step 8 Click **Upload** to upload the log or crash file from the controller. A message appears indicating the status of the upload.

Using the CLI to Upload Logs and Crash Files

To upload logs and crash files using the controller CLI, follow these steps:

Step 1 To transfer the file from the controller to a TFTP or FTP server, enter this command:

transfer upload mode {**tftp** | **ftp**}

Step 2 To specify the type of file to be uploaded, enter this command:

transfer upload datatype *datatype*

where *datatype is one of the following options:*

- **crashfile**—Uploads the system's crash file.
- **errorlog**—Uploads the system's error log.
- panic-crash-file—Uploads the kernel panic information if a kernel panic occurs.
- **systemtrace**—Uploads the system's trace file.
- **traplog**—Uploads the system's trap log.
- **watchdog-crash-file**—Uploads the console dump resulting from a software-watchdog-initiated reboot of the controller following a crash. The software watchdog module periodically checks the integrity of the internal software and makes sure that the system does not stay in an inconsistent or nonoperational state for a long period of time.

Step 3 To specify the path to the file, enter these commands:

- **transfer upload serverip** *server_ip_address*
- **transfer upload path** *server_path_to_file*
- **transfer upload filename** *filename*

Step 4 If you are using an FTP server, also enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 5 To see the updated settings, enter this command:

transfer upload start

Step 6 When prompted to confirm the current settings and start the software upload, answer **y**.

Uploading Core Dumps from the Controller

To help troubleshoot controller crashes, you can configure the controller to automatically upload its core dump file to an FTP server after experiencing a crash. You cannot upload the core dump file directly to an FTP or TFTP server but you can upload a crash file to an FTP or TFTP server. The controllers save the core dump file to flash memory following a crash. Follow the instructions in this section to perform one of these functions.

Configuring the Controller to Automatically Upload Core Dumps to an FTP Server

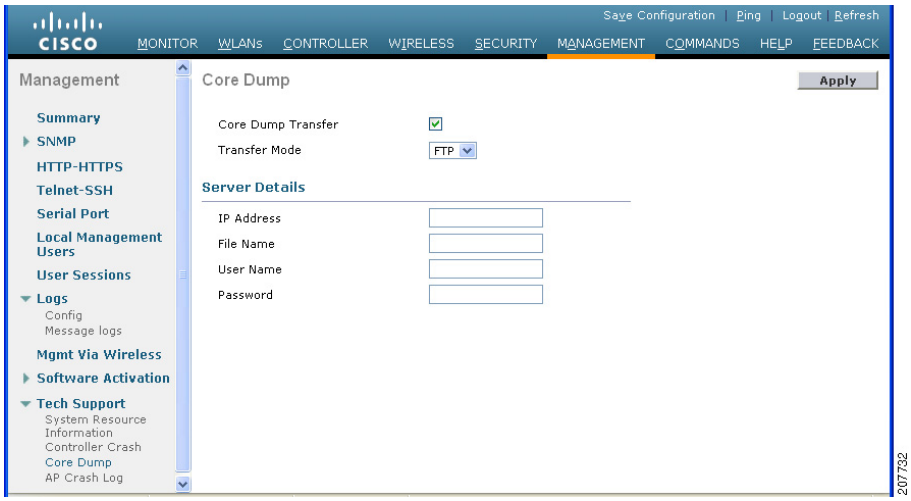
This section describes how to configure the controller to automatically upload core dumps to an FTP server.

Using the GUI to Configure the Controller to Automatically Upload Core Dumps to an FTP Server

To enable the controller to automatically upload a core dump file to an FTP server using the controller GUI, follow these steps:

Step 1 Choose **Management** > **Tech Support** > **Core Dump** to open the Core Dump page (see Figure D-5).

Figure D-5 Core Dump Page



Step 2 To enable the controller to generate a core dump file following a crash, select the **Core Dump Transfer** check box.

Step 3 To specify the type of server to which the core dump file is uploaded, choose **FTP** from the Transfer Mode drop-down list.

Step 4 In the IP Address text box, enter the IP address of the FTP server.

Note The controller must be able to reach the FTP server.

Step 5 In the File Name text box, enter the name that the controller uses to label the core dump file.

Step 6 In the User Name text box, enter the username for FTP login.

Step 7 In the Password text box, enter the password for FTP login.

Step 8 Click **Apply** to commit your changes.

Step 9 Click **Save Configuration** to save your changes.

Using the CLI to Configure the Controller to Automatically Upload Core Dumps to an FTP Server

To enable the controller to automatically upload a core dump file to an FTP server using the controller CLI, follow these steps:

Step 1 To enable or disable the controller to generate a core dump file following a crash, enter this command:

config coredump {enable | disable}

Step 2 To specify the FTP server to which the core dump file is uploaded, enter this command:

config coredump ftp *server_ip_address filename*

where

- *server_ip_address* is the IP address of the FTP server to which the controller sends its core dump file.

  Note The controller must be able to reach the FTP server.

- *filename* is the name that the controller uses to label the core dump file.

Step 3 To specify the username and password for FTP login, enter this command:

config coredump username *ftp_username* **password** *ftp_password*

Step 4 To save your changes, enter this command:

save config

Step 5 To see a summary of the controller's core dump file, enter this command:

show coredump summary

Information similar to the following appears:

```
Core Dump is enabled

FTP Server IP................................... 10.10.10.17
FTP Filename.................................... file1
FTP Username.................................... ftpuser
FTP Password.................................... *********
```

Uploading Core Dumps from Controller to a TFTP or FTP Server

Note This procedure is not applicable for Cisco 2106 and 4400 controllers.

To upload the core dump file from the flash memory of a controller to a TFTP or FTP server using the controller CLI, follow these steps:

Step 1 To see information about the core dump file in flash memory, enter this command:

show coredump summary

Information similar to the following appears:

```
Core Dump is disabled

Core Dump file is saved on flash

Sw Version..................................... 6.0.83.0
Time Stamp..................................... Wed Feb  4 13:23:11 2009
File Size...................................... 9081788
File Name Suffix.......................... filename.gz
```

Step 2 To transfer the file from the controller to a TFTP or FTP server, enter these commands:

- **transfer upload mode** {**tftp** | **ftp**}
- transfer upload datatype coredump
- **transfer upload serverip** *server_ip_address*
- **transfer upload path** *server_path_to_file*
- **transfer upload filename** *filename*

Note After the file is uploaded, it ends with a .gz suffix. If desired, you can upload the same core dump file multiple times with different names to different servers.

Step 3 If you are using an FTP server, also enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- transfer upload port *port*

Note The default value for the *port* parameter is 21.

Step 4 To view the updated settings, enter this command:

transfer upload start

Step 5 When prompted to confirm the current settings and start the software upload, answer **y**.

Uploading Packet Capture Files

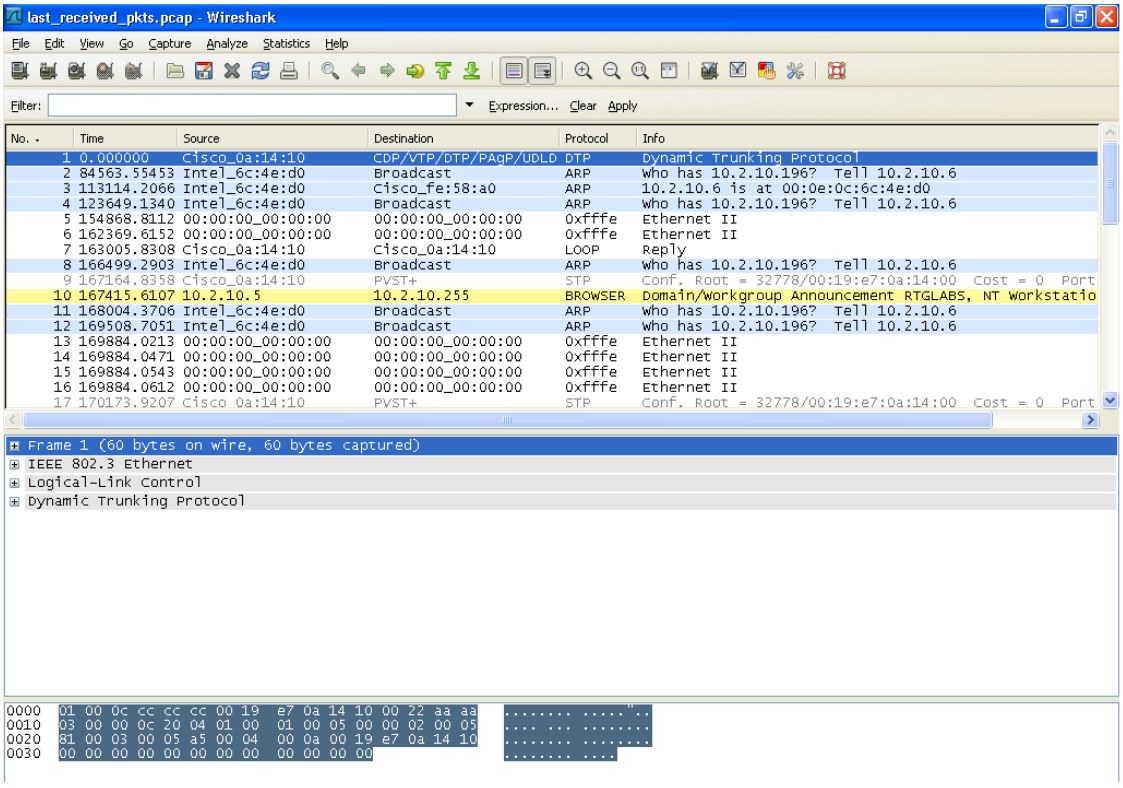
When a Cisco 5500 Series Controller's data plane crashes, it stores the last 50 packets that the controller received in flash memory. This information can be useful in troubleshooting the crash.

When a crash occurs, the controller generates a new packet capture file (*.pcap) file, and a message similar to the following appears in the controller crash file:

```
Last 5 packets processed at each core are stored in
 "last_received_pkts.pcap" captured file.
   - Frame 36,38,43,47,49, processed at core #0.
   - Frame 14,27,30,42,45, processed at core #1.
   - Frame 15,18,20,32,48, processed at core #2.
   - Frame 11,29,34,37,46, processed at core #3.
   - Frame 7,8,12,31,35, processed at core #4.
   - Frame 21,25,39,41,50, processed at core #5.
   - Frame 16,17,19,22,33, processed at core #6.
   - Frame 6,10,13,23,26, processed at core #7.
   - Frame 9,24,28,40,44, processed at core #8.
   - Frame 1,2,3,4,5, processed at core #9.
```

You can use the controller GUI or CLI to upload the packet capture file from the controller. You can then use Wireshark or another standard packet capture tool to view and analyze the contents of the file. Figure D-6 shows a sample output of a packet capture file in Wireshark.

Figure D-6 Sample Output of Packet Capture File in Wireshark



Note Only Cisco 5500 Series Controllers generate packet capture files. This feature is not available on other controller platforms.

Follow the instructions in this section to upload packet capture files from the controller through the GUI or CLI. However, before you begin, make sure you have a TFTP or FTP server available for the file upload. Follow these guidelines when setting up a TFTP or FTP server:

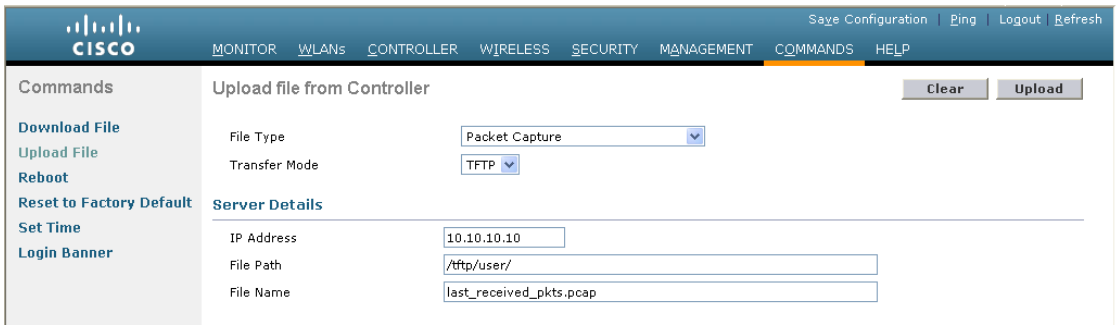
- If you are uploading through the service port, the TFTP or FTP server must be on the same subnet as the service port because the service port is not routable, or you must create static routes on the controller.
- If you are uploading through the distribution system network port, the TFTP or FTP server can be on the same or a different subnet because the distribution system port is routable.
- A third-party TFTP or FTP server cannot run on the same computer as WCS because the WCS built-in TFTP or FTP server and the third-party TFTP or FTP server require the same communication port.

Using the GUI to Upload Packet Capture Files

To upload a packet capture file from the controller using the controller GUI, follow these steps:

Step 1 Choose **Commands** > **Upload File** to open the Upload File from Controller page (see Figure D-7).

Figure D-7 Upload File from Controller Page



Step 2 From the File Type drop-down list, choose **Packet Capture**.

Step 3 From the Transfer Mode drop-down list, choose **TFTP** or **FTP**.

Step 4 In the IP Address text box, enter the IP address of the TFTP or FTP server.

Step 5 In the File Path text box, enter the directory path of the packet capture file.

Step 6 In the File Name text box, enter the name of the packet capture file. These files have a .pcap extension.

Step 7 If you are using an FTP server, follow these steps:

a. In the Server Login Username text box, enter the username to log into the FTP server.

b. In the Server Login Password text box, enter the password to log into the FTP server.

c. In the Server Port Number text box, enter the port number on the FTP server through which the upload occurs. The default value is 21.

Step 8 Click **Upload** to upload the packet capture file from the controller. A message appears indicating the status of the upload.

Step 9 Use Wireshark or another standard packet capture tool to open the packet capture file and see the last 50 packets that were received by the controller.

Using the CLI to Upload Packet Capture Files

To upload a packet capture file using the controller CLI, follow these steps:

Step 1 Log into the controller CLI.

Step 2 Enter the **transfer upload mode** {**tftp** | **ftp**} command.

Step 3 Enter the **transfer upload datatype packet-capture** command.

Step 4 Enter the **transfer upload serverip** *server-ip-address* command.

Step 5 Enter the **transfer upload path** *server-path-to-file* command.

Step 6 Enter the **transfer upload filename** *last_received_pkts*.pcap command.

Step 7 If you are using an FTP server, enter these commands:

- **transfer upload username** *username*
- **transfer upload password** *password*
- **transfer upload port** *port*

Note The default value for the *port* parameter is 21.

Step 8 Enter **the transfer upload start** command to see the updated settings and then answer **y** when prompted to confirm the current settings and start the upload process. This example shows the upload command output:

```
Mode..................................... TFTP
TFTP Server IP........................... 10.10.10.10
TFTP Path................................ /tftp/user/
TFTP Filename.............................. last_received_pkts.pcap
Data Type................................ Packet capture

Are you sure you want to start? (y/N) y

TFTP Packet Capture Dump starting.

File transfer operation completed successfully.
```

Step 9 Use Wireshark or another standard packet capture tool to open the packet capture file and see the last 50 packets that were received by the controller.

Monitoring Memory Leaks

This section provides instructions for troubleshooting hard-to-solve or hard-to-reproduce memory problems.

Caution The commands in this section can be disruptive to your system and should be run only when you are advised to do so by the Cisco Technical Assistance Center (TAC).

To monitor the controller for memory leaks using the controller CLI, follow these steps:

Step 1 To enable or disable monitoring for memory errors and leaks, enter this command:

config memory monitor errors {**enable** | **disable**}

The default value is disabled.

Note Your changes are not saved across reboots. After the controller reboots, it uses the default setting for this feature.

Step 2 If you suspect that a memory leak has occurred, enter this command to configure the controller to perform an auto-leak analysis between two memory thresholds (in kilobytes):

config memory monitor leaks *low_thresh high_thresh*

If the free memory is lower than the *low_thresh* threshold, the system crashes, generating a crash file. The default value for this parameter is 10000 kilobytes, and you cannot set it below this value.

Set the *high_thresh* threshold to the current free memory level or higher so that the system enters auto-leak-analysis mode. After the free memory reaches a level lower than the specified *high_thresh* threshold, the process of tracking and freeing memory allocation begins. As a result, the **debug memory events enable** command shows all allocations and frees, and the **show memory monitor detail** command starts to detect any suspected memory leaks. The default value for this parameter is 30000 kilobytes.

Step 3 To see a summary of any discovered memory issues, enter this command:

show memory monitor

Information similar to the following appears:

```
Memory Leak Monitor Status:
low_threshold(10000), high_threshold(30000), current status(disabled)

-----------------------------------------

Memory Error Monitor Status:
Crash-on-error flag currently set to (disabled)
No memory error detected.
```

Step 4 To see the details of any memory leaks or corruption, enter this command:

show memory monitor detail

Information similar to the following appears:

```
Memory error detected. Details:
-----------------------------------------------
-  Corruption detected at pmalloc entry address:        (0x179a7ec0)
-  Corrupt entry:headerMagic(0xdeadf00d),trailer(0xabcd),poison(0xreadceef),
```

```
entrysize(128),bytes(100),thread(Unknown task name, task id = (332096592)),
file(pmalloc.c),line(1736),time(1027)

Previous 1K memory dump from error location.
-----------------------------------------------
(179a7ac0): 00000000 00000000 00000000 ceeff00d readf00d 00000080 00000000 00000000
(179a7ae0): 17958b20 00000000 1175608c 00000078 00000000 readceef 179a7afc 00000001
(179a7b00): 00000003 00000006 00000001 00000004 00000001 00000009 00000009 0000020d
(179a7b20): 00000001 00000002 00000002 00000001 00000004 00000000 00000000 5d7b9aba
(179a7b40): cbddf004 192f465e 7791acc8 e5032242 5365788c a1b7cee6 00000000 00000000
(179a7b60): 00000000 00000000 00000000 00000000 00000000 ceeff00d readf00d 00000080
(179a7b80): 00000000 00000000 17958dc0 00000000 1175608c 00000078 00000000 readceef
(179a7ba0): 179a7ba4 00000001 00000003 00000006 00000001 00000004 00000001 00003763
(179a7bc0): 00000002 00000002 00000010 00000001 00000002 00000000 0000001e 00000013
(179a7be0): 0000001a 00000089 00000000 00000000 000000d8 00000000 00000000 17222194
(179a7c00): 1722246c 1722246c 00000000 00000000 00000000 00000000 00000000 ceeff00d
(179a7c20): readf00d 00000080 00000000 00000000 179a7b78 00000000 1175608c 00000078
```

Step 5 If a memory leak occurs, enter this command to enable debugging of errors or events during memory allocation:

debug memory {errors | events} {enable | disable}

Troubleshooting CCXv5 Client Devices

The controller supports three features designed to help troubleshoot communication problems with CCXv5 clients: diagnostic channel, client reporting, and roaming and real-time diagnostics. See the "Configuring Cisco Client Extensions" section on page 7-52 for more information on CCX.

Note These features are supported only on CCXv5 clients. They are not supported for use with non-CCX clients or with clients running an earlier version of CCX.

Diagnostic Channel

The diagnostic channel feature enables you to troubleshoot problems regarding client communication with a WLAN. The client and access points can be put through a defined set of tests in an attempt to identify the cause of communication difficulties the client is experiencing and then allow corrective measures to be taken to make the client operational on the network. You can use the controller GUI or CLI to enable the diagnostic channel, and you can use the controller CLI or WCS to run the diagnostic tests.

Note We recommend that you enable the diagnostic channel feature only for nonanchored SSIDs that use the management interface.

Client Reporting

The client reporting protocol is used by the client and the access point to exchange client information. Client reports are collected automatically when the client associates. You can use the controller GUI or CLI to send a client report request to any CCXv5 client any time after the client associates. There are four types of client reports:

- Client profile—Provides information about the configuration of the client.
- Operating parameters—Provides the details of the client's current operational modes.
- Manufacturers' information—Provides data about the wireless LAN client adapter in use.
- Client capabilities—Provides information about the client's capabilities.

Roaming and Real-Time Diagnostics

You can use roaming and real-time logs and statistics to solve system problems. The event log enables you to identify and track the behavior of a client device. It is especially useful when attempting to diagnose difficulties that a user may be having on a WLAN. The event log provides a log of events and reports them to the access point. There are three categories of event logs:

- Roaming log—This log provides a historical view of the roaming events for a given client. The client maintains a minimum of five previous roaming events including failed attempts and successful roams.
- Robust Security Network Association (RSNA) log—This log provides a historical view of the authentication events for a given client. The client maintains a minimum of five previous authentication attempts including failed attempts and successful ones.
- Syslog—This log provides internal system information from the client. For example, it may indicate problems with 802.11 operation, system operation, and so on.

The statistics report provides 802.1X and security information for the client. You can use the controller CLI to send the event log and statistics request to any CCXv5 client any time after the client associates.

Using the GUI to Configure the Diagnostic Channel

To configure the diagnostic channel using the controller GUI, follow these steps:

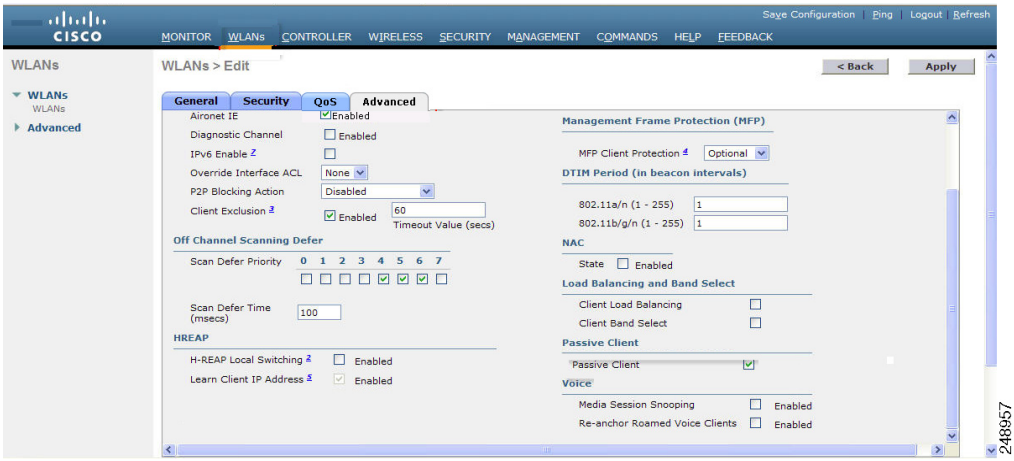
Step 1 Choose **WLANs** to open the WLANs page.

Step 2 Create a new WLAN or click the ID number of an existing WLAN.

Note We recommend that you create a new WLAN on which to run the diagnostic tests.

Step 3 When the WLANs > Edit page appears, choose the **Advanced** tab to open the WLANs > Edit (Advanced) page (see Figure D-8).

Figure D-8 WLANs > Edit (Advanced) Page



Step 4 If you want to enable diagnostic channel troubleshooting on this WLAN, select the **Diagnostic Channel** check box. Otherwise, leave this check box unselected, which is the default value.

Note You can use the CLI to initiate diagnostic tests on the client. See the "Using the CLI to Configure the Diagnostic Channel" section on page D-27 for details.

Step 5 Click **Apply** to commit your changes.

Step 6 Click **Save Configuration** to save your changes.

Using the CLI to Configure the Diagnostic Channel

To configure the diagnostic channel using the controller CLI, follow these steps:

Step 1 To enable diagnostic channel troubleshooting on a particular WLAN, enter this command:

config wlan diag-channel {**enable** | **disable**} *wlan_id*

Step 2 To verify that your change has been made, enter this command:

show wlan *wlan_id*

Information similar to the following appears:

```
WLAN Identifier.................................. 1
Profile Name..................................... employee1
Network Name (SSID).............................. employee
Status........................................... Disabled
MAC Filtering.................................... Disabled
Broadcast SSID................................... Enabled
AAA Policy Override.............................. Disabled
Number of Active Clients......................... 0
Exclusionlist Timeout............................ 60 seconds
Session Timeout.................................. Infinity
Interface........................................ virtual
WLAN ACL......................................... unconfigured
DHCP Server...................................... Default
DHCP Address Assignment Required................. Disabled
```

```
Quality of Service.............................. Silver (best effort)
WMM............................................. Disabled
CCX - AironetIe Support......................... Enabled
CCX - Gratuitous ProbeResponse (GPR)............ Disabled
CCX - Diagnostics Channel Capability.............. Enabled
...
```

Step 3 To send a request to the client to perform the DHCP test, enter this command:

config client ccx dhcp-test *client_mac_address*

Note This test does not require the client to use the diagnostic channel.

Step 4 To send a request to the client to perform the default gateway ping test, enter this command:

config client ccx default-gw-ping *client_mac_address*

Note This test does not require the client to use the diagnostic channel.

Step 5 To send a request to the client to perform the DNS server IP address ping test, enter this command:

config client ccx dns-ping *client_mac_address*

Note This test does not require the client to use the diagnostic channel.

Step 6 To send a request to the client to perform the DNS name resolution test to the specified host name, enter this command:

config client ccx dns-resolve *client_mac_address host_name*

Note This test does not require the client to use the diagnostic channel.

Step 7 To send a request to the client to perform the association test, enter this command:

config client ccx test-association *client_mac_address ssid bssid {***802.11a | 802.11b | 802.11g***} channel*

Step 8 To send a request to the client to perform the 802.1X test, enter this command:

config client ccx test-dot1x *client_mac_address profile_id bssid {***802.11a | 802.11b | 802.11g***} channel*

Step 9 To send a request to the client to perform the profile redirect test, enter this command:

config client ccx test-profile *client_mac_address profile_id*

The *profile_id should be from one of the client profiles for which client reporting is enabled.*

Note Users are redirected back to the parent WLAN, not to any other profile. The only profile shown is the user's parent profile. Note however that parent WLAN profiles can have one child diagnostic WLAN.

Step 10 Use these commands if necessary to abort or clear a test:

- To send a request to the client to abort the current test, enter this command:

  config client ccx test-abort *client_mac_address*

Only one test can be pending at a time, so this command aborts the current pending test.

- To clear the test results on the controller, enter this command:

  config client ccx clear-results *client_mac_address*

Step 11 To send a message to the client, enter this command:

config client ccx send-message *client_mac_address message_id*

where *message_id is one of the following:*

- 1 = The SSID is invalid.
- 2 = The network settings are invalid.
- 3 = There is a WLAN credibility mismatch.
- 4 = The user credentials are incorrect.
- 5 = Please call support.
- 6 = The problem is resolved.
- 7 = The problem has not been resolved.
- 8 = Please try again later.
- 9 = Please correct the indicated problem.
- 10 = Troubleshooting is refused by the network.
- 11 = Retrieving client reports.
- 12 = Retrieving client logs.
- 13 = Retrieval complete.
- 14 = Beginning association test.
- 15 = Beginning DHCP test.
- 16 = Beginning network connectivity test.
- 17 = Beginning DNS ping test.
- 18 = Beginning name resolution test.
- 19 = Beginning 802.1X authentication test.
- 20 = Redirecting client to a specific profile.
- 21 = Test complete.
- 22 = Test passed.
- 23 = Test failed.
- 24 = Cancel diagnostic channel operation or select a WLAN profile to resume normal operation.
- 25 = Log retrieval refused by the client.
- 26 = Client report retrieval refused by the client.
- 27 = Test request refused by the client.
- 28 = Invalid network (IP) setting.
- 29 = There is a known outage or problem with the network.
- 30 = Scheduled maintenance period.
- 31 = The WLAN security method is not correct.
- 32 = The WLAN encryption method is not correct.

- 33 = The WLAN authentication method is not correct.

Step 12 To see the status of the last test, enter this command:

show client ccx last-test-status *client_mac_address*

Information similar to the following appears for the default gateway ping test:

```
Test Type..................................... Gateway Ping Test
Test Status................................... Pending/Success/Timeout

Dialog Token.................................. 15
Timeout....................................... 15000 ms
Request Time.................................. 1329 seconds since system boot
```

Step 13 To see the status of the last test response, enter this command:

show client ccx last-response-status *client_mac_address*

Information similar to the following appears for the 802.1X authentication test:

```
Test Status................................... Success

Response Dialog Token......................... 87
Response Status............................... Successful
Response Test Type............................ 802.1x Authentication Test
Response Time................................. 3476 seconds since system boot
```

Step 14 To see the results from the last successful diagnostics test, enter this command:

show client ccx results *client_mac_address*

Information similar to the following appears for the 802.1X authentication test:

```
dot1x Complete................................ Success
EAP Method.................................... *1,Host OS Login Credentials
dot1x Status.............................. 255
```

Step 15 To see the relevant data frames captured by the client during the previous test, enter this command:

show client ccx frame-data *client_mac_address*

Information similar to the following appears:

```
LOG Frames:

Frame Number:................................. 1
Last Frame Number:............................ 1120
Direction:.................................... 1
Timestamp:.................................... 0d 00h 50m 39s 863954us
Frame Length:................................. 197
Frame Data:
00000000: 80 00 00 00 ff ff ff ff  ff ff 00 12 44 bd bd b0  ............D...
00000010: 00 12 44 bd bd b0 f0 af  43 70 00 f2 82 01 00 00  ..D.....Cp......
00000020: 64 00 11 08 00 01 00 01  08 8c 12 98 24 b0 48 60  d...........$.H`
00000030: 6c 05 04 01 02 00 00 85  1e 00 00 89 00 0f 00 ff  l...............
00000040: 03 19 00 41 50 32 33 2d  31 30 00 00 00 00 00 00  ...AP23-10......
00000050: 00 00 00 00 00 00 26 96  06 00 40 96 00 ff ff dd  ......&...@.....
00000060: 18 00 50 f2 01 01 00 00  50 f2 05 01 00 00 50 f2  ..P.....P.....P.
00000070: 05 01 00 00 40 96 00 28  00 dd 06 00 40 96 01 01  ....@..(....@...

00000080: 00 dd 05 00 40 96 03 04  dd 16 00 40 96 04 00 02  ....@......@....
00000090: 07 a4 00 00 23 a4 00 00  42 43 00 00 62 32 00 00  ....#...BC..b2..
000000a0: dd 05 00 40 96 0b 01 dd  18 00 50 f2 02 01 01 82  ...@......P.....
000000b0: 00 03 a4 00 00 27 a4 00  00 42 43 5e 00 62 32 2f  .....'...BC^.b2/

LOG Frames:
```

```
Frame Number:..................................... 2
Last Frame Number:................................ 1120
Direction:........................................ 1
Timestamp:........................................ 0d 00h 50m 39s 878289us
Frame Length:..................................... 147
Frame Data:
00000000: 80 00 00 00 ff ff ff ff  ff ff 00 0d ed c3 a0 22  ..............."
00000010: 00 0d ed c3 a0 22 00 bd  4d 50 a5 f7 78 08 00 00  ....."..MP..x...
00000020: 64 00 01 00 00 01 00 01  08 8c 12 98 24 b0 48 60  d...........$.H`
00000030: 6c 05 04 01 02 00 00 85  1e 00 00 84 00 0f 00 ff  l...............
00000040: 03 19 00 72 6f 67 75 65  2d 74 65 73 74 31 00 00  ...rogue-test1..
00000050: 00 00 00 00 00 00 23 96  06 00 40 96 00 10 00 dd  ......#...@.....
00000060: 06 00 40 96 01 01 00 dd  05 00 40 96 03 04 dd 05  ..@.......@.....
00000070: 00 40 96 0b 01 dd 18 00  50 f2 02 01 01 81 00 03  .@......P.......

00000080: a4 00 00 27 a4 00 00 42  43 5e 00 62 32 2f 00 d2  ...'...BC^.b2/..
00000090: b4 ab 84                                          ...

LOG Frames:

Frame Number:..................................... 3
Last Frame Number:................................ 1120
Direction:........................................ 1
Timestamp:........................................ 0d 00h 50m 39s 881513us
Frame Length:..................................... 189
Frame Data:
00000000: 80 00 00 00 ff ff ff ff  ff ff 00 12 44 bd 80 30  ............D..0
00000010: 00 12 44 bd 80 30 60 f7  46 c0 8b 4b d1 05 00 00  ..D..0`.F..K....
00000020: 64 00 11 08 00 01 00 01  08 8c 12 98 24 b0 48 60  d...........$.H`
00000030: 6c 05 04 00 02 00 00 85  1e 00 00 89 00 0f 00 ff  l...............
00000040: 03 19 00 41 50 34 30 2d  31 37 00 00 00 00 00 00  ...AP40-17......
00000050: 00 00 00 00 00 00 26 dd  18 00 50 f2 01 01 00 00  ......&...P.....
00000060: 50 f2 05 01 00 00 50 f2  05 01 00 00 40 96 00 28  P.....P.....@..(
00000070: 00 dd 06 00 40 96 01 01  00 dd 05 00 40 96 03 04  ....@.......@...

00000080: dd 16 00 40 96 04 00 05  07 a4 00 00 23 a4 00 00  ...@........#...
00000090: 42 43 00 00 62 32 00 00  dd 05 00 40 96 0b 01 dd  BC..b2.....@....
000000a0: 18 00 50 f2 02 01 01 85  00 03 a4 00 00 27 a4 00  ..P..........'..
000000b0: 00 42 43 5e 00 62 32 2f  00 0b 9a 1d 6f           .BC^.b2/....o
...
```

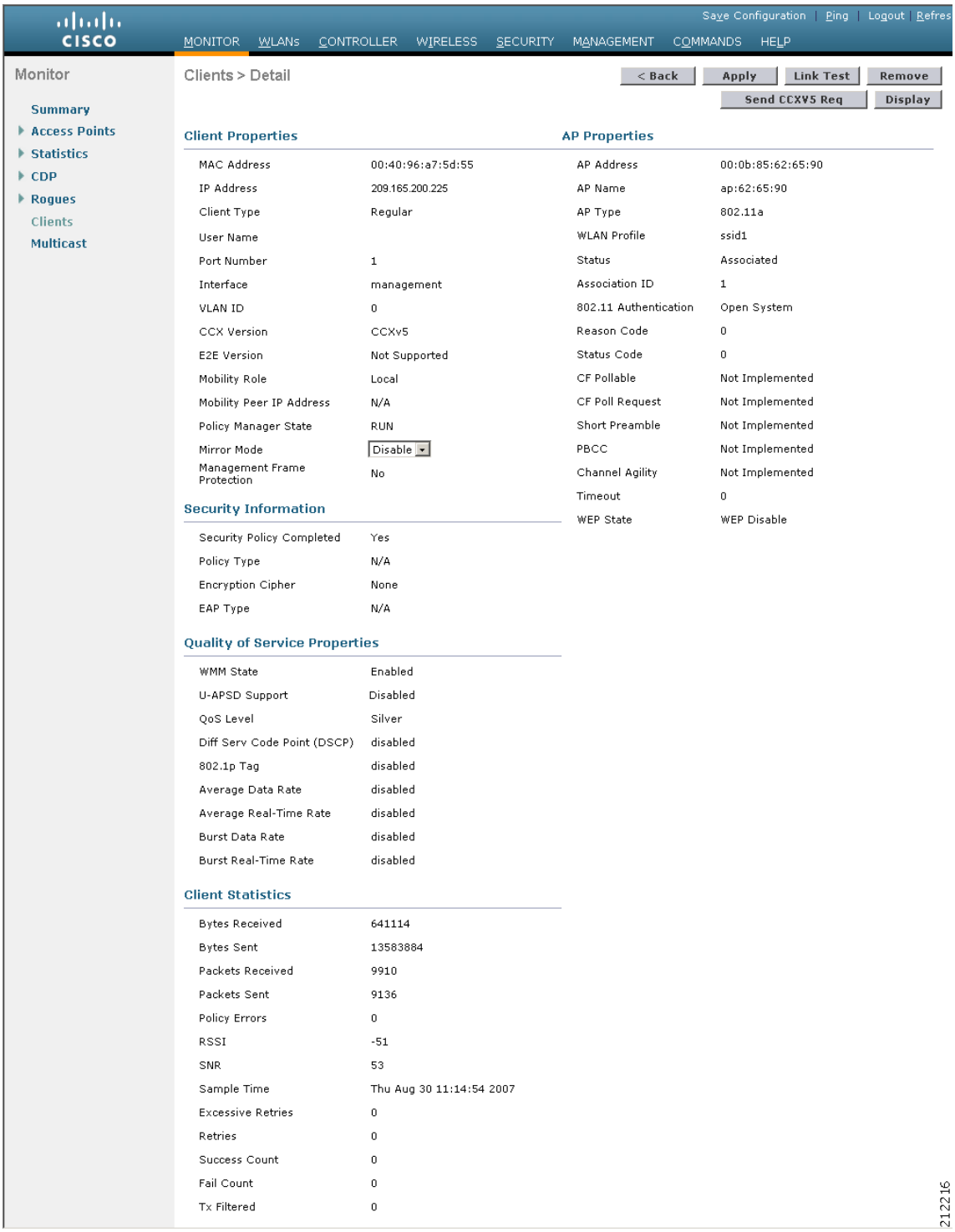
Using the GUI to Configure Client Reporting

To configure client reporting using the controller GUI, follow these steps:

Step 1 Choose **Monitor > Clients** to open the Clients page.

Step 2 Click the MAC address of the desired client. The Clients > Detail page appears (see Figure D-9).

Figure D-9 Clients > Detail Page

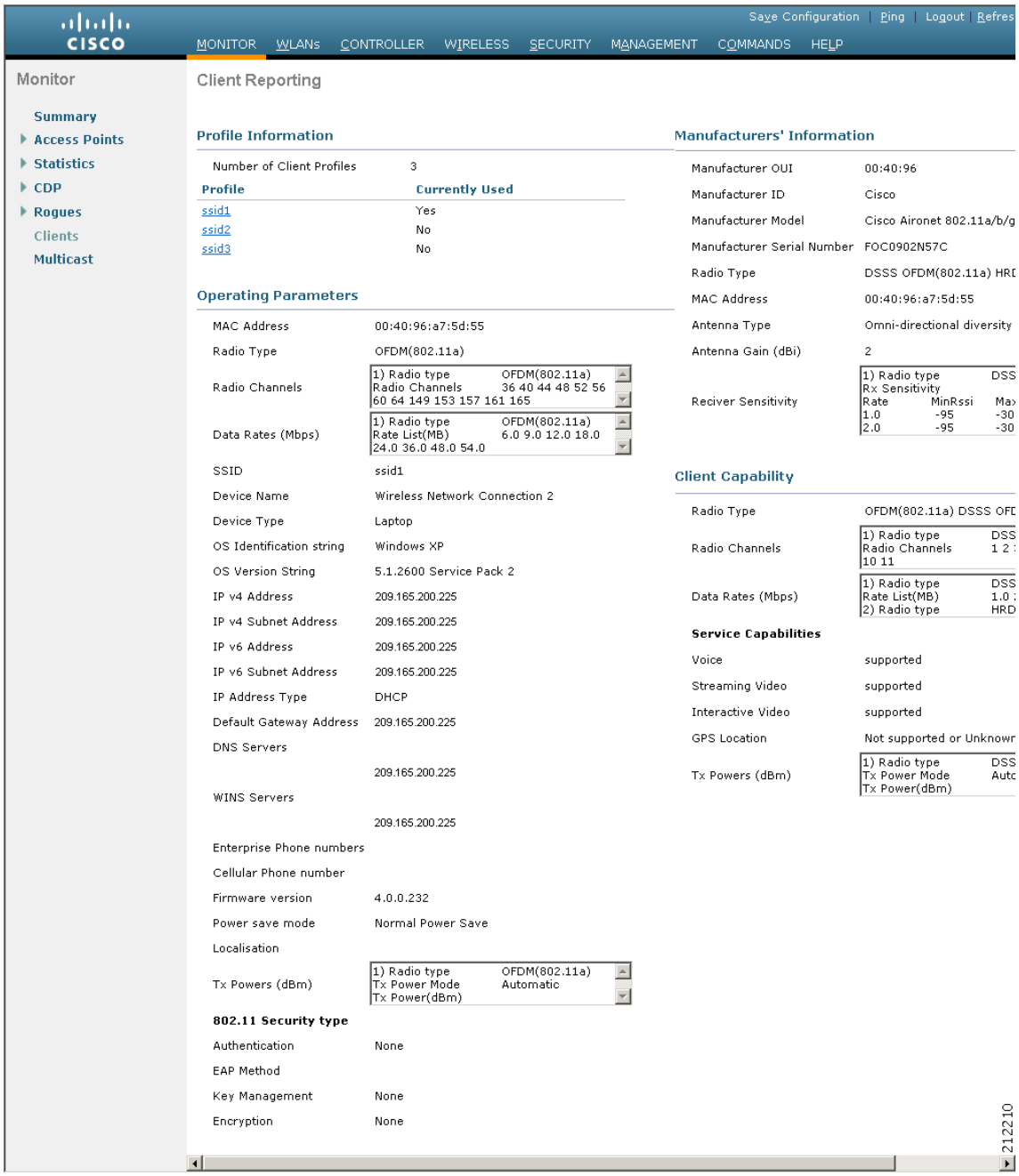


Step 3 To send a report request to the client, click **Send CCXV5 Req**.

Note You must create a Trusted Profile using ACAU for Cisco CB21AG or equivalent software from your CCXv5 vendor.

Step 4 To view the parameters from the client, click **Display**. The Client Reporting page appears (see Figure D-10).

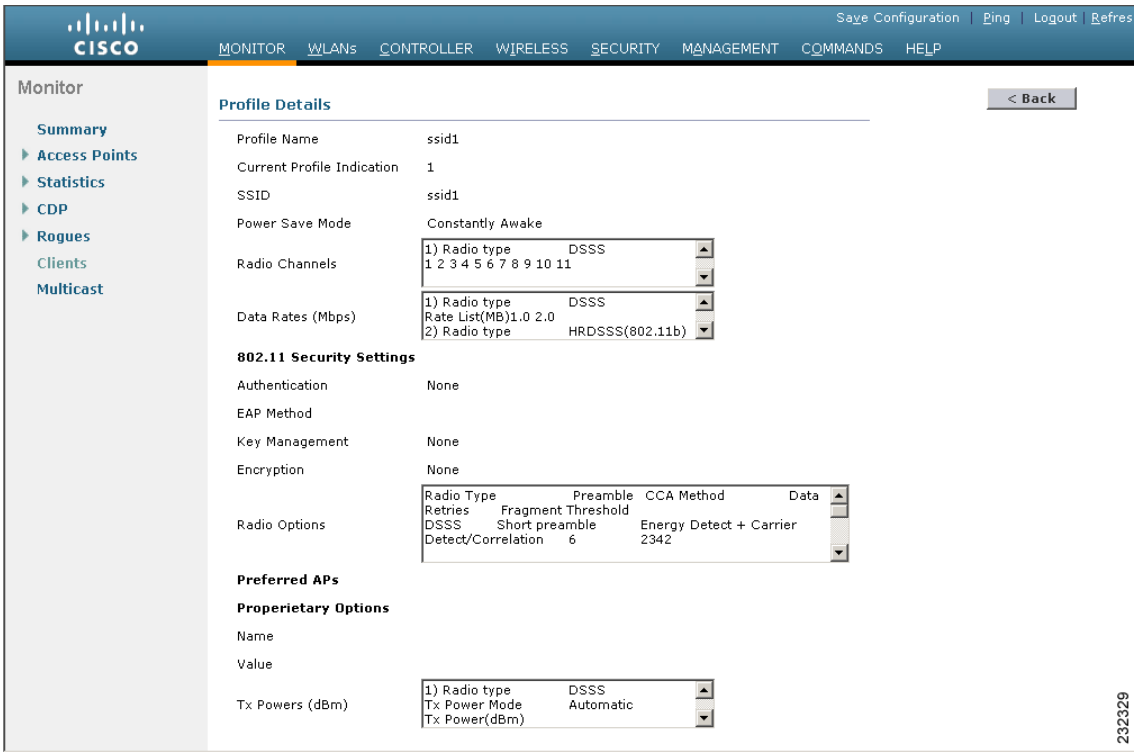
Figure D-10 Client Reporting Page



This page lists the client profiles and indicates if they are currently in use. It also provides information on the client's operating parameters, manufacturer, and capabilities.

Step 5 Click the link for the desired client profile. The Profile Details page appears (see Figure D-11).

Figure D-11 Profile Details Page



This page shows the client profile details, including the SSID, power save mode, radio channel, data rates, and 802.11 security settings.

Using the CLI to Configure Client Reporting

To configure client reporting using the controller CLI, follow these steps:

Step 1 To send a request to the client to send its profiles, enter this command:

config client ccx get-profiles *client_mac_address*

Step 2 To send a request to the client to send its current operating parameters, enter this command:

config client ccx get-operating-parameters *client_mac_address*

Step 3 To send a request to the client to send the manufacturer's information, enter this command:

config client ccx get-manufacturer-info *client_mac_address*

Step 4 To send a request to the client to send its capability information, enter this command:

config client ccx get-client-capability *client_mac_address*

Step 5 To clear the client reporting information, enter this command:

config client ccx clear-reports *client_mac_address*

Step 6 To see the client profiles, enter this command:

show client ccx profiles *client_mac_address*

Information similar to the following appears:

```
Number of Profiles.............................. 1
Current Profile................................. 1

Profile ID...................................... 1
Profile Name.................................... wifiEAP
SSID............................................ wifiEAP
Security Parameters[EAP Method,Credential]..... EAP-TLS,Host OS Login Credentials
Auth Method..................................... EAP
Key Management................................. WPA2+CCKM
Encryption...................................... AES-CCMP
Power Save Mode................................. Constantly Awake
Radio Configuration:
Radio Type...................................... DSSS
  Preamble Type................................. Long preamble
  CCA Method.................................... Energy Detect + Carrier
Detect/Correlation
  Data Retries.................................. 6
  Fragment Threshold............................ 2342
  Radio Channels................................ 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................. Automatic
  Rate List(MB)................................. 1.0 2.0

Radio Type...................................... HRDSSS(802.11b)
  Preamble Type................................. Long preamble
  CCA Method.................................... Energy Detect + Carrier
Detect/Correlation
  Data Retries.................................. 6
  Fragment Threshold............................ 2342
  Radio Channels................................ 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................. Automatic
  Rate List(MB)................................. 5.5 11.0

Radio Type...................................... ERP(802.11g)
  Preamble Type................................. Long preamble
  CCA Method.................................... Energy Detect + Carrier
Detect/Correlation
  Data Retries.................................. 6
  Fragment Threshold............................ 2342
  Radio Channels................................ 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................. Automatic
  Rate List(MB)................................. 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0

Radio Type...................................... OFDM(802.11a)
  Preamble Type................................. Long preamble
  CCA Method.................................... Energy Detect + Carrier
Detect/Correlation
  Data Retries.................................. 6
  Fragment Threshold............................ 2342
Radio Channels................................ 36 40 44 48 52 56 60 64 149 153 157 161
165
  Tx Power Mode................................. Automatic
  Rate List(MB)................................. 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0
```

Step 7 To see the client operating parameters, enter this command:

show client ccx operating-parameters *client_mac_address*

Information similar to the following appears:

```
Client Mac..................................... 00:40:96:b2:8d:5e
Radio Type..................................... OFDM(802.11a)

Radio Type..................................... OFDM(802.11a)
  Radio Channels............................... 36 40 44 48 52 56 60 64 100 104 108 112
116 120 124 128 132 136 140 149 153 157 161 165
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0

Power Save Mode................................ Normal Power Save
SSID........................................... wifi
Security Parameters[EAP Method,Credential]..... None
Auth Method.................................... None
Key Management................................. None
Encryption..................................... None
Device Name.................................... Wireless Network Connection 15
Device Type.................................... 0
OS Id.......................................... Windows XP
OS Version..................................... 5.1.2600 Service Pack 2
IP Type........................................ DHCP address
IPv4 Address................................... Available
IP Address..................................... 70.0.4.66
Subnet Mask.................................... 255.0.0.0
Default Gateway................................ 70.1.0.1
IPv6 Address................................... Not Available
IPv6 Address.................................  0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0:
0: 0: 0:
IPv6 Subnet Mask............................... 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0: 0:
0: 0: 0:
DNS Servers.................................... 103.0.48.0
WINS Servers...................................
System Name.................................... URAVAL3777
Firmware Version............................... 4.0.0.187
Driver Version................................. 4.0.0.187
```

Step 8 To see the client manufacturer information, enter this command:

show client ccx manufacturer-info *client_mac_address*

Information similar to the following appears:

```
Manufacturer OUI............................... 00:40:96
Manufacturer ID................................ Cisco
Manufacturer Model............................. Cisco Aironet 802.11a/b/g Wireless
Adapter
Manufacturer Serial............................ FOC1046N3SX
Mac Address.................................... 00:40:96:b2:8d:5e
Radio Type..................................... DSSS OFDM(802.11a) HRDSSS(802.11b)
ERP(802.11g)
Antenna Type................................... Omni-directional diversity
Antenna Gain................................... 2 dBi

Rx Sensitivity:
Radio Type..................................... DSSS
Rx Sensitivity ................................ Rate:1.0 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:2.0 Mbps, MinRssi:-95, MaxRssi:-30
Radio Type..................................... HRDSSS(802.11b)
Rx Sensitivity ................................ Rate:5.5 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:11.0 Mbps, MinRssi:-95, MaxRssi:-30
Radio Type..................................... ERP(802.11g)
Rx Sensitivity ................................ Rate:6.0 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:9.0 Mbps, MinRssi:-95, MaxRssi:-30
Rx Sensitivity ................................ Rate:12.0 Mbps, MinRssi:-95, MaxRssi:-30
```

```
Rx Sensitivity ................................ Rate:18.0 Mbps, MinRssi:-95, MaxRssi:-30
```

Step 9 To see the client's capability information, enter this command:

show client ccx client-capability *client_mac_address*

Note This command displays the client's available capabilities, not current settings for the capabilities.

Information similar to the following appears:

```
Service Capability............................. Voice, Streaming(uni-directional) Video,
Interactive(bi-directional) Video
Radio Type..................................... DSSS OFDM(802.11a) HRDSSS(802.11b)
ERP(802.11g)

Radio Type..................................... DSSS
  Radio Channels............................... 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 1.0 2.0

Radio Type..................................... HRDSSS(802.11b)
  Radio Channels............................... 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 5.5 11.0

Radio Type..................................... ERP(802.11g)
  Radio Channels............................... 1 2 3 4 5 6 7 8 9 10 11
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0

Radio Type..................................... OFDM(802.11a)
  Radio Channels............................... 36 40 44 48 52 56 60 64 100 104 108 112
116 120 124 128 132 136 140 149 153 157 161 165
  Tx Power Mode................................ Automatic
  Rate List(MB)................................ 6.0 9.0 12.0 18.0 24.0 36.0 48.0 54.0
```

Using the CLI to Configure Roaming and Real-Time Diagnostics

To configure roaming and real-time diagnostics using the controller CLI, follow these steps:

Step 1 To send a log request, enter this command:

config client ccx log-request *log_type client_mac_address*

where *log_type is roam, rsna, or syslog.*

Step 2 To view a log response, enter this command:

show client ccx log-response *log_type client_mac_address*

where *log_type is roam, rsna, or syslog.*

Information similar to the following appears for a log response with a *log_type* of roam:

```
Tue Jun 26 18:28:48 2007  Roaming Response LogID=133: Status=Successful
                          Event Timestamp=0d 00h 00m 13s 322396us
```

```
                          Source BSSID=00:0b:85:81:06:c2, Target BSSID=00:0b:85:81:06:c2,
Transition Time=3125(ms)
                          Transition Reason: Normal roam, poor link
                          Transition Result: Success
Tue Jun 26 18:28:48 2007  Roaming Response LogID=133: Status=Successful
                          Event Timestamp=0d 00h 00m 16s 599006us
                          Source BSSID=00:0b:85:81:06:c2, Target BSSID=00:0b:85:81:06:c2,
Transition Time=3235(ms)
                          Transition Reason: Normal roam, poor link
                          Transition Result: Success
                          Event Timestamp=0d 00h 00m 19s 882921us
                          Source BSSID=00:0b:85:81:06:c2, Target BSSID=00:0b:85:81:06:c2,
Transition Time=3234(ms)
                          Transition Reason: Normal roam, poor link
                          Transition Result: Success
Tue Jun 26 18:28:48 2007  Roaming Response LogID=133: Status=Successful
                          Event Timestamp=0d 00h 00m 08s 815477us
                          Source BSSID=00:0b:85:81:06:c2, Target BSSID=00:0b:85:81:06:d2,
Transition Time=3281(ms)
                          Transition Reason: First association to WLAN
                          Transition Result: Success
                          Event Timestamp=0d 00h 00m 26s 637084us
                          Source BSSID=00:0b:85:81:06:d2, Target BSSID=00:0b:85:81:06:c2,
Transition Time=3313(ms)
```

Information similar to the following appears for a log response with a *log_type* of rsna:

```
Tue Jun 26 18:24:09 2007  RSNA Response LogID=132: Status=Successful
                          Event Timestamp=0d 00h 00m 00s 246578us
                          Target BSSID=00:14:1b:58:86:cd
                          RSNA Version=1
                          Group Cipher Suite=00-0f-ac-02
                          Pairwise Cipher Suite Count = 1
                              Pairwise Cipher Suite 0 = 00-0f-ac-04
                          AKM Suite Count = 1
                              AKM Suite 0 = 00-0f-ac-01
                          RSN Capability = 0x0
                          RSNA Result: Success
Tue Jun 26 18:24:09 2007  RSNA Response LogID=132: Status=Successful
                          Event Timestamp=0d 00h 00m 00s 246625us
                          Target BSSID=00:14:1b:58:86:cd
                          RSNA Version=1
                          Group Cipher Suite=00-0f-ac-02
                          Pairwise Cipher Suite Count = 1
                              Pairwise Cipher Suite 0 = 00-0f-ac-04
                          AKM Suite Count = 1
                              AKM Suite 0 = 00-0f-ac-01
                          RSN Capability = 0x0
                          RSNA Result: Success
Tue Jun 26 18:24:09 2007  RSNA Response LogID=132: Status=Successful
                          Event Timestamp=0d 00h 00m 01s 624375us
                          Target BSSID=00:14:1b:58:86:cd
                          RSNA Version=1
                          Group Cipher Suite=00-0f-ac-02
                          Pairwise Cipher Suite Count = 1
                              Pairwise Cipher Suite 0 = 00-0f-ac-04
                          AKM Suite Count = 1
                              AKM Suite 0 = 00-0f-ac-01
                          RSN Capability = 0x0
                        RSNA Result: Success
```

Information similar to the following appears for a log response with a *log_type* of syslog:

```
Tue Jun 26 18:07:48 2007  SysLog Response LogID=131: Status=Successful
                          Event Timestamp=0d 00h 19m 42s 278987us
                          Client SysLog = '<11> Jun 19 11:49:47 uraval3777 Mandatory
elements missing in the OID response'
                          Event Timestamp=0d 00h 19m 42s 278990us
                          Client SysLog = '<11> Jun 19 11:49:50 uraval3777 Mandatory
elements missing in the OID response'
Tue Jun 26 18:07:48 2007  SysLog Response LogID=131: Status=Successful
                          Event Timestamp=0d 00h 19m 42s 278993us
                          Client SysLog = '<11> Jun 19 11:49:53 uraval3777 Mandatory
elements missing in the OID response'
                          Event Timestamp=0d 00h 19m 42s 278996us
                          Client SysLog = '<11> Jun 19 11:49:56 uraval3777 Mandatory
elements missing in the OID response'
Tue Jun 26 18:07:48 2007  SysLog Response LogID=131: Status=Successful
                          Event Timestamp=0d 00h 19m 42s 279000us
                          Client SysLog = '<11> Jun 19 11:50:00 uraval3777 Mandatory
elements missing in the OID response'
                          Event Timestamp=0d 00h 19m 42s 279003us
                          Client SysLog = '<11> Jun 19 11:50:03 uraval3777 Mandatory
elements missing in the OID response'
Tue Jun 26 18:07:48 2007  SysLog Response LogID=131: Status=Successful
                          Event Timestamp=0d 00h 19m 42s 279009us
                          Client SysLog = '<11> Jun 19 11:50:09 uraval3777 Mandatory
elements missing in the OID response'
                          Event Timestamp=0d 00h 19m 42s 279012us
                          Client SysLog = '<11> Jun 19 11:50:12 uraval3777 Mandatory
elements missing in the OID response'
```

Step 3 To send a request for statistics, enter this command:

config client ccx stats-request *measurement_duration stats_name client_mac_address*

where *stats_name is dot11 or security.*

Step 4 To view the statistics response, enter this command:

show client ccx stats-report *client_mac_address*

Information similar to the following appears:

```
Measurement duration = 1

     dot11TransmittedFragmentCount       = 1
     dot11MulticastTransmittedFrameCount = 2
     dot11FailedCount                    = 3
     dot11RetryCount                     = 4
     dot11MultipleRetryCount             = 5
     dot11FrameDuplicateCount            = 6
     dot11RTSSuccessCount                = 7
     dot11RTSFailureCount                = 8
     dot11ACKFailureCount                = 9
     dot11ReceivedFragmentCount          = 10
     dot11MulticastReceivedFrameCount    = 11
     dot11FCSErrorCount                  = 12
     dot11TransmittedFrameCount        = 13
```

Using the Debug Facility

The debug facility enables you to display all packets going to and from the controller CPU. You can enable it for received packets, transmitted packets, or both. By default, all packets received by the debug facility are displayed. However, you can define access control lists (ACLs) to filter packets before they are displayed. Packets not passing the ACLs are discarded without being displayed.

Each ACL includes an action (permit, deny, or disable) and one or more fields that can be used to match the packet. The debug facility provides ACLs that operate at the following levels and on the following values:

- Driver ACL
  - NPU encapsulation type
  - Port
- Ethernet header ACL
  - Destination address
  - Source address
  - Ethernet type
  - VLAN ID
- IP header ACL
  - Source address
  - Destination address
  - Protocol
  - Source port (if applicable)
  - Destination port (if applicable)
- EoIP payload Ethernet header ACL
  - Destination address
  - Source address
  - Ethernet type
  - VLAN ID
- EoIP payload IP header ACL
  - Source address
  - Destination address
  - Protocol
  - Source port (if applicable)
  - Destination port (if applicable)
- CAPWAP payload 802.11 header ACL
  - Destination address
  - Source address
  - BSSID
  - SNAP header type

- CAPWAP payload IP header ACL
  - Source address
  - Destination address
  - Protocol
  - Source port (if applicable)
  - Destination port (if applicable)

At each level, you can define multiple ACLs. The first ACL that matches the packet is the one that is selected.

To use the debug facility, follow these steps:

Step 1 To enable the debug facility, enter this command:

debug packet logging enable {**rx** | **tx** | **all**} *packet_count display_size*

where

- **rx** displays all received packets, **tx** displays all transmitted packets, and **all** displays both transmitted and received packets.
- *packet_count* is the maximum number of packets to log. You can enter a value between 1 and 65535 packets, and the default value is 25 packets.
- *display_size* is the number of bytes to display when printing a packet. By default, the entire packet is displayed.

Note To disable the debug facility, enter this command: **debug packet logging disable.**

Step 2 Use these commands to configure packet-logging ACLs:

- **debug packet logging acl driver** *rule_index action npu_encap port*

  where
  - *rule_index* is a value between 1 and 6 (inclusive).
  - *action* is permit, deny, or disable.
  - *npu_encap* specifies the NPU encapsulation type, which determines how packets are filtered. The possible values include dhcp, dot11-mgmt, dot11-probe, dot1x, eoip-ping, iapp, ip, lwapp, multicast, orphan-from-sta, orphan-to-sta, rbcp, wired-guest, or any.
  - *port* is the physical port for packet transmission or reception.
- **debug packet logging acl eth** *rule_index action dst src type vlan*

  where
  - *rule_index* is a value between 1 and 6 (inclusive).
  - *action* is permit, deny, or disable.
  - *dst* is the destination MAC address.
  - *src* is the source MAC address.
  - *type* is the two-byte type code (such as 0x800 for IP, 0x806 for ARP). This parameter also accepts a few common string values such as “ip” (for 0x800) or “arp” (for 0x806).
  - *vlan* is the two-byte VLAN ID.

- **debug packet logging acl ip** *rule_index action src dst proto src_port dst_port*

  where

  - *proto* is a numeric or any string recognized by getprotobyname(). The controller supports the following strings: ip, icmp, igmp, ggp, ipencap, st, tcp, egp, pup, udp, hmp, xns-idp, rdp, iso-tp4, xtp, ddp, idpr-cmtp, rspf, vmtp, ospf, ipip, and encap.
  - *src_port* is the UDP/TCP two-byte source port (for example, telnet, 23) or "any." The controller accepts a numeric or any string recognized by getservbyname(). The controller supports the following strings: tcpmux, echo, discard, systat, daytime, netstat, qotd, msp, chargen, ftp-data, ftp, fsp, ssh, telnet, smtp, time, rlp, nameserver, whois, re-mail-ck, domain, mtp, bootps, bootpc, tftp, gopher, rje, finger, www, link, kerberos, supdup, hostnames, iso-tsap, csnet-ns, 3com-tsmux, rtelnet, pop-2, pop-3, sunrpc, auth, sftp, uucp-path, nntp, ntp, netbios-ns, netbios-dgm, netbios-ssn, imap2, snmp, snmp-trap, cmip-man, cmip-agent, xdmcp, nextstep, bgp, prospero, irc, smux, at-rtmp, at-nbp, at-echo, at-zis, qmtp, z3950, ipx, imap3, ulistserv, https, snpp, saft, npmp-local, npmp-gui, and hmmp-ind.
  - *dst_port* is the UDP/TCP two-byte destination port (for example, telnet, 23) or "any." The controller accepts a numeric or any string recognized by getservbyname(). The controller supports the same strings as those for the *src_port.*
- **debug packet logging acl eoip-eth** *rule_index action dst src type vlan*
- **debug packet logging acl eoip-ip** *rule_index action src dst proto src_port dst_port*
- **debug packet logging acl lwapp-dot11** *rule_index action dst src bssid snap_type*

  where

  - *bssid* is the Basic Service Set Identifier.
  - *snap_type is the Ethernet type.*
- **debug packet logging acl lwapp-ip** *rule_index action src dst proto src_port dst_port*

Note To remove all configured ACLs, enter this command: **debug packet logging acl clear-all.**

Step 3 To configure the format of the debug output, enter this command:

debug packet logging format {**hex2pcap** | **text2pcap**}

The debug facility supports two output formats: hex2pcap and text2pcap. The standard format used by IOS supports the use of hex2pcap and can be decoded using an HTML front end. The text2pcap option is provided as an alternative so that a sequence of packets can be decoded from the same console log file. Figure D-12 shows an example of hex2pcap output, and Figure D-13 shows an example of text2pcap output.

Figure D-12 Sample Hex2pcap Output

```
tx len=118, encap=n/a, port=1
[0000]: 000C316E 7F80000B 854008c0 08004500 ..1n.....@.@..E.
[0010]: 00680000 40004001 5FBE0164 6C0E0164 .h..@.@._>.dl..d
[0020]: 6C010800 08D9E500 00000000 00000000 l....Ye.........
[0030]: 00000000 00000000 00000000 00001C1D ................
[0040]: 1E1F2021 22232425 26272829 2A2B2C2D ...!"#$%&'()*+,-
[0050]: 2E2F3031 32333435 36373839 3A3B3C3D ./0123456789:;<=
[0060]: 3E3F4041 42434445 46474849 4A4B4C4D >?@ABCDEFGHIJKLM
[0070]: 4E4F5051 5253                       NOPQRS
rx len=118, encap=ip, port=1
[0000]: 000B8540 08C0000C 316E7F80 08004500 ...@.@..1n....E.
[0010]: 00680000 4000FF01 A0BD0164 6C010164 .h..@....=.dl..d
[0020]: 6C0E0000 10D9E500 00000000 00000000 l....Ye.........
[0030]: 00000000 00000000 00000000 00001C1D ................
[0040]: 1E1F2021 22232425 26272829 2A2B2C2D ...!"#$%&'()*+,-
[0050]: 2E2F3031 32333435 36373839 3A3B3C3D ./0123456789:;<=
[0060]: 3E3F4041 42434445 46474849 4A4B4C4D >?@ABCDEFGHIJKLM
[0070]: 4E4F5051 5253                       NOPQRS
```

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Figure D-13 Sample Text2pcap Output

```
tx len=118, encap=n/a, port=1
0000 00 0C 31 6E 7F 80 00 0B 85 40 08 c0 08 00 45 00 ..1n.....@.@..E.
0010 00 68 00 00 40 00 40 01 5F BE 01 64 6C 0E 01 64 .h..@.@._>.dl..d
0020 6C 01 08 00 08 D9 E5 00 00 00 00 00 00 00 00 00 l....Ye.........
0030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 1C 1D ................
0040 1E 1F 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D ...!"#$%&'()*+,-
0050 2E 2F 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D ./0123456789:;<=
0060 3E 3F 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D >?@ABCDEFGHIJKLM
0070 4E 4F 50 51 52 53                              NOPQRS
rx len=118, encap=ip, port=1
0000 00 0B 85 40 08 C0 00 0C 31 6E 7F 80 08 00 45 00 ...@.@..1n....E.
0010 00 68 00 00 40 00 FF 01 A0 BD 01 64 6C 01 01 64 .h..@....=.dl..d
0020 6C 0E 00 00 10 D9 E5 00 00 00 00 00 00 00 00 00 l....Ye.........
0030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 1C 1D ................
0040 1E 1F 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D ...!"#$%&'()*+,-
0050 2E 2F 30 31 32 33 34 35 36 37 38 39 3A 3B 3C 3D ./0123456789:;<=
0060 3E 3F 40 41 42 43 44 45 46 47 48 49 4A 4B 4C 4D >?@ABCDEFGHIJKLM
0070 4E 4F 50 51 52 53                              NOPQRS
```

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Step 4 To determine why packets might not be displayed, enter this command:

debug packet error {**enable** | **disable**}

Step 5 To display the status of packet debugging, enter this command:

show debug packet

Information similar to the following appears:

```
Status..................................... disabled
Number of packets to display..................... 25
Bytes/packet to display.......................... 0
Packet display format............................ text2pcap

Driver ACL:
      [1]: disabled
      [2]: disabled
```

```
   [3]: disabled
   [4]: disabled
   [5]: disabled
   [6]: disabled
Ethernet ACL:
   [1]: disabled
   [2]: disabled
   [3]: disabled
   [4]: disabled
   [5]: disabled
   [6]: disabled
IP ACL:
   [1]: disabled
   [2]: disabled
   [3]: disabled
   [4]: disabled
   [5]: disabled
   [6]: disabled
EoIP-Ethernet ACL:
   [1]: disabled
   [2]: disabled
   [3]: disabled
   [4]: disabled
   [5]: disabled
   [6]: disabled
EoIP-IP ACL:
   [1]: disabled
   [2]: disabled
   [3]: disabled
   [4]: disabled
   [5]: disabled
   [6]: disabled
LWAPP-Dot11 ACL:
   [1]: disabled
   [2]: disabled
   [3]: disabled
   [4]: disabled
   [5]: disabled
   [6]: disabled
LWAPP-IP ACL:
   [1]: disabled
   [2]: disabled
   [3]: disabled
   [4]: disabled
   [5]: disabled
   [6]: disabled
```

Configuring Wireless Sniffing

The controller enables you to configure an access point as a network "sniffer," which captures and forwards all the packets on a particular channel to a remote machine that runs packet analyzer software. These packets contain information on time stamps, signal strength, packet sizes, and so on. Sniffers allow you to monitor and record network activity and to detect problems.

Supported third-party network analyzer software applications are as follows:

- Wildpackets Omnipeek or Airopeek
- AirMagnet Enterprise Analyzer

- Wireshark

Note The latest version of Wireshark can decode the packets by going to the Anaylze mode. Select **decode as**, and switch UDP5555 to decode as AIROPEEK.

Note You must disable IP-MAC address binding in order to use an access point in sniffer mode if the access point is joined to a Cisco 5500 Series Controller, a Cisco 2100 Series Controller, or a controller network module that runs software release 6.0 or later releases. To disable IP-MAC address binding, enter the **config network ip-mac-binding disable command in the controller CLI**. See the "Configuring IP-MAC Address Binding" section on page 4-67 for more information.

Note You must enable WLAN 1 in order to use an access point in sniffer mode if the access point is joined to a Cisco 5500 Series Controller, a Cisco 2100 Series Controller, or a controller network module that runs software release 6.0 or later releases. If WLAN 1 is disabled, the access point cannot send packets.

Prerequisites for Wireless Sniffing

To perform wireless sniffing, you need the following hardware and software:

- A dedicated access point—An access point configured as a sniffer cannot simultaneously provide wireless access service on the network. To avoid disrupting coverage, use an access point that is not part of your existing wireless network.
- A remote monitoring device—A computer capable of running the analyzer software.
- Windows XP or Linux operating system—The controller supports sniffing on both Windows XP and Linux machines.
- Software and supporting files, plug-ins, or adapters—Your analyzer software may require specialized files before you can successfully enable

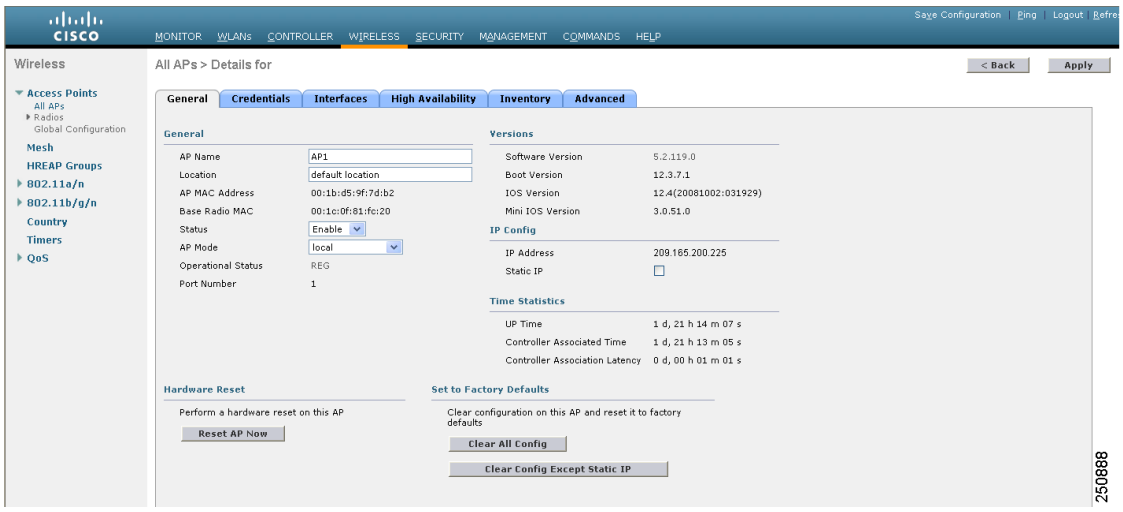
Using the GUI to Configure Sniffing on an Access Point

To configure sniffing on an access point using the controller GUI, follow these steps:

Step 1 Choose **Wireless > Access Points > All APs** to open the All APs page.

Step 2 Click the name of the access point that you want to configure as the sniffer. The All APs > Details for page appears (see Figure D-14).

Figure D-14 All APs > Details for Page



Step 3 From the AP Mode drop-down list, choose **Sniffer**.

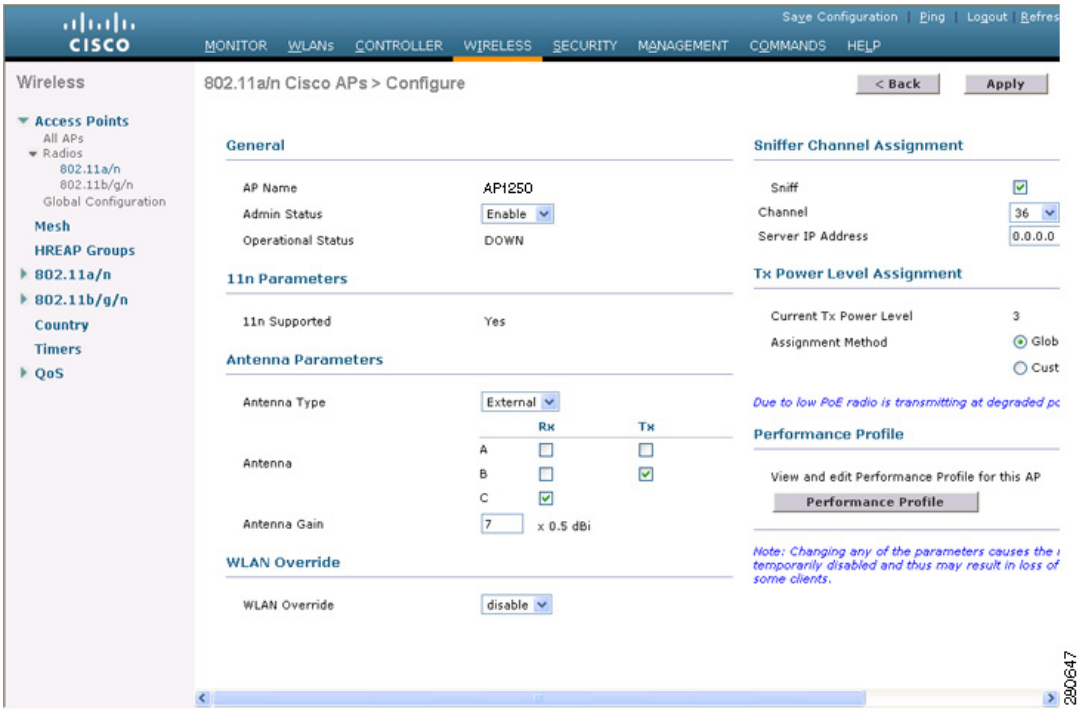
Step 4 Click **Apply** to commit your changes.

Step 5 Click **OK** when warned that the access point will be rebooted.

Step 6 Choose **Wireless > Access Points > Radios > 802.11a/n** (or **802.11b/g/n**) to open the 802.11a/n (or 802.11b/g/n) Radios page.

Step 7 Hover your cursor over the blue drop-down arrow for the desired access point and choose **Configure**. The 802.11a/n (or 802.11b/g/n) Cisco APs > Configure page appears (see Figure D-15).

Figure D-15 802.11a/n Cisco APs > Configure Page



Step 8 Select the **Sniff** check box to enable sniffing on this access point, or leave it unselected to disable sniffing. The default value is unchecked.

Step 9 If you enabled sniffing in Step 8, follow these steps:

a. From the Channel drop-down list, choose the channel on which the access point sniffs for packets.

b. In the Server IP Address text box, enter the IP address of the remote machine running Omnipeek, Airopeek, AirMagnet, or Wireshark.

Step 10 Click **Apply** to commit your changes.

Step 11 Click **Save Configuration** to save your changes.

Using the CLI to Configure Sniffing on an Access Point

To configure sniffing on an access point using the controller CLI, follow these steps:

Step 1 To configure the access point as a sniffer, enter this command:

config ap mode sniffer *Cisco_AP*

where *Cisco_AP* is the access point configured as the sniffer.

Step 2 When warned that the access point will be rebooted and asked if you want to continue, enter **Y**. The access point reboots in sniffer mode.

Step 3 To enable sniffing on the access point, enter this command:

config ap sniff {802.11a | 802.11b} enable *channel server_IP_address Cisco_AP*

where

- *channel* is the radio channel on which the access point sniffs for packets. The default values are 36 (802.11a/n) and 1 (802.11b/g/n).
- *server_IP_address* is the IP address of the remote machine running Omnipeek, Airopeek, AirMagnet, or Wireshark.
- *Cisco_AP* is the access point configured as the sniffer.

Note To disable sniffing on the access point, enter the **config ap sniff {802.11a | 802.11b} disable** *Cisco_AP command.*

Step 4 To save your changes, enter this command:

save config

Step 5 To view the sniffer configuration settings for an access point, enter this command:

show ap config {802.11a | 802.11b} *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 17
Cisco AP Name.................................... AP1131:46f2.98ac
...
AP Mode ......................................... Sniffer
Public Safety ................................... Global: Disabled, Local: Disabled
Sniffing ........................................ No
...
```

Troubleshooting Access Points Using Telnet or SSH

The controller supports the use of the Telnet and Secure Shell (SSH) protocols to troubleshoot lightweight access points. Using these protocols makes debugging easier, especially when the access point is unable to connect to the controller.

- To avoid potential conflicts and security threats to the network, the following commands are unavailable while a Telnet or SSH session is enabled: **config terminal, telnet, ssh, rsh, ping, traceroute, clear, clock, crypto, delete, fsck, lwapp, mkdir, radius, release, reload, rename, renew, rmdir, save, set, test, upgrade**.
- Commands available during a Telnet or SSH session include **debug, disable, enable, help, led, login, logout, more, no debug, show, systat, undebug, where**.

You can configure Telnet or SSH by using the controller CLI in software release 5.0 or later releases or using the controller GUI in software release 6.0 or later releases.

Note See the "Configuring Telnet and SSH Sessions" section on page 2-34 for instructions on configuring Telnet or SSH sessions on the controller.

Using the GUI to Troubleshoot Access Points Using Telnet or SSH

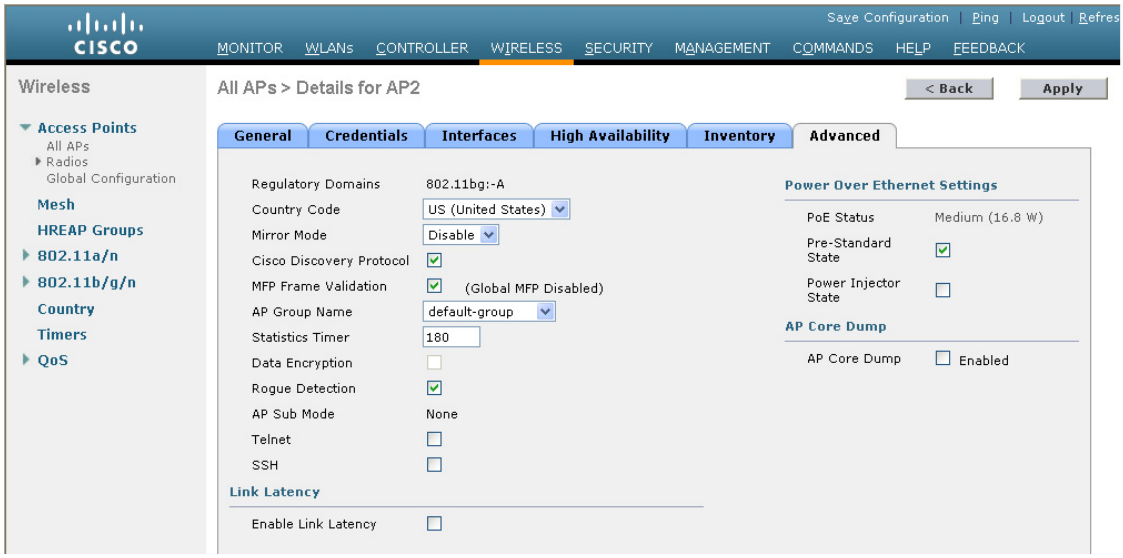
To enable Telnet or SSH access (or both) on lightweight access points using the controller GUI, follow these steps:

Step 1 Choose **Wireless** > **Access Points** > **All APs** to open the All APs page.

Step 2 Click the name of the access point for which you want to enable Telnet or SSH.

Step 3 Choose the **Advanced** tab to open the All APs > Details for (Advanced) page (see Figure D-16).

Figure D-16 All APs > Details for (Advanced) Page



Step 4 To enable Telnet connectivity on this access point, select the **Telnet** check box. The default value is unchecked.

Step 5 To enable SSH connectivity on this access point, select the **SSH** check box. The default value is unchecked.

Step 6 Click **Apply** to commit your changes.

Step 7 Click **Save Configuration** to save your changes.

Using the CLI to Troubleshoot Access Points Using Telnet or SSH

To enable Telnet or SSH access (or both) on lightweight access points using the controller CLI, follow these steps:

Step 1 To enable Telnet or SSH connectivity on an access point, enter this command:

config ap {telnet | ssh} enable *Cisco_AP*

The default value is disabled.

Note To disable Telnet or SSH connectivity on an access point, enter this command:
config ap {telnet | ssh} disable *Cisco_AP*

Step 2 To save your changes, enter this command:

save config

Step 3 To see whether Telnet or SSH is enabled on an access point, enter this command:

show ap config general *Cisco_AP*

Information similar to the following appears:

```
Cisco AP Identifier.............................. 5
Cisco AP Name.................................... AP33
Country code..................................... Multiple Countries:US,AE,AR,AT,AU,BH
Reg. Domain allowed by Country................... 802.11bg:-ABCENR 802.11a:-ABCEN
AP Country code.................................. US - United States
AP Regulatory Domain............................. 802.11bg:-A 802.11a:-A
Switch Port Number .............................. 2
MAC Address...................................... 00:19:2f:11:16:7a
IP Address Configuration......................... Static IP assigned
IP Address....................................... 10.22.8.133
IP NetMask....................................... 255.255.248.0
Gateway IP Addr.................................. 10.22.8.1
Domain.......................................
Name Server.....................................
Telnet State..................................... Enabled
Ssh State........................................ Enabled
...
```

Debugging the Access Point Monitor Service

The controller sends access point status information to the Cisco 3300 Series Mobility Services Engine (MSE) using the access point monitor service.

The MSE sends a service subscription and an access point monitor service request to get the status of all access points currently known to the controller. When any change is made in the status of an access point, a notification is sent to the MSE.

Using the CLI to Debug Access Point Monitor Service Issues

If you experience any problems with the access point monitor service, enter this command:

debug service ap-monitor {**all** | **error** | **event** | **nmsp** | **packet**} {**enable** | **disable**}

where

- **all** configures debugging of all access point status messages.
- **error** configures debugging of access point monitor error events.
- **event** configures debugging of access point monitor events.
- **nmsp** configures debugging of access point monitor NMSP events.
- **packet** configures debugging of access point monitor packets.

- **enable** enables the debub service ap-monitor mode.
- **disable** disables the debug service ap-monitor mode.

Troubleshooting OfficeExtend Access Points

This section provides troubleshooting information if you experience any problems with your OfficeExtend access points.

Interpreting OfficeExtend LEDs

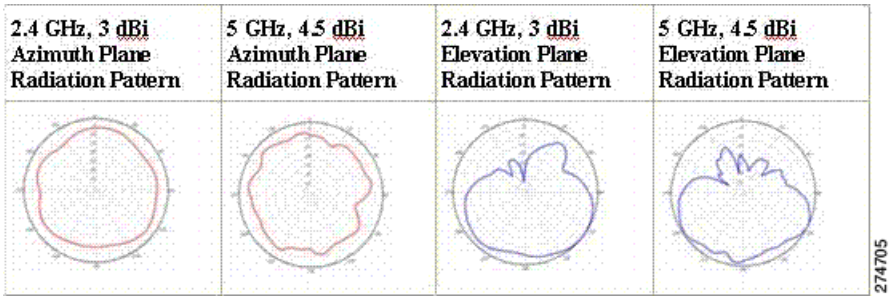
The LED patterns are different for 1130 series and 1140 series OfficeExtend access points. See the *Cisco OfficeExtend Access Point Quick Start Guide* for a description of the LED patterns. You can find this guide at this URL:

http://www.cisco.com/en/US/products/hw/wireless/index.html

Positioning OfficeExtend Access Points for Optimal RF Coverage

When positioning your OfficeExtend access point, consider that its RF signals are emitted in a cone shape spreading outward from the LED side of the access point (see Figure D-17). Be sure to mount the access point so that air can flow behind the metal back plate and prevent the access point from overheating.

Figure D-17 OfficeExtend Access Point Radiation Patterns



Troubleshooting Common Problems

Most of the problems experienced with OfficeExtend access points are one of the following:

- The access point cannot join the controller because of network or firewall issues.

  Resolution: Follow the instructions in the "Viewing Access Point Join Information" section on page 8-55 to view join statistics for the OfficeExtend access point, or find the access point's public IP address and perform pings of different packet sizes from inside the company.

- The access point joins but keeps dropping off. This behavior usually occurs because of network problems or when the network address translation (NAT) or firewall ports close because of short timeouts.

Resolution: Ask the teleworker for the LED status.

- Clients cannot associate because of NAT issues.

  Resolution: Ask the teleworker to perform a speed test and a ping test. Some servers do not return big packet pings.

- Clients keep dropping data. This behavior usually occurs because the home router closes the port because of short timeouts.

  Resolution: Perform client troubleshooting in WCS to determine if the problem is related to the OfficeExtend access point or the client.

- The access point is not broadcasting the enterprise WLAN.

  Resolution: Ask the teleworker to check the cables, power supply, and LED status. If you still cannot identify the problem, ask the teleworker to try the following:

  - Connect to the home router directly and see if the PC is able to connect to an Internet website such as http://www.cisco.com/. If the PC cannot connect to the Internet, check the router or modem. If the PC can connect to the Internet, check the home router configuration to see if a firewall or MAC-based filter is enabled that is blocking the access point from reaching the Internet.
  - Log into the home router and check to see if the access point has obtained an IP address. If it has, the access point's LED normally blinks orange.

- The access point cannot join the controller, and you cannot identify the problem.

  Resolution: A problem could exist with the home router. Ask the teleworker to check the router manual and try the following:

  - Assign the access point a static IP address based on the access point's MAC address.
  - Put the access point in a demilitarized zone (DMZ), which is a small network inserted as a neutral zone between a company's private network and the outside public network. It prevents outside users from getting direct access to a server that has company data.
  - If problems still occur, contact your company's IT department for assistance.

- The teleworker experiences problems while configuring a personal SSID on the access point.

  Resolution: Clear the access point configuration and return it to factory default settings by clicking **Clear Config** on the access point GUI or by entering the clear ap config *Cisco_AP* command and then follow the steps in the "Configuring a Personal SSID on an OfficeExtend Access Point" section on page 8-85 to try again. If problems still occur, contact your company's IT department for assistance.

- The home network needs to be rebooted.

  Resolution: Ask the teleworker to follow these steps:

  a. Leave all devices networked and connected, and then power down all the devices.
  b. Turn on the cable or DSL modem, and then wait for 2 minutes. (Check the LED status.)
  c. Turn on the home router, and then wait for 2 minutes. (Check the LED status.)
  d. Turn on the access point, and then wait for 5 minutes. (Check the LED status.)
  e. Turn on the client.

APPENDIX E

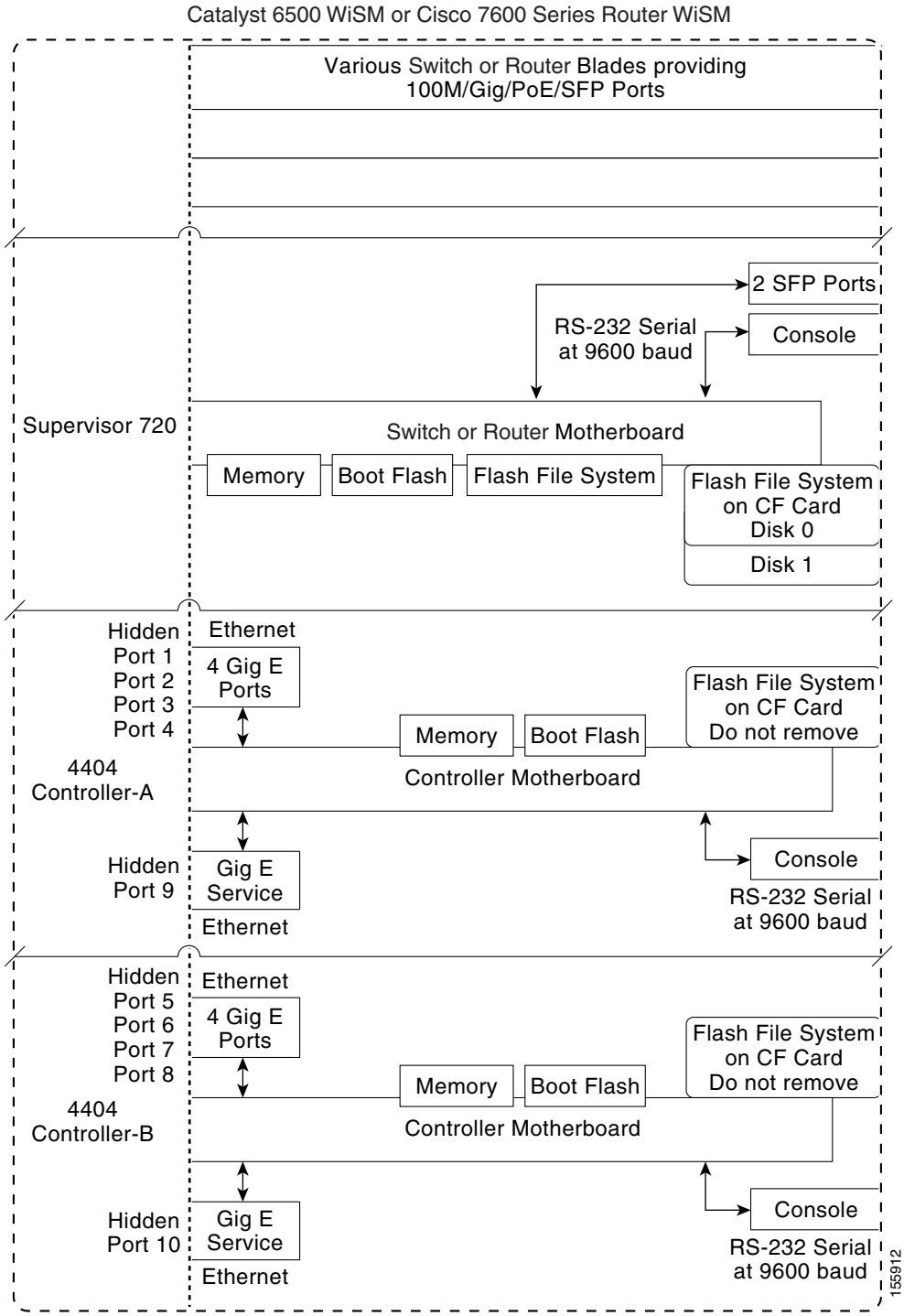
Logical Connectivity Diagrams

This appendix provides logical connectivity diagrams for the controllers integrated into other Cisco products, specifically the Catalyst 3750G Integrated Wireless LAN Controller Switch, the Cisco WiSM, and the Cisco 28/37/38xx Series Integrated Services Router. These diagrams show the internal connections between the switch or router and the controller. The software commands used for communication between the devices are also provided. This appendix contains these sections:

Cisco WiSM

Figure E-1 shows the logical connectivity for the Cisco WiSM.

Figure E-1 Logical Connectivity Diagram for the Cisco WiSM



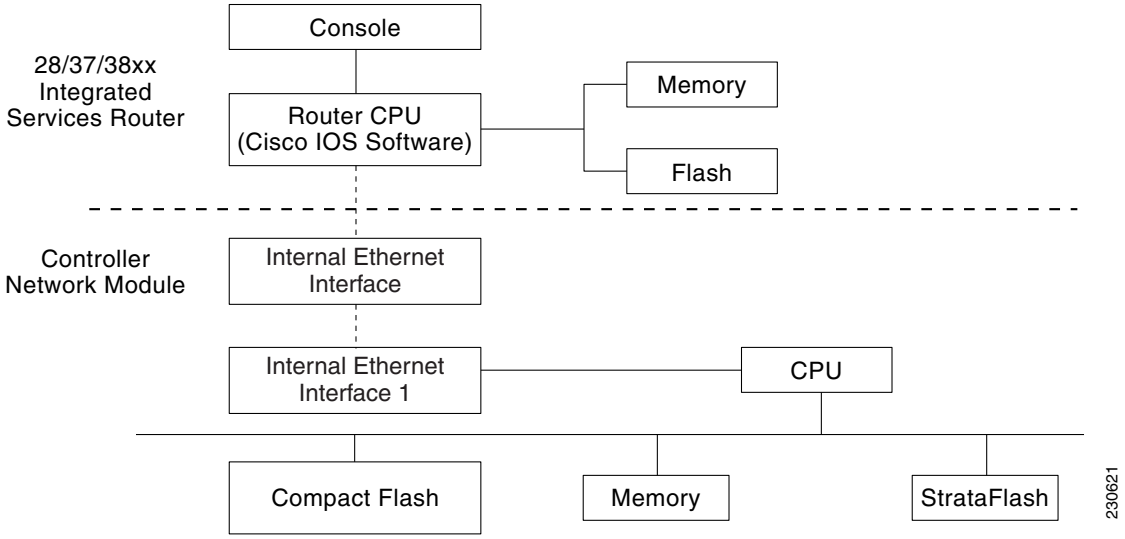
The commands used for communication between the Cisco WiSM, the Supervisor 720, and the 4404 controllers are documented in *Configuring a Cisco Wireless Services Module and Wireless Control System* at this URL:

http://www.cisco.com/en/US/docs/wireless/technology/wism/technical/reference/appnote.html#wp39498

Cisco 28/37/38xx Integrated Services Router

Figure E-2 shows the logical connectivity for the Cisco 28/37/38xx integrated services router.

Figure E-2 Logical Connectivity Diagram for the Cisco 28/37/38xx Integrated Services Router



These commands are used for communication between the 28/37/38xx Integrated Services Router and the controller network module. They are initiated from the router. The commands vary depending on the version of the network module.

These commands are used for communication between the router and Fast Ethernet versions of the controller network module:

- **interface wlan-controller** *slot/unit* (and support for subinterfaces with **dot1q encap**)
- **show interfaces wlan-controller** *slot/unit*
- **show controllers wlan-controller** *slot/unit*
- **test service-module wlan-controller** *slot/unit*
- **test HW-module wlan-controller** *slot/unit* **reset** {**enable** | **disable**}
- **service-module wlan-controller** *slot/port* {**reload** | **reset** | **session** [**clear**] | **shutdown** | **status**}

These commands are used for communication between the router and Gigabit Ethernet versions of the controller network module:

- **interface integrated-service-engine** *slot/unit* (and support for subinterfaces with **dot1q encap**)
- **show interfaces integrated-service-engine** *slot/unit*
- **show controllers integrated-service-engine** *slot/unit*
- **test service-module integrated-service-engine** *slot/unit*
- **test HW-module integrated-service-engine** *slot/unit* **reset** {**enable** | **disable**}

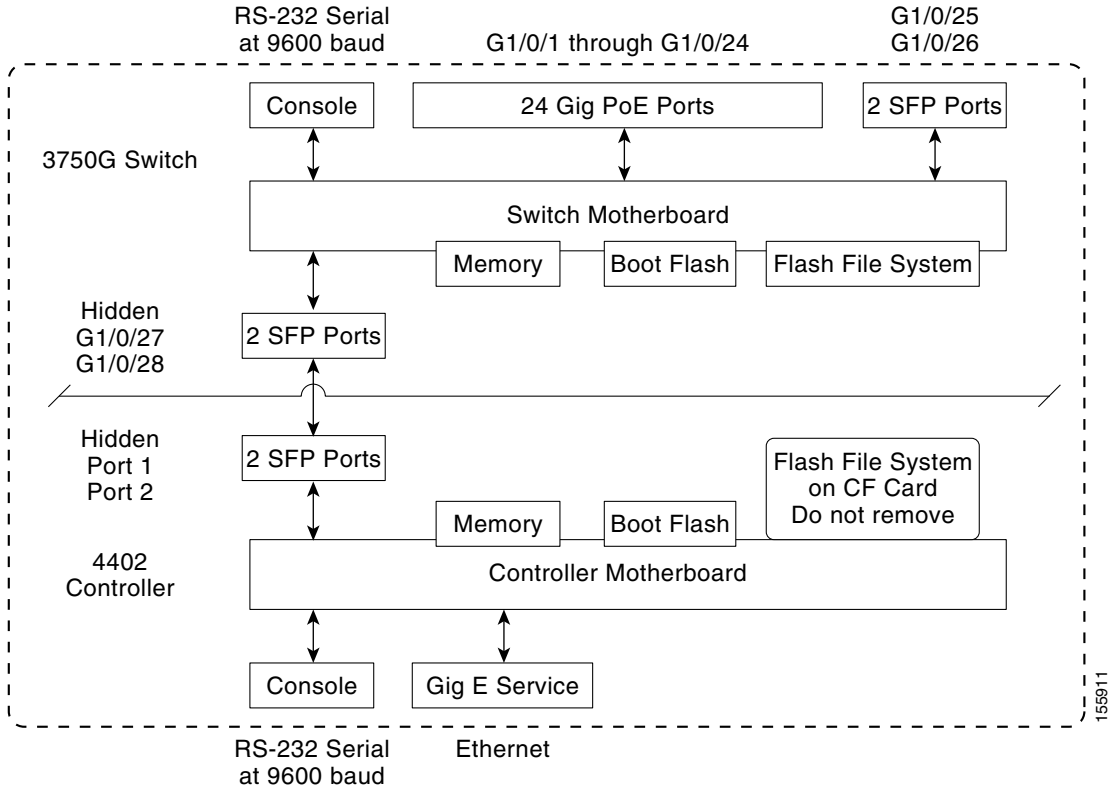
- **service-module integrated-service engine** *slot/port* {**reload** | **reset** | **session** [**clear**] | **shutdown** | **status**}

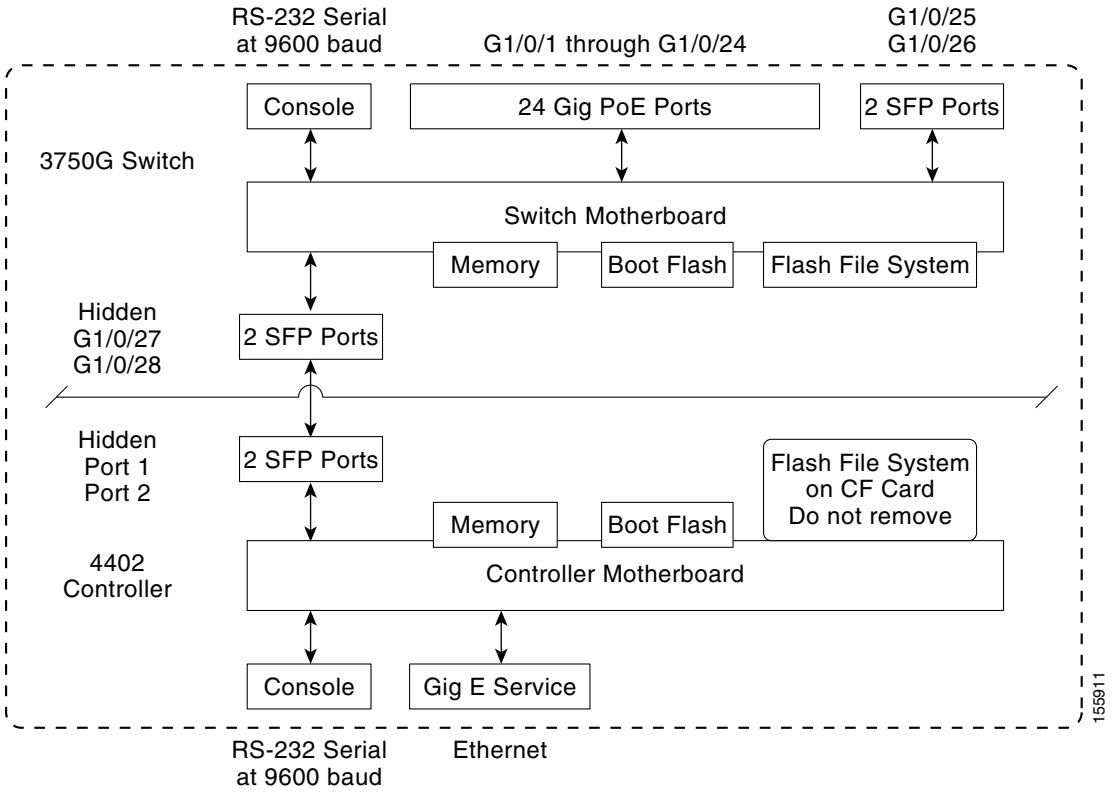
Note See the *Cisco Wireless LAN Controller Network Module Feature Guide* for more information. You can find this document at this URL:
http://www.cisco.com/univercd/cc/td/doc/product/software/ios124/124newft/124limit/124x/124xa2/boxernm.htm#wp2033271

Catalyst 3750G Integrated Wireless LAN Controller Switch

Figure E-3 shows the logical connectivity for the catalyst 3750G integrated wireless LAN.

Figure E-3 Logical Connectivity Diagram for the Catalyst 3750G Integrated Wireless LAN Controller Switch





These commands are used for communication between the Catalyst 3750G switch and the 4402 controller.

Login Command

This command is used to initiate a telnet session from the switch to the controller:

session *switch_number* **processor 1**

Because there can be several switches in a stack, the *switch_number* parameter is used to indicate to which controller in the stack this session should be directed. Once a session is established, the user interacts with the controller CLI. Entering **exit** terminates the session and returns the user to the switch CLI.

Show Commands

These commands are used to view the status of the internal controller. They are initiated from the switch.

- **show platform wireless-controller** *switch_number* **summary**

  Information similar to the following appears:

```
Switch  Status  State
1       up      operational
2       up      operational
```

- **show platform wireless-controller** *switch_number* **status**

Information similar to the following appears:

```
Switch  Service IP      Management IP   SW Version      Status
------+---------------+---------------+---------------+-------
 1      127.0.1.1       70.1.30.1       4.0.52.0        operational
 2      127.0.1.2       70.1.31.1       4.0.45.0        operational
```

- **show platform wireless-controller** *switch_number* **management-info**

```
sw vlan ip                gateway         http https mac            version
1  0    70.1.30.1/16       70.1.1.1        1    1     0016.9dca.d963 4.0.52.0
2  0    70.1.31.1/16       70.1.1.1        0    1     0016.9dca.dba3 4.0.45.0
```

Debug Commands

The Wireless Control Protocol (WCP) is an internal keep-alive protocol that runs between the switch and the controller. It enables the switch to monitor the health of the controller and to report any problems. It uses UDP and runs over the two internal Gigabit ports, but it creates an internal VLAN 4095 to separate control traffic from data traffic. Every 20 seconds the switch sends a keep-alive message to the controller. If the controller does not acknowledge 16 consecutive keep-alive messages, the switch declares the controller dead and sends a reset signal to reboot the controller.

These commands are used to monitor the health of the internal controller.

This command is initiated from the controller.

- **debug wcp** *?*

  where *?* is one of the following:

  packet—Debugs WCP packets.

  events—Debugs WCP events.

  Information similar to the following appears:

```
Tue Feb  7 23:30:31 2006: Received WCP_MSG_TYPE_REQUEST
Tue Feb  7 23:30:31 2006: Received WCP_MSG_TYPE_REQUEST,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:30:31 2006: Sent WCP_MSG_TYPE_RESPONSE,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:30:51 2006: Received WCP_MSG_TYPE_REQUEST
Tue Feb  7 23:30:51 2006: Received WCP_MSG_TYPE_REQUEST,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:30:51 2006: Sent WCP_MSG_TYPE_RESPONSE,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:31:11 2006: Received WCP_MSG_TYPE_REQUEST
Tue Feb  7 23:31:11 2006: Received WCP_MSG_TYPE_REQUEST,of type WCP_TLV_KEEP_ALIVE
Tue Feb  7 23:31:11 2006: Sent WCP_MSG_TYPE_RESPONSE,of type WCP_TLV_KEEP_ALIVE
```

This command is initiated from the switch.

- **debug platform wireless-controller** *switch_number ?*

  where *?* is one of the following:

  all—All

  errors—Errors

  packets—WCP packets

  sm—State machine

  wcp—WCP protocol

Reset Commands

These two commands (in this order) are used to reset the controller from the switch. They are not yet available but will be supported in a future release.

- **test wireless-controller stop** *switch_number*
- **test wireless-controller start** *switch_number*

Note A direct console connection to the controller does not operate when hardware flow control is enabled on the PC. However, the switch console port operates with hardware flow control enabled.

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