networktest

# HP/Cisco Switching and Routing Interoperability Cookbook

May 2011

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## ILLUSTRATIONS

# Introduction

## Objective

This configuration guide aims to help networking professionals interconnect HP Networking and Cisco Catalyst switches using a variety of protocols commonly found in enterprise campus networks. By following the step-by-step procedures described in this document, it should be possible to verify interoperability and to pass traffic between the two vendors' switches.

## Intended audience

This guide is intended for any network architect, administrator, or engineer who needs to interconnect HP and Cisco Ethernet switches.

This guide assumes familiarity with basic Ethernet and TCP/IP networking concepts, as well as at least limited experience with the HP Networking and Cisco IOS command-line interfaces (CLIs). No previous experience is assumed for the protocols discussed in this document.

For basic TCP/IP networking concepts, the standard references are ***Internetworking with TCP/IP, Volume 1*** by Douglas E. Comer and ***TCP/IP Illustrated, Volume 1*** by W. Richard Stevens.

For IP multicast topics, ***Deploying IP Multicast in the Enterprise*** by Thomas A. Maufer is a popular choice.

## Devices under test

Using the commands given in this document, Network Test has verified interoperability between the HP A9505, HP E5406zl, and HP A5800 Ethernet switches and Cisco Catalyst 6509, Cisco Catalyst 4506, and Catalyst 3750-E Ethernet switches. Appendix B lists software versions used.

Except where specifically noted, command syntax for HP Networking and Cisco Catalyst switches does not change across product lines. In cases where HP A-series and E-series switches use different command syntax, this is explicitly noted.

## Conventions used in this document

The following table lists text and syntax conventions.

| Conventions | Description | Examples |
|---|---|---|
| **Bold Type** | Represents user-inputted text. | To enter configuration mode, type the **`system-view`** command:<br><br>`<HP5800>` **`system-view`** |
| `Fixed-width text like this` | Represents output that appears on the terminal screen. | `<A9505>` **`display stp bridge`**<br><br>`MSTID Port Role STP State Protection`<br><br>`0 Bridge-Aggregation20 ROOT FORWARDING NONE`<br><br>`0 GigabitEthernet3/0/11 DESI FORWARDING NONE`<br><br>`0 GigabitEthernet3/0/16 DESI FORWARDING NONE` |
| *Italic text like this* | • Introduces important new terms<br>• Identifies book titles<br>• Identifies RFC and Internet-draft titles | • A policy *term* is a named structure that defines match conditions and actions.<br>• *TCP/IP Illustrated Volume 1* by W. Richard Stevens.<br>• RFC 4814, *Hash and Stuffing: Overlooked Factors in Network Device Benchmarking* |

## Interoperability testing

For each protocol tested, this document uses a five-section format consisting of objective, technical background, HP configuration, Cisco configuration, and test validation.

## Topology

Except where otherwise noted, engineers used the standard test bed shown in Figure 1 below to validate protocol interoperability. The test bed uses the three-tier network design commonly found in campus enterprise networks, with access, distribution, and core layers represented. In this example network, access switches (HP A5800 and Cisco Catalyst C3750-E) connect to distribution switches (HP E5406zl and Cisco Catalyst 4506), which in turn connect to core switches (HP A9505 and Cisco Catalyst 6509). For redundancy, multiple connections exist between switch layers.

Test engineers configured link aggregation between HP A5800 and HP E5406zl switches; between HP E5406zl and HP A9505 switches; between HP A9505 and Cisco Catalyst 6509 switches; between Cisco Catalyst 6509 and Cisco Catalyst 4506 switches; and between Cisco Catalyst 4506 and Cisco Catalyst 3750-E switches. The use of link aggregation is not mandatory, however.

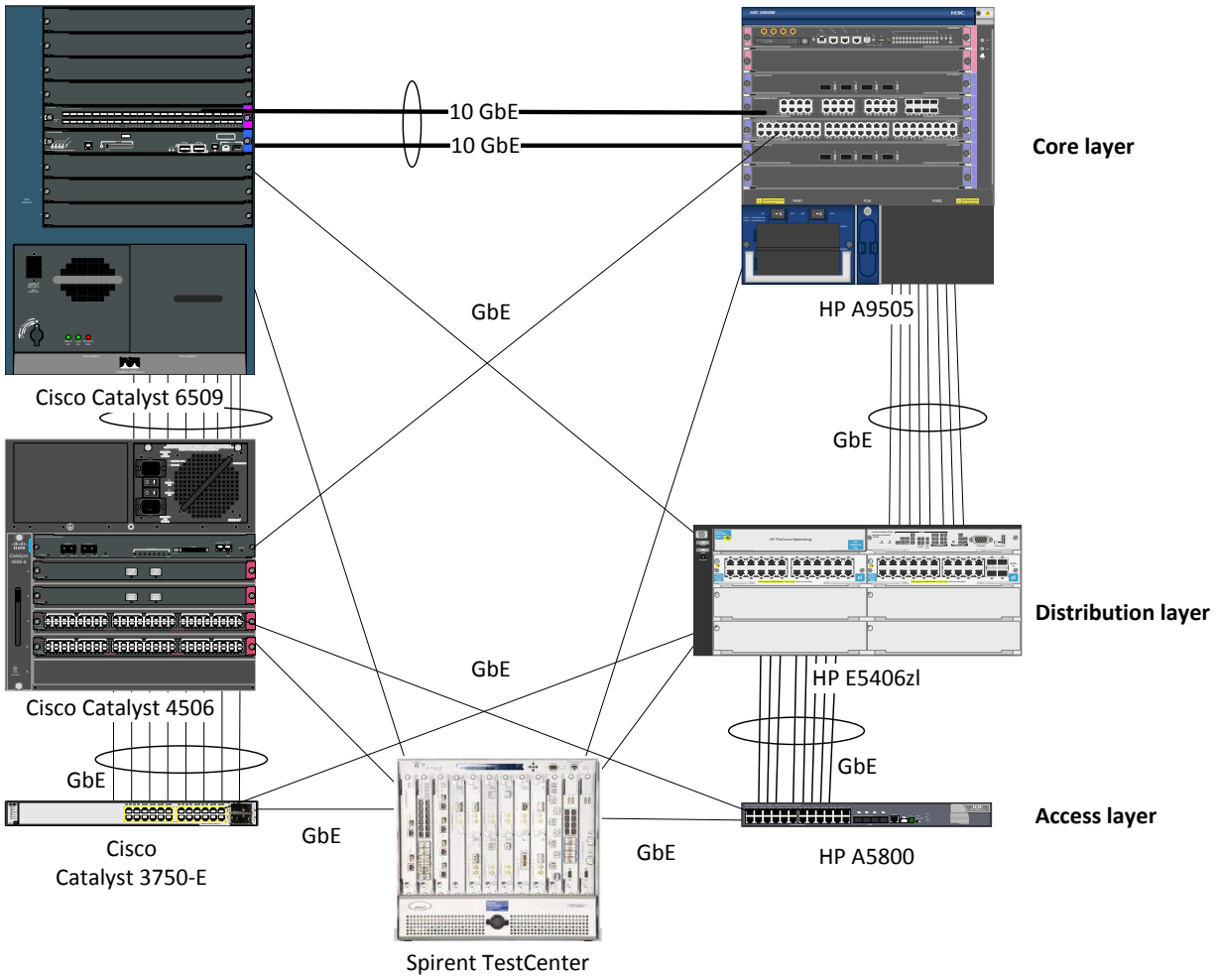


Figure 1: HP-Cisco interoperability test bed

## Virtual LAN (VLAN) trunking

### Objective

To verify interoperability of IEEE 802.1Q VLAN trunking between HP Networking and Cisco Catalyst switches using tagged traffic.

To verify interoperability of IEEE 802.1Q VLAN trunking between HP Networking and Cisco Catalyst switches using untagged traffic.

### Background

The IEEE 802.1Q specification defines a method of defining virtual broadcast domains. A 4-byte VLAN header, usually called a "tag," allows definition of broadcast domains that may differ from physical switch topology. With VLANs, all switch ports are members of the same broadcast domain; with VLAN tagging, a network manager can set up multiple broadcast domains across switches, and restrict broadcasts for different VLANs on different ports.

### Topology

This configuration example will validate VLAN trunking interoperability between HP Networking and Cisco Catalyst switches in three ways:

- The switches will forward allowed tagged traffic from multiple VLANs across a trunk port.
- The switches will forward allowed untagged traffic from a native VLAN across a trunk port.
- The switch will not forward disallowed tagged traffic across a trunk port.

The final example above is a negative test to verify that switches with VLAN trunking will forward only traffic explicitly permitted by the switch configurations.

This test used the standard test bed (see Figure 1, above). In this example, all interswitch communication is done via VLAN trunks. The trunk ports on each switch will allow tagged traffic with VLAN IDs from 301 through 303, and untagged traffic from ports with VLAN ID of 300. A fifth VLAN, with an ID of 304, is also defined by the trunk ports are configured not to allow that traffic.

## HP A-series commands

First, define VLANs 300 to 304.

```
<HP5800> system-view
[HP5800] vlan 300 to 304
```

Then, define a VLAN trunk port that allows tagged traffic from VLANs 301-303, and native untagged traffic on VLAN 300.

```
[HP5800] interface GigabitEthernet1/0/23
[HP5800-gigabitethernet1/0/23]  port link-mode bridge
[HP5800-gigabitethernet1/0/23]  port link-type trunk
[HP5800-gigabitethernet1/0/23]  undo port trunk permit vlan 1
[HP5800-gigabitethernet1/0/23]  port trunk permit vlan 300 to 303
[HP5800-gigabitethernet1/0/23]  port trunk pvid vlan 300
[HP5800-gigabitethernet1/0/23]  quit
```

Next, define access-mode interfaces allowing untagged traffic for VLANs 300-304.

```
[HP5800] interface GigabitEthernet1/0/1
[HP5800-Gigabitethernet1/0/1]  port link-mode bridge
[HP5800-Gigabitethernet1/0/1]  port access vlan 300
[HP5800-Gigabitethernet1/0/1] interface GigabitEthernet1/0/2
[HP5800-Gigabitethernet1/0/2]  port link-mode bridge
[HP5800-Gigabitethernet1/0/2]  port access vlan 301
[HP5800-Gigabitethernet1/0/2] interface GigabitEthernet1/0/3
[HP5800-Gigabitethernet1/0/3]  port link-mode bridge
[HP5800-Gigabitethernet1/0/3]  port access vlan 302
[HP5800-Gigabitethernet1/0/3] interface GigabitEthernet1/0/4
[HP5800-Gigabitethernet1/0/4]  port link-mode bridge
[HP5800-Gigabitethernet1/0/4]  port access vlan 303
[HP5800-Gigabitethernet1/0/4] interface GigabitEthernet1/0/5
[HP5800-Gigabitethernet1/0/5]  port link-mode bridge
[HP5800-Gigabitethernet1/0/5]  port access vlan 304
[HP5800-Gigabitethernet1/0/5]  quit
[HP5800]  quit
```

## HP E-series commands

HP E-series switches combine trunk creation, access ports, and VLAN assignment together into a single VLAN construct. A port that is a member of a single VLAN carrying only untagged traffic is an access port (ports A1-A5 in this example). A port that is a member of multiple VLANs that carries both tagged and untagged traffic is a VLAN trunk port (ports A9-A10 in this example). Here we define VLANs 300-304 and assign ports to them.

```
HP5406ZL# configure
HP5406ZL(config)# vlan 300
HP5406ZL(vlan-300)#    name "VLAN300"
HP5406ZL(vlan-300)#    untagged A1,A9-A10
HP5406ZL(vlan-300)#    ip address 10.1.2.1 255.255.0.0
HP5406ZL(vlan-300)#    exit
```

```
HP5406ZL(config)# vlan 301
HP5406ZL(vlan-301)#    name "VLAN301"
HP5406ZL(vlan-301)#    untagged A2
HP5406ZL(vlan-301)#    ip address 10.2.2.1 255.255.0.0
HP5406ZL(vlan-301)#    tagged A9-A10
HP5406ZL(vlan-301)#    exit
HP5406ZL(config)# vlan 302
HP5406ZL(vlan-302)#    name "VLAN302"
HP5406ZL(vlan-302)#    untagged A3
HP5406ZL(vlan-302)#    ip address 10.3.2.1 255.255.0.0
HP5406ZL(vlan-302)#    tagged A9-A10
HP5406ZL(vlan-302)#    exit
HP5406ZL(config)# vlan 303
HP5406ZL(vlan-303)#    name "VLAN303"
HP5406ZL(vlan-303)#    untagged A4
HP5406ZL(vlan-303)#    ip address 10.4.2.1 255.255.0.0
HP5406ZL(vlan-303)#    tagged A9-A10
HP5406ZL(vlan-303)#    exit
HP5406ZL(config)# vlan 304
HP5406ZL(vlan-304)#    name "VLAN304"
HP5406ZL(vlan-304)#    untagged A5
HP5406ZL(vlan-304)#    ip address 10.5.2.1 255.255.0.0
HP5406ZL(vlan-304)#    exit
HP5406ZL(config)#    exit
```

## Cisco commands

The following commands apply to a Cisco Catalyst 6509. The syntax is similar for the Catalyst 3750-E switches and Cisco Catalyst 4506 switches.

First, define VLANs 300 to 304.

```
Cat6509# configure terminal
Cat6509(config)# vlan 300-304
```

Then, define a VLAN trunk port that allows tagged traffic from VLANs 301-303, and native untagged traffic on 300.

```
Cat6509(config)# interface GigabitEthernet4/9
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport trunk encapsulation dot1q
Cat6509(config-if)#  switchport trunk native vlan 300
Cat6509(config-if)#  switchport trunk allowed vlan 300-303
Cat6509(config-if)#  switchport mode trunk
Cat6509(config-if)#  exit
```

Next, define access-mode interfaces allowing untagged traffic from VLANs 300-304.

```
Cat6509(config)# interface GigabitEthernet6/0/1
Cat6509(config-if)#  switchport access vlan 300
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)# interface GigabitEthernet6/0/2
```

```
Cat6509(config-if)#  switchport access vlan 301
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)# interface GigabitEthernet6/0/3
Cat6509(config-if)#  switchport access vlan 302
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)# interface GigabitEthernet6/0/4
Cat6509(config-if)#  switchport access vlan 303
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)# interface GigabitEthernet6/0/5
Cat6509(config-if)#  switchport access vlan 304
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  end
```

### Validation

The Spirent TestCenter traffic generator/analyzer can be configured to offer traffic between pairs of access-mode interfaces on each switch. In all cases – involving unicast, multicast, or broadcast traffic – traffic will stay local to the VLAN in which it is defined. For example, traffic offered to VLAN 300 on the HP switches will be forwarded only to interfaces in VLAN 300 on the Cisco switches and vice-versa.

If desired, port mirroring can be enabled on either HP or Cisco switches to verify that the trunk ports carry tagged traffic VLAN IDs 301-303 and untagged traffic for VLAN ID 300. As a final verification that VLANs limit broadcast domains, Spirent TestCenter can be configured to offer traffic on access ports with VLAN 304. The trunk ports on all switches will not forward this traffic.

## Jumbo frame switching

### Objective

To validate the ability of HP Networking and Cisco Catalyst switches to correctly forward bidirectional traffic consisting of jumbo frames.

### Background

For many years the IEEE Ethernet specification has defined the maximum length of an Ethernet frame to be 1,518 bytes (or 1,522 bytes with an 802.1Q VLAN tag). The use of jumbo frames – those larger than 1518 bytes – remains nonstandard. However, jumbo frames can improve the performance of applications involving bulk data transfer, such as backup and disaster recovery.

HP and Cisco switches both support 9,216-byte jumbo frames, including Ethernet CRC. This section explains how to configure both vendors' switches to exchange jumbo frames.

## Topology

In this example, the Spirent TestCenter traffic generator offers 9,216-byte jumbo Ethernet frames using a "partially meshed" topology, meaning all traffic offered to ports on HP switches are destined to ports on Cisco switches and visa-versa. VLAN trunk ports connect the switches and VLAN access ports at the edge accept untagged jumbo frames. However, the ability to switch jumbo frames does not depend on VLAN tagging. This example would also work with all interfaces passing untagged traffic.

Figure 2 below illustrates the configuration used to validate jumbo frame switching. This test deviates from the standard test bed by the removal of the link aggregation trunks between the Cisco Catalyst 4506 and the Cisco Catalyst 3750-E as well as the link aggregation trunk between the Cisco Catalyst 4506 and the Cisco Catalyst 6509. There is also no connection between the Cisco Catalyst 4506 and the Cisco Catalyst 6509. As noted in the configuration sections below, all interfaces explicitly support switching of jumbo frames. Engineers configured all interswitch trunks to use VLAN trunking, in this case carrying traffic from VLAN 300.

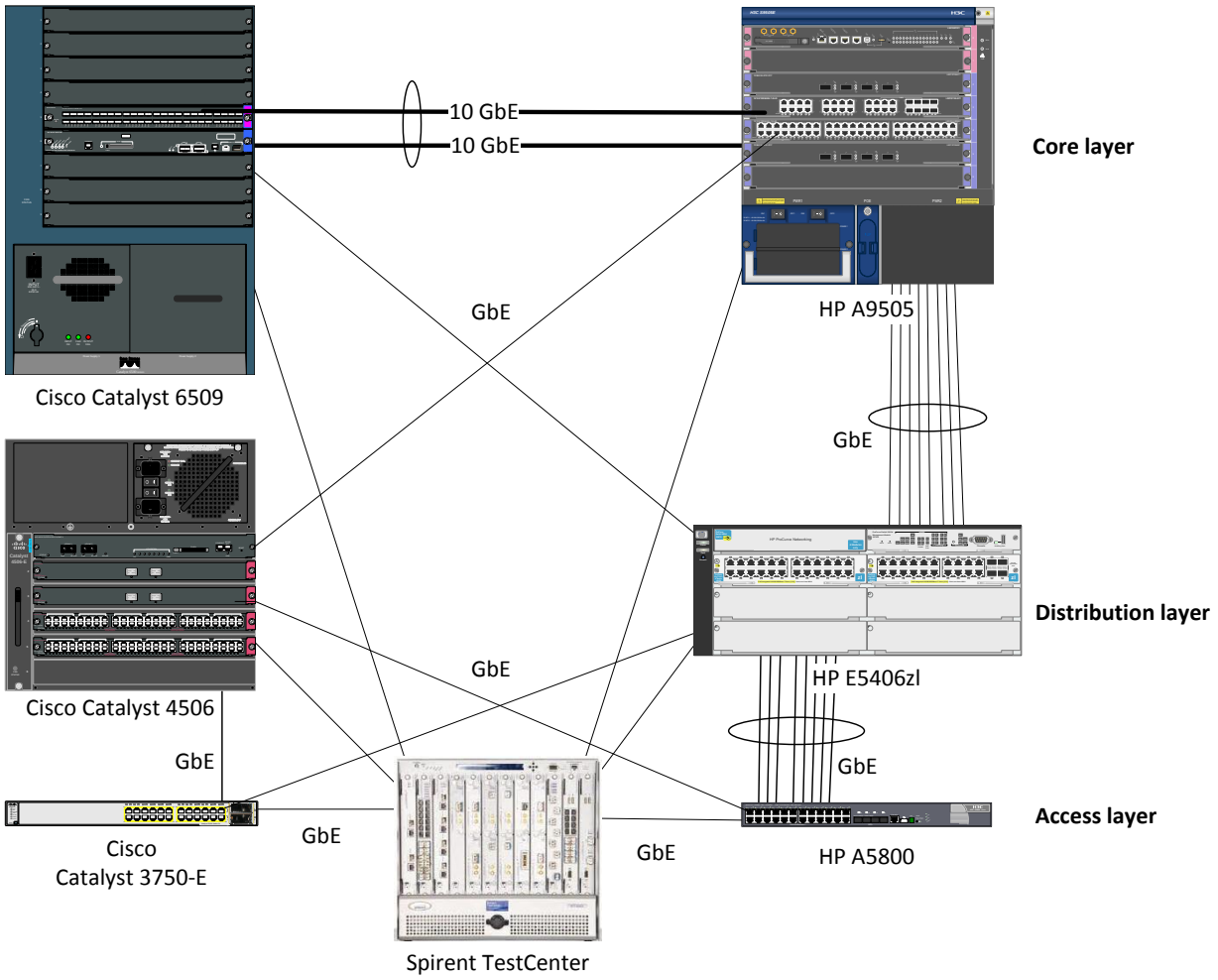


Figure 2: Jumbo frame switching test bed

## HP A-series commands

HP A-series switches have jumbo frames enabled by default. The following commands are used to explicitly set the maximum transmission unit (MTU). The MTU is set in the interface configuration context.

```
<HP5800> system-view
[HP5800] interface GigabitEthernet1/0/1
[HP5800-Gigabitethernet1/0/1] port link-mode bridge
[HP5800-Gigabitethernet1/0/1] jumboframe enable 9216
[HP5800-Gigabitethernet1/0/1] quit
[HP5800] quit
```

## HP E-series commands

HP E-series switches set the MTU on a per-VLAN basis. When enabled, all ports on that VLAN will forward jumbo frames.

```
HP5406ZL# configure
HP5406ZL(config)# vlan 300
HP5406ZL(vlan-300)#    name "VLAN306"
HP5406ZL(vlan-300)#    untagged A1-A5,A9-A10,Trk1-Trk2
HP5406ZL(vlan-300)#    ip address 10.1.2.1 255.255.0.0
HP5406ZL(vlan-300)#    jumbo
HP5406ZL(vlan-300)#      exit
HP5406ZL(config)#      exit
```

## Cisco commands

On Cisco Catalyst 6509 and Cisco Catalyst 4506 switches, jumbo frame support varies by line card. For line cards that support jumbo frames, MTU is set on a per-interface basis.

```
Cat6509# configure terminal
Cat6509(config)# interface GigabitEthernet4/48
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport access vlan 300
Cat6509(config-if)# switchport mode access
Cat6509(config-if)# mtu 9216
Cat6509(config-if)# end
```

On Cisco Catalyst 3750-E switches, MTU is set systemwide:

```
Cat3750E# configure terminal
Cat3750E(config)# system mtu jumbo 9216
Cat3750E(config)# end
```

## Validation

Generating jumbo frames between the attached clients and servers will validate the ability of the switches to exchange jumbo traffic. All switches will forward all jumbo frames with zero frame loss.

## Jumbo frame routing

### Objective

To validate the ability of HP Networking and Cisco Catalyst switches to correctly route bidirectional traffic consisting of jumbo frames.

### Background

Some routing protocols, such as open shortest path first (OSPF), require that both routers use the same MTU before exchanging routing information. For Ethernet interfaces, the requirement for matched MTUs applies equally to jumbo frames (those larger than 1518 bytes) as to standard-length frames.

HP Networking and Cisco Catalyst switches both support 9,216-byte jumbo frames, including Ethernet CRC. This section explains how to configure both vendors' devices to set up on an OSPF routing session using jumbo frames.

### Topology

In this example, the HP A9505, HP E5406zl, and HP A5800 switches are configured as OSPF routers exchanging jumbo frames with Cisco Catalyst 6509, Cisco Catalyst 4506, and Cisco Catalyst 3750-E switches.

Figure 3 below illustrates the configuration used to validate jumbo frame routing. This test deviates from the standard test bed by the removal of the link aggregation trunks between the Cisco Catalyst 4506 and the Cisco Catalyst 3750-E, and between the Cisco Catalyst 4506 and the Cisco Catalyst 6509. There is also no connection between the Cisco Catalyst 4506 and the Cisco Catalyst 6509. In addition, all devices routed traffic at layer 3 in this test. In this example, OSPF routing sessions are established between all connected devices.

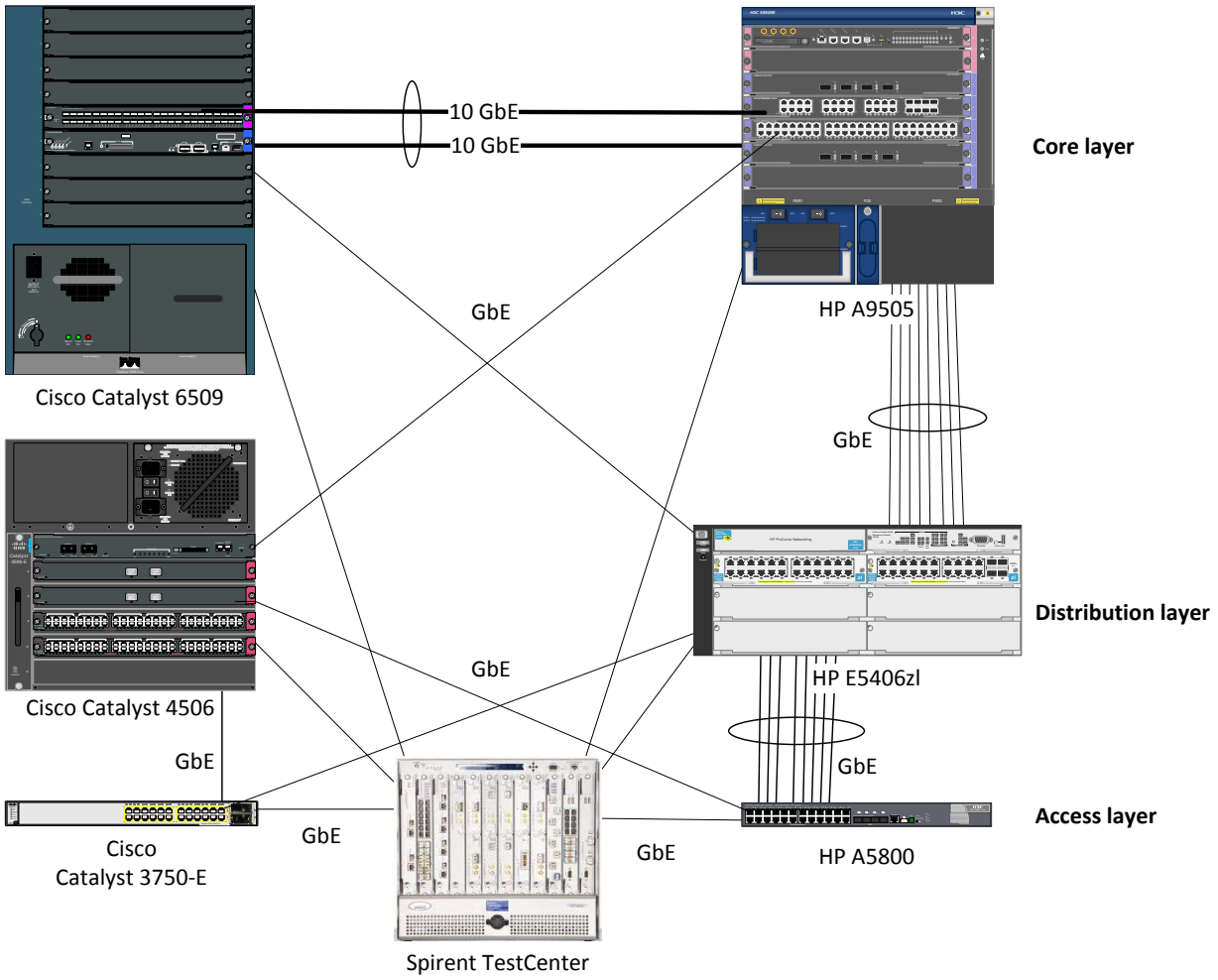


Figure 3: Jumbo frame routing test bed

## HP A-series commands

HP A-series switches have jumbo frames enabled by default. The following commands are used to set the jumbo frame MTU. The frame size is set in the interface configuration context.

```
<HP5800> system-view
[HP5800] interface GigabitEthernet1/0/1
[HP5800-Gigabitethernet1/0/1] port link-mode bridge
[HP5800-Gigabitethernet1/0/1] jumboframe enable 9216
[HP5800-Gigabitethernet1/0/1] quit
[HP5800] quit
```

Then OSPF is configured. In this example, the interface is a member of OSPF area 0.

```
[HP5800] ospf 1 router-id 10.0.0.1
[HP5800-OSPF] area 0.0.0.0
[HP5800-OSPF] network 10.0.0.0 0.0.255.255
[HP5800-OSPF] quit
```

## HP E-series commands

HP E-series switches set MTU on a per-VLAN basis. When enabled, all ports on that VLAN will forward jumbo frames.

```
HP5406ZL# configure
HP5406ZL(config)# vlan 300
HP5406ZL(vlan-300)#    name "VLAN306"
HP5406ZL(vlan-300)#    untagged A1-A5,A9-A10,Trk1-Trk2
HP5406ZL(vlan-300)#    ip address 10.1.2.1 255.255.0.0
HP5406ZL(vlan-300)#    jumbo
HP5406ZL(vlan-300)#      exit
```

Then set up OSPF routing. In our configuration, the VLAN interfaces were used as the routable interfaces. The **`area backbone`** command designates OSPF area 0.

```
HP5406(config)# ip routing
HP5406(config)# ip router-id 10.0.32.1
HP5406(config)# router ospf
HP5406(ospf)#    area backbone range 10.0.0.0 255.255.0.0 type summary
HP5406(ospf)#    exit
HP5406(config)# vlan 33
HP5406(vlan-33)#    ip ospf 10.0.33.1 area backbone
HP5406(vlan-33)#    exit
HP5406(config)# vlan 34
HP5406(vlan-34)#    ip ospf 10.0.34.1 area backbone
HP5406(vlan-34)#    exit
HP5406(config)# vlan 35
HP5406(vlan-35)#    ip ospf 10.0.35.1 area backbone
HP5406(vlan-35)#    exit
HP5406(config)# vlan 36
HP5406(vlan-36)#    ip ospf 10.0.36.1 area backbone
HP5406(vlan-36)#    exit
HP5406(config)# vlan 37
HP5406(vlan-37)#    ip ospf 10.0.37.1 area backbone
HP5406(vlan-37)#
HP5406(config)# vlan 38
HP5406(vlan-38)#    ip ospf 10.0.38.1 area backbone
HP5406(vlan-38)#    exit
HP5406(config)# vlan 39
HP5406(vlan-39)#    ip ospf 10.0.39.1 area backbone
HP5406(vlan-39)#    exit
HP5406(config)# vlan 40
HP5406(vlan-40)#    ip ospf 10.0.40.1 area backbone
HP5406(vlan-40)#    exit
HP5406(config)#    exit
```

## Cisco commands

On Cisco Catalyst 6509 and Cisco Catalyst 4506 switches, jumbo frame support varies by line card. For those line cards that support jumbo frames, MTU is set on a per-interface basis. Cisco

IOS has separate commands for **`mtu`**, describing the maximum transmission unit for the *Ethernet* frame and for the **`ip mtu`**, describing the MTU for the *IP packet*.

Configure the interface with a jumbo frame size.

```
Cat6509# configure terminal
Cat6509(config)# interface GigabitEthernet4/9
Cat6509(config-if)# ip address 10.0.42.2 255.255.255.0
Cat6509(config-if)# ip mtu 9198
Cat6509(config-if)# exit
```

Then set up OSPF.

```
Cat6509(config)# router ospf 1
Cat6509(config-router)#  log-adjacency-changes
Cat6509(config-router)#  network 10.0.0.0 0.0.255.255 area 0
Cat6509(config-router)#  exit
```

Then set up the VLAN for jumbo frames. This is required to route jumbo frames between VLANs. All interfaces in the VLAN must be set to allow jumbo frames before this command will take effect.

```
Cat6509(config)# interface Vlan193
Cat6509(config-if)# mtu 9216
Cat6509(config-if)#  end
```

On Cisco Catalyst 3750-E switches, MTU is set systemwide:

```
Cat3750E# configure terminal
Cat3750E(config)# system mtu jumbo 9216
Cat3750E(config)# system mtu routing 9198
Cat3750E(config)# router ospf 1
Cat3750E(config-router)#  log-adjacency-changes
Cat3750E(config-router)#  network 10.0.43.2 0.0.0.0 area 0
Cat3750E(config-router)#  network 10.0.75.2 0.0.0.0 area 0
Cat3750E(config-router)#  network 10.0.128.0 0.0.127.255 area 0
Cat3750E(config-router)#  network 192.168.1.0 0.0.0.255 area 0
Cat3750E(config-router)#  network 192.168.2.0 0.0.0.255 area 0
Cat3750E(config-router)#  end
```

## Validation

Unless both HP and Cisco interfaces agree on MTU size, OSPF routing adjacencies will remain in ExStart state, and will never transition to OSPF "full" state. To verify that an OSPF adjacency has entered OSPF "full" state on the HP A-series switches, use the **`display ospf peer`** command. To verify that an OSPF adjacency has entered OSPF "full" state on HP E-series and Cisco switches, use the **`show ip ospf neighbor`** command.

The fact that both routers are in Full state indicates they have agreed to exchange IP packets up to 9,198 bytes long (or 9,216 bytes, including Ethernet header and CRC). OSPF routing session establishment will not work unless both sides agree on MTU size.

## Link aggregation

### Objective

To validate the ability of HP Networking and Cisco Catalyst switches to correctly forward traffic over a logical connection created using IEEE 802.3ad link aggregation.

### Background

The IEEE 802.3ad link specification defines a standards-based method for aggregating multiple physical Ethernet links into a single logical link. The logical link, known as a link aggregation group (LAG), is comprised of multiple *members* (pairs of physical interfaces on each switch). LAGs may be defined statically or dynamically, the latter using the link aggregation control protocol (LACP). With LACP enabled, 802.3ad-compliant switches can dynamically add or remove up to eight LAG members.

Link aggregation is useful both for increasing bandwidth beyond the limits of single physical interfaces and, especially when used with LACP, for adding redundancy to network connections.

### Topology

In this example, an HP A9505 switch uses two-member LAGs to exchange traffic with a Cisco Catalyst 6509 switch and a Cisco Catalyst 4506 switch. An HP E5406zl switch uses two-member LAGs to exchange traffic with a Cisco Catalyst 6509 switch and a Cisco Catalyst 3750-E switch. An HP A5800 switch uses two-member LAGs to exchange traffic with a Cisco Catalyst 4506 switch.

Figure 4 below shows the topology used to validate link aggregation and LACP functionality. This test deviates from the standard test bed with the additional of several link aggregation groups between the HP E5406zl and the Cisco Catalyst 3750-E, between the HP 5406zl and the Cisco Catalyst 6509, between the HP A9505 and the Cisco Catalyst 4506, and between the HP 5800 and the Cisco C5406. Other connections have been removed between the HP 5406zl and the HP 5800, between the HP 5406zl and HP 9505, between the Cisco Catalyst 3750-E and the Cisco Catalyst 4506, and between the Cisco Catalyst 4506 and the Cisco Catalyst 6509.

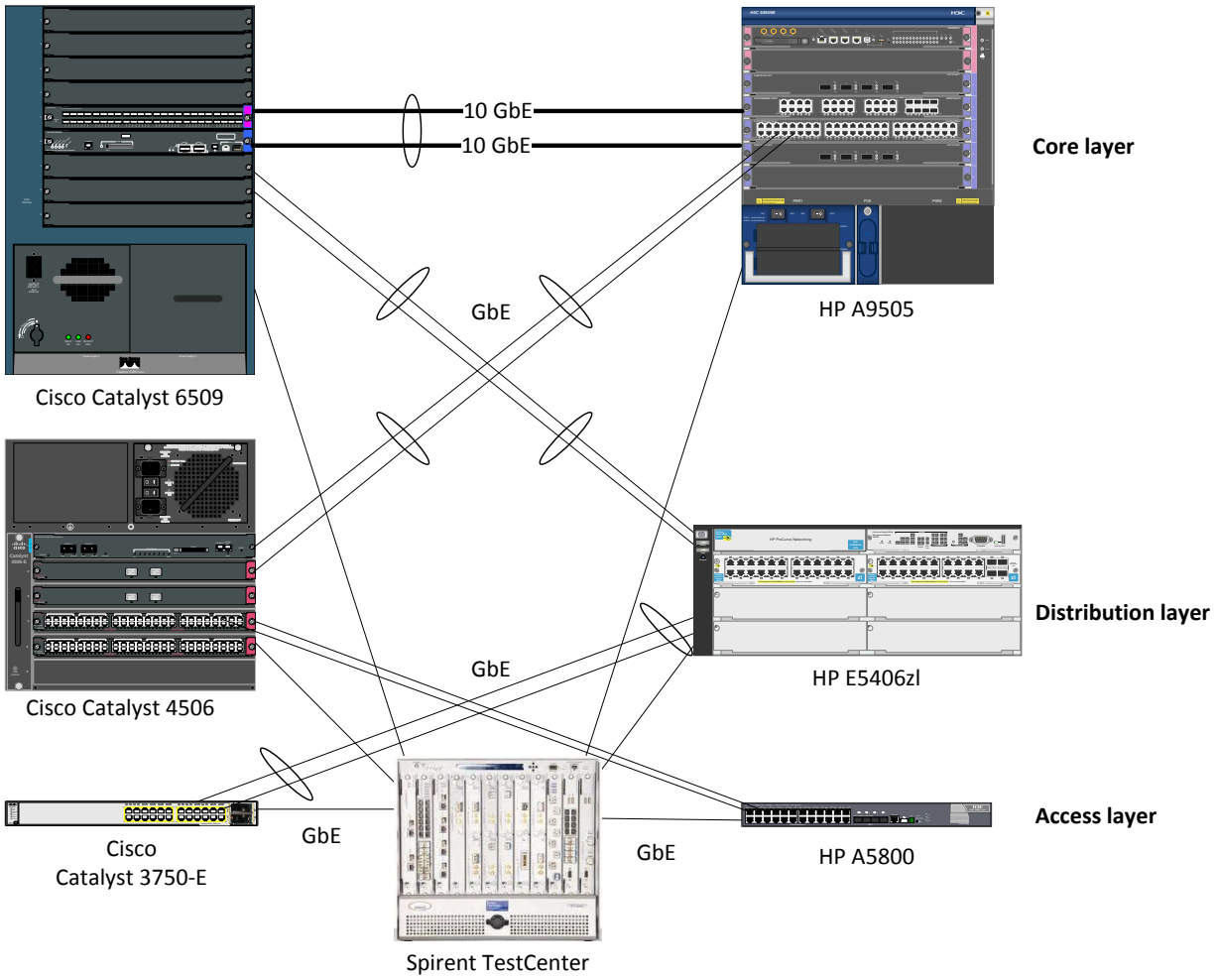


Figure 4: Link aggregation test bed

## HP A-series commands

On these HP switches, link aggregation is a two-step process. First a virtual *bridge aggregation* interface is created. Then physical interfaces are associated with the virtual bridge interface. While this example involves a VLAN trunk, a common use of link aggregation, it is not a requirement.

Create the bridge aggregation interface.

```
<HP5800> system-view
[HP5800] interface Bridge-Aggregation31
[HP5800-bridge-aggregation31]  description linkagg_to_4506
[HP5800-bridge-aggregation31]  port link-type trunk
[HP5800-bridge-aggregation31]  undo port trunk permit vlan 1
[HP5800-bridge-aggregation31]  port trunk permit vlan 300 to 303
[HP5800-bridge-aggregation31]  port trunk pvid vlan 300
```

```
[HP5800-bridge-aggregation31]  link-aggregation mode dynamic
[HP5800-bridge-aggregation31]
          link-aggregation load-sharing mode destination-mac source-mac
[HP5800-bridge-aggregation31] quit
```

Then assign physical interfaces to the bridge aggregation virtual interface.

```
[HP5800] interface GigabitEthernet1/0/17
[HP5800-gigabitethernet1/0/17]  port link-mode bridge
[HP5800-gigabitethernet1/0/17]  port link-type trunk
[HP5800-gigabitethernet1/0/17]  undo port trunk permit vlan 1
[HP5800-gigabitethernet1/0/17]  port trunk permit vlan 300 to 303
[HP5800-gigabitethernet1/0/17]  port trunk pvid vlan 300
[HP5800-gigabitethernet1/0/17]  port link-aggregation group 31
[HP5800-gigabitethernet1/0/17] interface GigabitEthernet1/0/18
[HP5800-gigabitethernet1/0/18]  port link-mode bridge
[HP5800-gigabitethernet1/0/18]  port link-type trunk
[HP5800-gigabitethernet1/0/18]  undo port trunk permit vlan 1
[HP5800-gigabitethernet1/0/18]  port trunk permit vlan 300 to 303
[HP5800-gigabitethernet1/0/18]  port trunk pvid vlan 300
[HP5800-gigabitethernet1/0/18]  port link-aggregation group 31
[HP5800-gigabitethernet1/0/18]  quit
[HP5800]  quit
```

## HP E-series commands

HP E-series switches create *trunks* to support LACP. A single command creates the trunk and assigns physical members to the trunk.

```
HP5406ZL# configure
HP5406ZL(config)# trunk A9,A12 Trk31 LACP
HP5406ZL(config)# exit
```

## Cisco commands

Cisco Catalyst switches, like HP A-series switches, perform a two-step process to create a *Port Channel*. The following commands apply to a Cisco Catalyst 6509. The syntax is similar for the Catalyst 3750-E switches and Cisco Catalyst 4506 switches.

First, create the link aggregation group. Here we also create a VLAN trunk.

```
Cat6509# configure terminal
Cat6509(config)# interface Port-channel1
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport trunk encapsulation dot1q
Cat6509(config-if)#  switchport trunk native vlan 300
Cat6509(config-if)#  switchport trunk allowed vlan 300-303
Cat6509(config-if)#  switchport mode trunk
```

```
Cat6509(config-if)#  exit
```

Next, add interfaces to the link aggregation group. The command **channel-group 1** adds an interface to the link aggregation group created in the previous step, while **mode active** enables LACP.

```
Cat6509(config-)# interface GigabitEthernet4/1
Cat6509(config-if)# no ip address
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk native vlan 300
Cat6509(config-if)# switchport trunk allowed vlan 300-303
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)#`channel-group 1 mode active
Cat6509(config)# interface GigabitEthernet4/3
Cat6509(config-if)# no ip address
Cat6509(config-if)# switchport
Cat6509(config-if)# switchport trunk encapsulation dot1q
Cat6509(config-if)# switchport trunk native vlan 300
Cat6509(config-if)# switchport trunk allowed vlan 300-303
Cat6509(config-if)# switchport mode trunk
Cat6509(config-if)# channel-group 1 mode active
Cat6509(config-if)# end
```

### Validation

The command **display link-aggregation summary** on HP A-series switches will show the status of the bridge aggregation interfaces. On HP E-series switches, the **show lacp** command will verify correct operation.

The correct operation of a LAG can with two or more members also can be verified by offering traffic at a rate higher than any single LAG member can carry. If the switch forwards all traffic across the LAG without loss, the LAG is operating properly.

## Spanning tree case 1: RSTP/Rapid-PVST+

### Objective

To verify interoperability of a rapid spanning tree topology between HP Networking and Cisco Catalyst switches using RSTP and Rapid-PVST+.

To measure convergence time of a rapid spanning tree topology between HP and Cisco after a link failure.

## Background

The spanning tree protocol is widely used in campus enterprise networks for loop prevention and redundancy. Rapid spanning tree, defined in IEEE 802.1w, provides much faster convergence time after a link or device failure than the original 802.1D spanning tree specification

## Topology

This example uses redundant paths between HP Networking and Cisco Catalyst switches. The default spanning tree mode in Cisco Catalyst switches is that vendor's proprietary per-VLAN spanning tree plus (PVST+) mode, which is interoperable with other vendors' rapid spanning tree implementations.

Figure 1 above shows the RSTP validation test bed. All ports on all switches are access-mode members of the default VLAN. Rapid spanning is enabled on all the HP switches. Cisco's "Rapid-PVST+" is enabled on all the Cisco switches and is interoperable with standard rapid spanning tree. Traffic offered from the Spirent TestCenter generator/analysis verifies the spanning tree topology.

## HP A-series commands

Assign all members to be access-mode members of the default VLAN. Here is the command for interface GigabitEthernet1/0/6; the same command would apply to all interfaces participating in the spanning tree topology.

```
<HP5800> system view
[HP5800] interface GigabitEthernet1/0/6
[HP5800-Gigabitethernet1/0/6] port link-mode bridge
[HP5800-Gigabitethernet1/0/6] quit
```

Then enable rapid spanning tree on the HP A-series switches.

```
<HP5800> system-view
[HP5800] stp mode rstp
[HP5800] stp enable
[HP5800] quit
```

## HP E-series commands

On HP E-series switches, by default all members are access-mode members of the default VLAN and therefore no per-interface command needs to be done.

Enable rapid spanning tree on the HP E-series switches.

```
HP5406ZL# configure
HP5406ZL(config)# spanning-tree
HP5406ZL(config)# spanning-tree priority 9 force-version rstp-operation
HP5406ZL(config)# exit
```

## Cisco commands

First, assign all members to be access-mode members of the default VLAN. The following commands apply to a Cisco Catalyst 6509. The syntax is similar for Cisco Catalyst 3750-E and Cisco Catalyst 4506 switches.

Here is the command for interface GigabitEthernet6/0/3; the same command would apply to all interfaces participating in the spanning tree topology.

```
Cat6509# configure terminal
Cat6509(config)# interface GigabitEthernet6/0/3
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  exit
```

Then enable rapid-pvst mode on the Cisco switches.

```
Cat6509(config)# spanning-tree mode rapid-pvst
Cat6509(config)# end
```

## Validation

HP A-series switches can use the command **`display stp brief`** to verify the state of rapid spanning tree.

```
<A9505>display stp br
 MSTID      Port                        Role  STP State     Protection
   0        Bridge-Aggregation10        ROOT  FORWARDING    NONE
   0        Bridge-Aggregation20        DESI  FORWARDING    NONE
   0        GigabitEthernet3/0/11       ALTE  DISCARDING    NONE
   0        GigabitEthernet3/0/16       DESI  FORWARDING    NONE
```

HP E-series switches uses the command **`show spanning-tree`** to display spanning-tree state.

```
E5406zl# show spanning-tree

 Multiple Spanning Tree (MST) Information

  STP Enabled   : Yes
  Force Version : RSTP-operation
…

                  |           Prio            | Designated    Hello
  Port   Type     | Cost      rity State      | Bridge        Time PtP Edge
  ------ --------- + --------- ---- ---------- + ------------- ---- --- ----
  A1     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A2     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A3     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A4     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A5     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A6     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A7     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A8     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A9     100/1000T | 20000     128  Blocking   | 001de6-eb7001 2    Yes No
  A10    100/1000T | 20000     128  Blocking   | 002155-740000 2    Yes No
…

  E2     10GbE-CX4 | 2000      128  Forwarding | 001560-f56200 2    Yes Yes
  F1     10GbE-CX4 | 2000      128  Forwarding | 001560-f56200 2    Yes Yes
  F2     10GbE-CX4 | 2000      128  Forwarding | 001560-f56200 2    Yes Yes
  Trk1             | 20000     64   Blocking   | 002389-11d000 2    Yes No
  Trk2             | 20000     64   Forwarding | 000fe2-f3e292 2    Yes No
```

To verify all switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames from Spirent TestCenter or other source and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames.

To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames from Spirent TestCenter or other traffic generator. Convergence time can be derived from frame loss. For example, if Spirent TestCenter generates traffic at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then rapid spanning tree convergence time is 47 ms.

## Spanning tree case 2: MSTP/PVST+

### Objective

To verify interoperability of multiple spanning tree protocol (MSTP) and per-vlan spanning tree protocol plus (PVST+) between HP Networking and Cisco Catalyst switches, respectively.

To measure convergence time of an MSTP-PVST+ topology between HP Networking and Cisco Catalyst switches after a link failure.

### Background

As defined in IEEE specification 802.1s, the multiple spanning tree protocol (MSTP) adds loop prevention and redundancy on a per-VLAN basis. With MSTP, individual spanning tree topologies can be configured for each VLAN.

The goal of this exercise is to demonstrate interoperability in a multiple-VLAN environment when the HP Networking and Cisco Catalyst switches use different variations of spanning tree: MSTP on HP and PVST+ on a Cisco Catalyst switch.

### Topology

This example uses redundant paths between the HP Networking and Cisco Catalyst switches. VLAN Ids of 300 to 304 have been defined on all switches. MSTP is enabled on all the HP switches, and Rapid PVST+ is enabled on all the Cisco switches.

Figure 1 above illustrates the MSTP-PVST+ validation test bed. The links interconnecting each switch are trunk ports that allow tagged traffic from VLAN IDs 300 to 304. Access ports were configured on the access layer switches, with one port assigned to each VLAN. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology in each VLAN.

### HP A-series commands

Create VLAN IDs 300 to 304.

```
<HP5800> system-view
[HP5800] vlan 300 to 304
```

Configure access-mode ports for their respective VLANs.

```
[HP5800] interface GigabitEthernet1/0/1
[HP5800-Gigabitethernet1/0/1]  port link-mode bridge
[HP5800-Gigabitethernet1/0/1]  port access vlan 300
[HP5800-Gigabitethernet1/0/1] interface GigabitEthernet1/0/2
[HP5800-Gigabitethernet1/0/2]  port link-mode bridge
[HP5800-Gigabitethernet1/0/2]  port access vlan 301
[HP5800-Gigabitethernet1/0/2] interface GigabitEthernet1/0/3
[HP5800-Gigabitethernet1/0/3]  port link-mode bridge
[HP5800-Gigabitethernet1/0/3]  port access vlan 302
[HP5800-Gigabitethernet1/0/3] interface GigabitEthernet1/0/4
[HP5800-Gigabitethernet1/0/4]  port link-mode bridge
[HP5800-Gigabitethernet1/0/4]  port access vlan 303
[HP5800-Gigabitethernet1/0/4] interface GigabitEthernet1/0/5
[HP5800-Gigabitethernet1/0/5]  port link-mode bridge
[HP5800-Gigabitethernet1/0/5]  port access vlan 304
```

Configure interswitch connections as trunk ports. Here is interface GigabitEthernet1/0/23 as an example.

```
[HP5800] interface GigabitEthernet1/0/23
[HP5800-Gigabitethernet1/0/23]  port link-mode bridge
[HP5800-Gigabitethernet1/0/23]  port link-type trunk
[HP5800-Gigabitethernet1/0/23]  undo port trunk permit vlan 1
[HP5800-Gigabitethernet1/0/23]  port trunk permit vlan 300 to 303
[HP5800-Gigabitethernet1/0/23]  port trunk pvid vlan 300
[HP5800-Gigabitethernet1/0/23]  quit
```

Enable multiple spanning tree. This requires enabling MSTP (the default on HP A-series switches) and configuring one multiple spanning tree instance per VLAN.

```
[HP5800] stp enable
[HP5800] stp region-configuration
[HP5800-mst-region]  instance 2 vlan 300
[HP5800-mst-region]  instance 3 vlan 301
[HP5800-mst-region]  instance 4 vlan 302
[HP5800-mst-region]  instance 5 vlan 303
[HP5800-mst-region]  instance 6 vlan 304
[HP5800-mst-region]  active region-configuration
[HP5800-mst-region]  quit
[HP5800]  quit
```

## HP E-series commands

Create the VLANs and assign physical interfaces to them. Interfaces that have both untagged (access ports) and tagged VLAN IDs are VLAN trunks.

```
HP5406ZL# configure
HP5406ZL(config)# vlan 300
HP5406ZL(vlan-300)#    name "VLAN300"
HP5406ZL(vlan-300)#    untagged A1,A9-A10
HP5406ZL(vlan-300)#    ip address 10.1.2.1 255.255.0.0
HP5406ZL(vlan-300)#    exit
```

```
HP5406ZL(config)# vlan 301
HP5406ZL(vlan-300)#    name "VLAN301"
HP5406ZL(vlan-300)#    untagged A2
HP5406ZL(vlan-300)#    ip address 10.2.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(config)#    exit
HP5406ZL(vlan-300)# vlan 302
HP5406ZL(vlan-300)#    name "VLAN302"
HP5406ZL(vlan-300)#    untagged A3
HP5406ZL(vlan-300)#    ip address 10.3.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(vlan-300)#    exit
HP5406ZL(config)# vlan 303
HP5406ZL(vlan-300)#    name "VLAN303"
HP5406ZL(vlan-300)#    untagged A4
HP5406ZL(vlan-300)#    ip address 10.4.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(vlan-300)#    exit
HP5406ZL(config)# vlan 304
HP5406ZL(vlan-300)#    name "VLAN304"
HP5406ZL(vlan-300)#    untagged A5
HP5406ZL(vlan-300)#    ip address 10.5.2.1 255.255.0.0
HP5406ZL(vlan-300)#    exit
```

Create the MSTP instances, and assign one VLAN to each instance.

```
HP5406ZL(config)# spanning-tree
HP5406ZL(config)# spanning-tree instance 2 vlan 300
HP5406ZL(config)# spanning-tree instance 3 vlan 301
HP5406ZL(config)# spanning-tree instance 4 vlan 302
HP5406ZL(config)# spanning-tree instance 5 vlan 303
HP5406ZL(config)# spanning-tree instance 6 vlan 304
HP5406ZL(config)# spanning-tree priority 9
HP5406ZL(config)# exit
```

## Cisco commands

The following commands apply to a Cisco Catalyst 3750-E switch. The syntax is similar for the Cisco Catalyst 6509 and Cisco Catalyst 4506 switches.

Create the VLANs.

```
Cat3750E# configure terminal
Cat3750E(config)# vlan 300-304
```

Configure access-mode ports for their respective VLANs.

```
Cat3750E(config)# interface GigabitEthernet6/0/1
Cat3750E(config)#  switchport
Cat3750E(config-if)#  switchport access vlan 300
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
```

```
Cat3750E(config-if)# interface GigabitEthernet6/0/2
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 301
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/3
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 302
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/4
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 303
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/5
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 304
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)#  exit
```

Configure interswitch connections as trunk ports. Here is interface GigabitEthernet6/0/10 as an example.

```
Cat3750E(config)# interface GigabitEthernet6/0/10
Cat3750E(config-if)#  switchport trunk encapsulation dot1q
Cat3750E(config-if)#  switchport trunk native vlan 300
Cat3750E(config-if)#  switchport trunk allowed vlan 300-303
Cat3750E(config-if)#  switchport mode trunk
Cat3750E(config-if)#  exit
```

Enable PVST+. On a new switch, PVST+ already is enabled by default.

```
Cat3750E(config)# spanning-tree mode pvst
Cat3750E(config)# end
```

## Validation

HP A-series switches can use the command **`display stp brief`** to verify the state of spanning tree on HP A-series switches.

```
<A9505>display stp brief
 MSTID      Port                        Role  STP State     Protection
   0        Bridge-Aggregation10        DESI  FORWARDING    NONE
   0        Bridge-Aggregation20        ROOT  FORWARDING    NONE
   0        GigabitEthernet3/0/11       DESI  FORWARDING    NONE
   0        GigabitEthernet3/0/16       DESI  FORWARDING    NONE
   2        Bridge-Aggregation10        DESI  FORWARDING    NONE
   2        Bridge-Aggregation20        MAST  FORWARDING    NONE
   2        GigabitEthernet3/0/11       DESI  FORWARDING    NONE
   3        Bridge-Aggregation10        DESI  FORWARDING    NONE
```

```
  3        Bridge-Aggregation20         MAST  FORWARDING    NONE
  3        GigabitEthernet3/0/11        DESI  FORWARDING    NONE
  4        Bridge-Aggregation10         DESI  FORWARDING    NONE
  4        Bridge-Aggregation20         MAST  FORWARDING    NONE
  4        GigabitEthernet3/0/11        DESI  FORWARDING    NONE
  5        Bridge-Aggregation10         DESI  FORWARDING    NONE
  5        Bridge-Aggregation20         MAST  FORWARDING    NONE
  5        GigabitEthernet3/0/11        DESI  FORWARDING    NONE
```

HP E-Series uses the command **`show spanning-tree`** to display the state of spanning tree on HP E-Series switches.

```
E5406zl# show spanning-tree

 Multiple Spanning Tree (MST) Information

  STP Enabled   : Yes
  Force Version : MSTP-operation
…
                  |           Prio            | Designated    Hello
  Port   Type     | Cost      rity State      | Bridge        Time PtP Edge
  ------ --------- + --------- ---- ---------- + ------------- ---- --- ----
  A1     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A2     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A3     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A4     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A5     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A6     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A7     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A8     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A9     100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
  A10    100/1000T | 20000     128  Forwarding | 001560-f56200 2    Yes Yes
…
  E2     10GbE-CX4 | 2000      128  Forwarding | 001560-f56200 2    Yes Yes
  F1     10GbE-CX4 | 2000      128  Forwarding | 001560-f56200 2    Yes Yes
  F2     10GbE-CX4 | 2000      128  Forwarding | 001560-f56200 2    Yes Yes
  Trk1             | 20000     64   Forwarding | 001560-f56200 2    Yes No
  Trk2             | 20000     64   Forwarding | 000fe2-f3e292 2    Yes No
```

To verify all switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames from Spirent TestCenter or other source to each VLAN and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames.

To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames from Spirent TestCenter or other traffic generator. Convergence time can be derived from frame loss. For example, if Spirent TestCenter generates

traffic at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then spanning tree convergence time is 47 ms.

## Spanning tree case 3: MSTP/Rapid-PVST+

### Objective

To verify interoperability of multiple spanning tree protocol (MSTP) and rapid per-VLAN spanning tree protocol plus (Rapid PVST+) between HP Networking and Cisco Catalyst switches, respectively.

To measure convergence time of an MSTP-Rapid PVST+ topology between HP Networking and Cisco Catalyst switches after a link failure.

### Background

As defined in IEEE specification 802.1s, the multiple spanning tree protocol (MSTP) adds loop prevention and redundancy on a per-VLAN basis. With MSTP, individual spanning tree topologies can be configured for each VLAN.

The goal of this exercise is to demonstrate interoperability in a multiple-VLAN environment when the HP Networking and Cisco Catalyst switches use different variations of spanning tree: MSTP on HP switches and Rapid PVST+ on Cisco Catalyst switches.

### Topology

This example uses redundant paths between the HP Networking and Cisco Catalyst switches. VLAN Ids of 300 to 304 have been defined on all switches. MSTP is enabled on all HP switches, with Rapid PVST+ defined on all Cisco switches.

Figure 1 above illustrates the MSTP-Rapid PVST+ validation test bed. The links interconnecting each switch are trunk ports that allow tagged traffic from the VLAN IDs 300 to 304. Access ports were configured on the access layer switches, with one port per vlan being configured. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology in each VLAN.

## HP A-series commands

Create VLAN IDs 300 to 304.

```
<HP5800> system-view
[HP5800] vlan 300 to 304
```

Configure access-mode ports for their respective VLANs.

```
[HP5800] interface GigabitEthernet1/0/1
[HP5800-Gigabitethernet1/0/1]  port link-mode bridge
[HP5800-Gigabitethernet1/0/1]  port access vlan 300
[HP5800-Gigabitethernet1/0/1] interface GigabitEthernet1/0/2
[HP5800-Gigabitethernet1/0/2]  port link-mode bridge
[HP5800-Gigabitethernet1/0/2]  port access vlan 301
[HP5800-Gigabitethernet1/0/2] interface GigabitEthernet1/0/3
[HP5800-Gigabitethernet1/0/3]  port link-mode bridge
[HP5800-Gigabitethernet1/0/3]  port access vlan 302
[HP5800-Gigabitethernet1/0/3] interface GigabitEthernet1/0/4
[HP5800-Gigabitethernet1/0/4]  port link-mode bridge
[HP5800-Gigabitethernet1/0/4]  port access vlan 303
[HP5800-Gigabitethernet1/0/4] interface GigabitEthernet1/0/5
[HP5800-Gigabitethernet1/0/5]  port link-mode bridge
[HP5800-Gigabitethernet1/0/5]  port access vlan 304
[HP5800-Gigabitethernet1/0/5]  quit
```

Configure interswitch connections as trunk ports. Here is interface GigabitEthernet1/0/23 as an example.

```
[HP5800] interface GigabitEthernet1/0/23
[HP5800-Gigabitethernet1/0/23]  port link-mode bridge
[HP5800-Gigabitethernet1/0/23]  port link-type trunk
[HP5800-Gigabitethernet1/0/23]  undo port trunk permit vlan 1
[HP5800-Gigabitethernet1/0/23]  port trunk permit vlan 300 to 303
[HP5800-Gigabitethernet1/0/23]  port trunk pvid vlan 300
[HP5800-Gigabitethernet1/0/23]  quit
```

Enable multiple spanning tree. This requires enable MSTP (the default on HP switches) and configuring one multiple spanning tree instance per VLAN.

```
[HP5800] stp enable
[HP5800] stp region-configuration
[HP5800-mst-region]  instance 2 vlan 300
[HP5800-mst-region]  instance 3 vlan 301
[HP5800-mst-region]  instance 4 vlan 302
[HP5800-mst-region]  instance 5 vlan 303
[HP5800-mst-region]  instance 6 vlan 304
[HP5800-mst-region]  active region-configuration
[HP5800-mst-region]  quit
[HP5800]  quit
```

## HP E-series commands

Create the VLANs and assign physical interfaces to them. Interfaces that have both untagged (access ports) and tagged VLAN IDs are VLAN trunks.

```
HP5406ZL# configure
HP5406ZL(config)# vlan 300
HP5406ZL(vlan-300)#    name "VLAN300"
HP5406ZL(vlan-300)#    untagged A1,A9-A10
HP5406ZL(vlan-300)#    ip address 10.1.2.1 255.255.0.0
HP5406ZL(vlan-300)#    exit
HP5406ZL(config)# vlan 301
HP5406ZL(vlan-300)#    name "VLAN301"
HP5406ZL(vlan-300)#    untagged A2
HP5406ZL(vlan-300)#    ip address 10.2.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(config)#    exit
HP5406ZL(vlan-300)# vlan 302
HP5406ZL(vlan-300)#    name "VLAN302"
HP5406ZL(vlan-300)#    untagged A3
HP5406ZL(vlan-300)#    ip address 10.3.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(vlan-300)#    exit
HP5406ZL(config)# vlan 303
HP5406ZL(vlan-300)#    name "VLAN303"
HP5406ZL(vlan-300)#    untagged A4
HP5406ZL(vlan-300)#    ip address 10.4.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(vlan-300)#    exit
HP5406ZL(config)# vlan 304
HP5406ZL(vlan-300)#    name "VLAN304"
HP5406ZL(vlan-300)#    untagged A5
HP5406ZL(vlan-300)#    ip address 10.5.2.1 255.255.0.0
HP5406ZL(vlan-300)#    exit
```

Create the multiple spanning tree protocol instances, and assign one VLAN to each instance.

```
HP5406ZL(config)# spanning-tree
HP5406ZL(config)# spanning-tree instance 2 vlan 300
HP5406ZL(config)# spanning-tree instance 3 vlan 301
HP5406ZL(config)# spanning-tree instance 4 vlan 302
HP5406ZL(config)# spanning-tree instance 5 vlan 303
HP5406ZL(config)# spanning-tree instance 6 vlan 304
HP5406ZL(config)# spanning-tree priority 9tree instance 2 vlan 300
HP5406ZL(config)# spanning-tree instance 3 vlan 301
HP5406ZL(config)# spanning-tree instance 4 vlan 302
HP5406ZL(config)# spanning-tree instance 5 vlan 303
HP5406ZL(config)# spanning-tree instance 6 vlan 304
HP5406ZL(config)# spanning-tree priority 9
```

## Cisco commands

The following commands apply to a Cisco Catalyst 3750-E switch. The syntax is similar for the Catalyst 6509 switches and Cisco Catalyst 4506 switches.

Create the VLANs.

```
Cat3750E# configure terminal
Cat3750E(config)# vlan 300-304
```

Configure access-mode ports for the respective VLANs.

```
Cat3750E(config)# interface GigabitEthernet6/0/1
Cat3750E(config)#  switchport
Cat3750E(config-if)#  switchport access vlan 300
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/2
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 301
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/3
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 302
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/4
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 303
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/5
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 304
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)#  exit
```

Configure interswitch connections as trunk ports. Here is interface GigabitEthernet6/0/10.

```
Cat3750E(config)# interface GigabitEthernet6/0/10
Cat3750E(config-if)#  switchport trunk encapsulation dot1q
Cat3750E(config-if)#  switchport trunk native vlan 300
Cat3750E(config-if)#  switchport trunk allowed vlan 300-303
Cat3750E(config-if)#  switchport mode trunk
Cat3750E(config-if)#  exit
```

Enable Rapid PVST+.

```
Cat3750E(config)# spanning-tree mode rapid-pvst
Cat3750E(config)# end
```

### Validation

HP A-series switches can use the command **`display stp brief`** to verify the state of spanning tree on HP A-series switches. HP E-series uses the command **`show spanning-tree`** to display the state of spanning tree on HP E-series switches.

To verify switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames from Spirent TestCenter to each VLAN and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames.

To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames from Spirent TestCenter or other traffic generator. Convergence time can be derived from frame loss. For example, if Spirent TestCenter generates traffic at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then spanning tree convergence time is 47 ms.

## Spanning tree case 4: MSTP/MSTP

### Objective

To verify interoperability of a multiple spanning tree topology between HP Networking and Cisco Catalyst switches.

To measure convergence time of a multiple spanning tree topology between HP and Cisco switches after a link failure.

### Background

As defined in IEEE specification 802.1s, the multiple spanning tree protocol (MSTP) adds loop prevention and redundancy on a per-VLAN basis. With MSTP, a separate spanning tree topology can be configured for each VLAN.

MSTP is the default spanning tree protocol for HP Networking switches. MSTP is enabled by default on HP A-series switches, and disabled by default on HP E-series switches.

## Topology

This example uses redundant paths between the HP Networking and Cisco Catalyst switches. VLAN IDs of 300 to 304 have been defined on all switches, and MSTP is enabled on all switches.

Figure 1 above illustrates the MSTP validation test bed. The links interconnecting each switch are trunk ports that allow tagged traffic from the VLAN IDs 300 to 304. Access ports were configured on the access layer switches, with one port per VLAN being configured. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies the spanning tree topology in each VLAN.

## HP A-series commands

Create VLAN IDs 300 to 304.

```
<HP5800> system-view
[HP5800] vlan 300 to 304
```

Configure access-mode ports for their respective VLANs.

```
[HP5800] interface GigabitEthernet1/0/1
[HP5800-Gigabitethernet1/0/1]  port link-mode bridge
[HP5800-Gigabitethernet1/0/1]  port access vlan 300
[HP5800-Gigabitethernet1/0/1] interface GigabitEthernet1/0/2
[HP5800-Gigabitethernet1/0/2]  port link-mode bridge
[HP5800-Gigabitethernet1/0/2]  port access vlan 301
[HP5800-Gigabitethernet1/0/2] interface GigabitEthernet1/0/3
[HP5800-Gigabitethernet1/0/3]  port link-mode bridge
[HP5800-Gigabitethernet1/0/3]  port access vlan 302
[HP5800-Gigabitethernet1/0/3] interface GigabitEthernet1/0/4
[HP5800-Gigabitethernet1/0/4]  port link-mode bridge
[HP5800-Gigabitethernet1/0/4]  port access vlan 303
[HP5800-Gigabitethernet1/0/4] interface GigabitEthernet1/0/5
[HP5800-Gigabitethernet1/0/5]  port link-mode bridge
[HP5800-Gigabitethernet1/0/5]  port access vlan 304
[HP5800-Gigabitethernet1/0/5]  quit
```

Configure interswitch connections as trunk ports. Here is interface GigabitEthernet1/0/23 as an example.

```
[HP5800] interface GigabitEthernet1/0/23
[HP5800-Gigabitethernet1/0/23]  port link-mode bridge
[HP5800-Gigabitethernet1/0/23]  port link-type trunk
[HP5800-Gigabitethernet1/0/23]  undo port trunk permit vlan 1
[HP5800-Gigabitethernet1/0/23]  port trunk permit vlan 300 to 303
[HP5800-Gigabitethernet1/0/23]  port trunk pvid vlan 300
[HP5800-Gigabitethernet1/0/23]  quit
```

Enable multiple spanning tree. This requires enabling MSTP (the default on HP A-series switches) and configuring one multiple spanning tree instance per VLAN.

```
[HP5800] stp enable
[HP5800] stp region-configuration
[HP5800-mst-region]  instance 2 vlan 300
[HP5800-mst-region]  instance 3 vlan 301
[HP5800-mst-region]  instance 4 vlan 302
[HP5800-mst-region]  instance 5 vlan 303
[HP5800-mst-region]  instance 6 vlan 304
[HP5800-mst-region]  active region-configuration
[HP5800-mst-region]  quit
[HP5800]  quit
```

## HP E-series commands

Create the VLANs and assign physical interfaces to them. Interfaces that have both untagged (access ports) and tagged VLAN IDs are VLAN trunks.

```
HP5406ZL# configure
HP5406ZL(config)# vlan 300
HP5406ZL(vlan-300)#    name "VLAN300"
HP5406ZL(vlan-300)#    untagged A1,A9-A10
HP5406ZL(vlan-300)#    ip address 10.1.2.1 255.255.0.0
HP5406ZL(vlan-300)#    exit
HP5406ZL(config)# vlan 301
HP5406ZL(vlan-300)#    name "VLAN301"
HP5406ZL(vlan-300)#    untagged A2
HP5406ZL(vlan-300)#    ip address 10.2.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(config)#    exit
HP5406ZL(vlan-300)# vlan 302
HP5406ZL(vlan-300)#    name "VLAN302"
HP5406ZL(vlan-300)#    untagged A3
HP5406ZL(vlan-300)#    ip address 10.3.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(vlan-300)#    exit
HP5406ZL(config)# vlan 303
HP5406ZL(vlan-300)#    name "VLAN303"
HP5406ZL(vlan-300)#    untagged A4
HP5406ZL(vlan-300)#    ip address 10.4.2.1 255.255.0.0
HP5406ZL(vlan-300)#    tagged A9-A10
HP5406ZL(vlan-300)#    exit
HP5406ZL(config)# vlan 304
HP5406ZL(vlan-300)#    name "VLAN304"
HP5406ZL(vlan-300)#    untagged A5
HP5406ZL(vlan-300)#    ip address 10.5.2.1 255.255.0.0
HP5406ZL(vlan-300)#    exit
```

Create the multiple spanning tree protocol instances, and assign one VLAN to each instance.

```
HP5406ZL(config)# spanning-tree
HP5406ZL(config)# spanning-tree instance 2 vlan 300
HP5406ZL(config)# spanning-tree instance 3 vlan 301
HP5406ZL(config)# spanning-tree instance 4 vlan 302
HP5406ZL(config)# spanning-tree instance 5 vlan 303
HP5406ZL(config)# spanning-tree instance 6 vlan 304
HP5406ZL(config)# spanning-tree priority 9
HP5406ZL(config)# exit
```

## Cisco commands

The following commands apply to a Cisco Catalyst 3750-E. The syntax is similar for the Catalyst 6509 switches and Cisco Catalyst 4506 switches.

Create the VLANs.

```
Cat3750E# configure terminal
Cat3750E(config)# vlan 300-304
```

Configure access-mode ports for their respective VLANs.

```
Cat3750E(config)# interface GigabitEthernet6/0/1
Cat3750E(config)#  switchport
Cat3750E(config-if)#  switchport access vlan 300
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/2
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 301
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/3
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 302
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/4
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 303
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)# interface GigabitEthernet6/0/5
Cat3750E(config-if)#  switchport
Cat3750E(config-if)#  switchport access vlan 304
Cat3750E(config-if)#  switchport mode access
Cat3750E(config-if)#  spanning-tree portfast
Cat3750E(config-if)#  exit
```

Configure interswitch connections as trunk ports. Here is interface GigabitEthernet6/0/10 as an example.

```
Cat3750E(config)# interface GigabitEthernet6/0/10
Cat3750E(config-if)#  switchport trunk encapsulation dot1q
Cat3750E(config-if)#  switchport trunk native vlan 300
Cat3750E(config-if)#  switchport trunk allowed vlan 300-303
Cat3750E(config-if)#  switchport mode trunk
Cat3750E(config-if)#  exit
```

Enable multiple spanning tree. This requires enable MSTP and configuring one multiple spanning tree instance per VLAN.

```
Cat3750E(config)# spanning-tree mode mst
Cat3750E(config)# spanning-tree mst configuration
Cat3750E(config-mst)#  instance 1 vlan 300
Cat3750E(config-mst)#  instance 2 vlan 301
Cat3750E(config-mst)#  instance 3 vlan 302
Cat3750E(config-mst)#  instance 4 vlan 303
Cat3750E(config-mst)#  instance 5 vlan 304
Cat3750E(config-mst)#  end
```

## Validation

HP A-series switches can use the command **`display stp brief`** to verify the state of spanning tree on HP A-series switches. HP E-series uses the command **`show spanning-tree`** to display the state of spanning tree on HP E-series switches.

To verify all switches send traffic only over the spanning tree interfaces in forwarding state, generate a known quantity of frames from Spirent TestCenter or other source to each VLAN and compare switch interface packet counters with those sent and received on each interface. Interfaces in blocking state will receive spanning tree BPDU frames but should transmit no frames.

To determine convergence time, disable one of the spanning tree interfaces in forwarding state while offering a known quantity of frames from Spirent TestCenter or other traffic generator. Convergence time can be derived from frame loss. For example, if Spirent TestCenter generates traffic at a rate of 1,000 frames per second, each dropped frame is equivalent to 1 millisecond of convergence time. If the switches drop 47 frames, then spanning tree convergence time is 47 ms.

## OSPFv2 (OSPF for IPv4)

### Objective

To verify that HP Networking and Cisco Catalyst switches are able to establish open shortest path first version 2 (OSPFv2) connections and exchange topology information.

### Background

Intended for use on IPv4 networks, OSPFv2 supports IP subnetting and redistribution of routing information learned via other protocols. OSPF also allows session authentication and uses IP multicast for distribution of routing updates.

OSPF uses areas to segment traffic, with area 0 designated as the backbone network. OSPF typically involves coordination among multiple internal routers; area border routers (ABRs) connected to multiple areas; and autonomous system boundary routers (ASBRs).

In addition to standard areas, OSPFv2 also defines two special types of areas: Stubs are areas into which information on external routes is not sent. Instead, the area border router (ABR) generates a default external route into the stub area. A Not-So-Stubby-Area (NSSA) is like a stub area, but it can import external routes into the area for redistribution via OSPF.

### Topology

This example uses multiple paths between HP and Cisco devices. Each HP and Cisco switch was configured with multiple networks, which were then advertised by OSPF to its neighbors.

Figure 1 above illustrates the OSPFv2 test bed. Access switches were connected to both distribution switches and the distribution switches were connected to both core switches. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies that traffic is indeed being passed between networks.

### HP A-series commands

In this example, switched virtual interfaces (SVIs) are created using VLAN interfaces. Physical interfaces are then mapped to the VLAN interfaces. Routing is done between VLAN interfaces on each switch.

Create the VLANs.

```
<HP5800> system-view
[HP5800] vlan 1
[HP5800] vlan 2 to 9
```

Create the switched virtual interfaces.

```
[HP5800] interface Vlan-interface2
[HP5800-vlan-interface2] ip address 10.0.2.1 255.255.255.0
[HP5800-vlan-interface2] interface Vlan-interface3
[HP5800-vlan-interface3] ip address 10.0.3.1 255.255.255.0
[HP5800-vlan-interface3] interface Vlan-interface4
[HP5800-vlan-interface4] ip address 10.0.4.1 255.255.255.0
[HP5800-vlan-interface4] interface Vlan-interface5
[HP5800-vlan-interface5] ip address 10.0.5.1 255.255.255.0
[HP5800-vlan-interface5] interface Vlan-interface6
[HP5800-vlan-interface6] ip address 10.0.6.1 255.255.255.0
[HP5800-vlan-interface6] interface Vlan-interface7
[HP5800-vlan-interface7] ip address 10.0.7.1 255.255.255.0
[HP5800-vlan-interface7] interface Vlan-interface8
[HP5800-vlan-interface8] ip address 10.0.8.1 255.255.255.0
[HP5800-vlan-interface8] interface Vlan-interface9
[HP5800-vlan-interface9] ip address 10.0.9.1 255.255.255.0
[HP5800-vlan-interface9] quit
```

Associate the physical interfaces with the corresponding SVIs.

```
[HP5800] interface GigabitEthernet1/0/1
[HP5800-Gigabitethernet1/0/1]  port link-mode bridge
[HP5800-Gigabitethernet1/0/1]  port access vlan 2
[HP5800-Gigabitethernet1/0/1] interface GigabitEthernet1/0/2
[HP5800-Gigabitethernet1/0/2]  port link-mode bridge
[HP5800-Gigabitethernet1/0/2]  port access vlan 3
[HP5800-Gigabitethernet1/0/2] interface GigabitEthernet1/0/3
[HP5800-Gigabitethernet1/0/3]  port link-mode bridge
[HP5800-Gigabitethernet1/0/3]  port access vlan 4
[HP5800-Gigabitethernet1/0/3] interface GigabitEthernet1/0/4
[HP5800-Gigabitethernet1/0/4]  port link-mode bridge
[HP5800-Gigabitethernet1/0/4]  port access vlan 5
[HP5800-Gigabitethernet1/0/4] interface GigabitEthernet1/0/5
[HP5800-Gigabitethernet1/0/5]  port link-mode bridge
[HP5800-Gigabitethernet1/0/5]  port access vlan 6
[HP5800-Gigabitethernet1/0/5] interface GigabitEthernet1/0/6
[HP5800-Gigabitethernet1/0/6]  port link-mode bridge
[HP5800-Gigabitethernet1/0/6]  port access vlan 7
[HP5800-Gigabitethernet1/0/6] interface GigabitEthernet1/0/7
[HP5800-Gigabitethernet1/0/7]  port link-mode bridge
[HP5800-Gigabitethernet1/0/7]  port access vlan 8
[HP5800-Gigabitethernet1/0/7] interface GigabitEthernet1/0/8
[HP5800-Gigabitethernet1/0/8]  port link-mode bridge
[HP5800-Gigabitethernet1/0/8]  port access vlan 9
[HP5800-Gigabitethernet1/0/8]  quit
```

Configure OSPF routing.

```
[HP5800] ospf 1 router-id 10.0.0.1
[HP5800-ospf]  area 0.0.0.0
[HP5800-ospf]   network 10.0.0.0 0.0.255.255
[HP5800-ospf]   quit
[HP5800]   quit
```

## HP E-series commands

For the HP E-series switches, a single command sets up VLANs and assigns physical interfaces to those VLANs.

Enable IP routing .

```
HP5406ZL> configure
HP5406ZL(config)> ip routing
```

Define and configure VLANs.

```
HP5406ZL(config)> vlan 33
HP5406ZL(vlan-33)>    name "VLAN33"
HP5406ZL(vlan-33)>    untagged A1
HP5406ZL(vlan-33)>    ip address 10.0.33.1 255.255.255.0
HP5406ZL(vlan-33)>    exit
HP5406ZL(vlan-33)> vlan 34
HP5406ZL(vlan-34)>    name "VLAN34"
HP5406ZL(vlan-34)>    untagged A2
HP5406ZL(vlan-34)>    ip address 10.0.34.1 255.255.255.0
HP5406ZL(vlan-34)>    exit
HP5406ZL(vlan-34)> vlan 35
HP5406ZL(vlan-35)>    name "VLAN35"
HP5406ZL(vlan-35)>    untagged A3
HP5406ZL(vlan-35)>    ip address 10.0.35.1 255.255.255.0
HP5406ZL(vlan-35)>    exit
HP5406ZL(vlan-35)> vlan 36
HP5406ZL(vlan-36)>    name "VLAN36"
HP5406ZL(vlan-36)>    untagged A4
HP5406ZL(vlan-36)>    ip address 10.0.36.1 255.255.255.0
HP5406ZL(vlan-36)>    exit
HP5406ZL(vlan-36)> vlan 37
HP5406ZL(vlan-37)>    name "VLAN37"
HP5406ZL(vlan-37)>    untagged A5
HP5406ZL(vlan-37)>    ip address 10.0.37.1 255.255.255.0
HP5406ZL(vlan-37)>    exit
HP5406ZL(vlan-37)> vlan 38
HP5406ZL(vlan-38)>    name "VLAN38"
HP5406ZL(vlan-38)>    untagged A6
HP5406ZL(vlan-38)>    ip address 10.0.38.1 255.255.255.0
HP5406ZL(vlan-38)>    exit
HP5406ZL(vlan-38)> vlan 39
HP5406ZL(vlan-39)>    name "VLAN39"
HP5406ZL(vlan-39)>    untagged A7
HP5406ZL(vlan-39)>    ip address 10.0.39.1 255.255.255.0
```

```
HP5406ZL(vlan-39)>    exit
HP5406ZL(vlan-39)> vlan 40
HP5406ZL(vlan-40)>    name "VLAN40"
HP5406ZL(vlan-40)>    untagged A8
HP5406ZL(vlan-40)>    ip address 10.0.40.1 255.255.255.0
HP5406ZL(vlan-40)>    exit
```

Enable OSPF routing and configure the VLANs for OSPF.

```
HP5406ZL(config)> ip router-id 10.0.32.1
HP5406ZL(config)> router ospf
HP5406ZL(ospf)>    area backbone range 10.0.0.0 255.255.0.0 type summary
HP5406ZL(ospf)>    exit
HP5406ZL(config)> vlan 33
HP5406ZL(vlan-33)>    ip ospf 10.0.33.1 area backbone
HP5406ZL(vlan-33)>    exit
HP5406ZL(vlan-33)> vlan 34
HP5406ZL(vlan-34)>    ip ospf 10.0.34.1 area backbone
HP5406ZL(vlan-34)>    exit
HP5406ZL(vlan-34)> vlan 35
HP5406ZL(vlan-35)>    ip ospf 10.0.35.1 area backbone
HP5406ZL(vlan-35)>    exit
HP5406ZL(vlan-35)> vlan 36
HP5406ZL(vlan-36)>    ip ospf 10.0.36.1 area backbone
HP5406ZL(vlan-36)>    exit
HP5406ZL(vlan-36)> vlan 37
HP5406ZL(vlan-37)>    ip ospf 10.0.37.1 area backbone
HP5406ZL(vlan-37)>    exit
HP5406ZL(vlan-37)> vlan 38
HP5406ZL(vlan-38)>    ip ospf 10.0.38.1 area backbone
HP5406ZL(vlan-38)>    exit
HP5406ZL(vlan-38)> vlan 39
HP5406ZL(vlan-39)>    ip ospf 10.0.39.1 area backbone
HP5406ZL(vlan-39)>    exit
HP5406ZL(vlan-39)> vlan 40
HP5406ZL(vlan-40)>    ip ospf 10.0.40.1 area backbone
HP5406ZL(vlan-40)>    exit
HP5406ZL>    exit
```

## Cisco commands

On Cisco Catalyst switches, like HP A-series switches, create the VLANs first and then assign physical interfaces to the VLAN interfaces. The following commands apply to a Cisco Catalyst 6509. The syntax is similar for Cisco Catalyst 3750-E switches and Cisco Catalyst 4506 switches.

First, enable routing.

```
Cat6509# configure terminal
Cat6509(config)# ip routing
```

Then, create the VLAN interfaces.

```
Cat6509(config)# interface Vlan129
Cat6509(config-if)#  ip address 10.0.129.1 255.255.255.0
Cat6509(config-if)# interface Vlan130
Cat6509(config-if)#  ip address 10.0.130.1 255.255.255.0
Cat6509(config-if)# interface Vlan131
Cat6509(config-if)#  ip address 10.0.131.1 255.255.255.0
Cat6509(config-if)# interface Vlan132
Cat6509(config-if)#  ip address 10.0.132.1 255.255.255.0
Cat6509(config-if)# interface Vlan133
Cat6509(config-if)#  ip address 10.0.133.1 255.255.255.0
Cat6509(config-if)# interface Vlan134
Cat6509(config-if)#  ip address 10.0.134.1 255.255.255.0
Cat6509(config-if)# interface Vlan135
Cat6509(config-if)#  ip address 10.0.135.1 255.255.255.0
Cat6509(config-if)# interface Vlan136
Cat6509(config-if)#  ip address 10.0.136.1 255.255.255.0
Cat6509(config-if)#  exit
```

Next, assign physical interfaces to the VLANs.

```
Cat6509(config)# interface GigabitEthernet1/0/1
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport access vlan 129
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  spanning-tree portfast
Cat6509(config-if)# interface GigabitEthernet1/0/2
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport access vlan 130
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  spanning-tree portfast
Cat6509(config-if)# interface GigabitEthernet1/0/3
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport access vlan 131
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  spanning-tree portfast
Cat6509(config-if)# interface GigabitEthernet1/0/4
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport access vlan 132
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  spanning-tree portfast
Cat6509(config-if)# interface GigabitEthernet1/0/5
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport access vlan 133
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  spanning-tree portfast
Cat6509(config-if)# interface GigabitEthernet1/0/6
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport access vlan 134
Cat6509(config-if)#  switchport mode access
```

```
Cat6509(config-if)#  spanning-tree portfast
Cat6509(config-if)# interface GigabitEthernet1/0/7
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport access vlan 135
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  spanning-tree portfast
Cat6509(config-if)# interface GigabitEthernet1/0/8
Cat6509(config-if)#  no ip address
Cat6509(config-if)#  switchport
Cat6509(config-if)#  switchport access vlan 136
Cat6509(config-if)#  switchport mode access
Cat6509(config-if)#  spanning-tree portfast
Cat6509(config-if)#  exit
```

Finally, enable OSPF routing.

```
Cat6509(config)# router ospf 1
Cat6509(config-ospf)#  log-adjacency-changes
Cat6509(config-ospf)#  network 10.0.0.0 0.0.255.255 area 0
Cat6509(config-ospf)#  end
```

### Validation

If the HP and Cisco devices are unable to complete OSPF negotiation, routing adjacencies will remain in the ExStart state. Fully functional adjacencies will be in the Full state. To verify that an OSPF adjacency has entered OSPF Full state on the HP switches, use the **`display ospf peer`** command on A-series switches and the **`show ip ospf neighbor`** command on E-series switches.

## OSPFv3 (OSPF for IPv6)

### Objective

To verify that HP Networking and Cisco Catalyst switches are able to establish open shortest path first version 3 (OSPFv3) connections and exchange topology information.

### Background

OSPFv3 updates the routing protocol for use on IPv6 networks. In a mixed IPv4/IPv6 environment, OSPFv2 must be used in conjunction with OSPFv3.

While the basic mechanics of OSPF are identical in both versions, OSPFv3 introduces new link-state advertisement (LSA) types; removes addressing semantics from OSPF headers; generalizes

flooding; and removes OSPF-layer authentication, among other changes. RFC 5340 describes OSPFv3.

## Topology

This example uses multiple paths between HP and Cisco devices. Each HP and Cisco switch was configured with multiple networks, which were then advertised by OSPF to its neighbors. The switches have been configured in dual-stack IPv4/IPv6 mode, running both OSPFv2 (to support IPv4 traffic) and OSPFv3 (to support IPv6 traffic).

Figure 1 above illustrates the OSPv3 test bed. Both access switches were connected to both distribution switches, and both distribution switches in turn were connected to both core switches. Traffic offered from the Spirent TestCenter traffic generator/analyzer verifies that traffic is correctly routed between networks.

## HP A-series commands

In this example, switched virtual interfaces (SVIs) are created using VLAN interfaces. Physical interfaces are then mapped to the VLAN interfaces. Routing is done between VLAN interfaces on each switch. Unlike OSPFv2, OSPv3 configuration is done on the actual routable interface.

While not required, the configuration is using a dual-stack IPv4/IPv6 setup.

First, enable IPv6.

```
<HP9505> system-view
[HP9505] ipv6
```

Then, configure the VLAN interfaces.

```
[HP9505] vlan 65
[HP9505] vlan 75
[HP9505] interface Vlan-interface65
[HP9505-vlan-interface65]  ipv6 address 2002:9505:0:65::1/64
[HP9505-vlan-interface65]  ospfv3 1 area 0.0.0.0
[HP9505-vlan-interface65]  ip address 10.0.65.1 255.255.255.0
[HP9505-vlan-interface65] interface Vlan-interface75
[HP9505-vlan-interface75]  ipv6 address 2002:9595:4506:75::1/64
[HP9505-vlan-interface75]  ospfv3 1 area 0.0.0.0
[HP9505-vlan-interface75]  ip address 10.0.75.1 255.255.255.0
[HP9505-vlan-interface75]  quit
```

Next, assign the physical interfaces to the VLANs.

```
[HP9505] interface GigabitEthernet3/0/9
[HP9505-Gigabitethernet3/0/9]  port access vlan 65
[HP9505-Gigabitethernet3/0/9] interface GigabitEthernet3/0/11
[HP9505-Gigabitethernet3/0/11]  port access vlan 75
[HP9505-Gigabitethernet3/0/11]  quit
```

Finally, configure the OSPFv3 and OSPFv2 routing processes.

```
[HP9505] ospf 1 router-id 10.0.64.1
[HP9505-ospf]  area 0.0.0.0
[HP9505-ospf]   network 10.0.0.0 0.0.255.255
[HP9505-ospf] ospfv3 1
[HP9505-ospfv3]  router-id 10.0.64.1
[HP9505-ospfv3]  area 0.0.0.0
[HP9505-ospfv3]  quit
[HP9505]  quit
```

## HP E-series commands

For HP E-series switches, a single command sets up VLANs and assigns physical interfaces to the VLANs.

First, enable routing.

```
HP5406ZL# configure
HP5406ZL(config)# ip routing
HP5406ZL(config)# ipv6 unicast-routing
```

Next,  create the VLAN and assign the associated physical interfaces to it.

```
HP5406ZL(config)# vlan 42
HP5406ZL(vlan-42)#    name "VLAN42"
HP5406ZL(vlan-42)#    untagged A9
HP5406ZL(vlan-42)#    ip address 10.0.42.1 255.255.255.0
HP5406ZL(vlan-42)#    ipv6 address 2002:5406:6509:42::1/64
HP5406ZL(vlan-42)#    exit
```

Then, configure the OSPF processes.

```
HP5406ZL(config)# ip router-id 10.0.32.1
HP5406ZL(config)# router ospf
HP5406ZL(ospf)#    area backbone range 10.0.0.0 255.255.0.0 type summary
HP5406ZL(ospf)#    exit
HP5406ZL(config)# router ospf3
HP5406ZL(ospf3)#    area backbone
HP5406ZL(ospf3)#    enable
HP5406ZL(ospf3)#    exit
```

Finally, enable OSPF on the VLAN.

```
HP5406ZL(config)# vlan 42
HP5406ZL(vlan-42)#    ip ospf 10.0.42.1 area backbone
HP5406ZL(vlan-42)#    ipv6 ospf3 area backbone
HP5406ZL(vlan-42)#    exit
```

## Cisco commands

On Cisco Catalyst switches, like HP A-series switches, create the VLANs first and then assign physical interfaces to the VLAN instances. The following commands apply to a Cisco Catalyst 6509. Except where noted, the syntax is similar for the Cisco Catalyst 3750-E and Cisco Catalyst 4506 switches.

First, enable IPv6 routing.

```
Cat6509# configure terminal
Cat6509(config)# ipv6 unicast-routing
```

Configuration syntax is slightly different on the Cisco Catalyst 3750-E. First, configure the system to support IPv6.

```
Cat3750E# configure terminal
Cat3750E(config)# sdm prefer dual-ipv4-and-ipv6 default
Cat3750E(config)# ip routing
Cat3750E(config)# ipv6 unicast-routing
```

Cisco Catalyst 3750-E, Cisco Catalyst 4506, and Cisco Catalyst 6509 switches use the same commands for the remaining steps.

Configure the physical interface. With OSPFv3, the primary configuration is done on the port.

```
Cat6509(config)# interface GigabitEthernet4/9
Cat6509(config-if)#  ip address 10.0.42.2 255.255.255.0
Cat6509(config-if)#  ipv6 address 2002:5406:6509:42::2/64
Cat6509(config-if)#  ipv6 ospf 1 area 0
Cat6509(config-if)#  exit
```

Finally, configure the OSPF router processes. On Cisco Catalyst switches, **`ospf`** refers to OSPFv2 while **`ipv6 ospf`** refers to OSPFv3.

```
Cat6509(config)# router ospf 1
Cat6509(config-ospf)#  log-adjacency-changes
Cat6509(config-ospf)#  network 10.0.42.2 0.0.0.0 area 0
Cat6509(config-ospf)#  network 10.0.73.2 0.0.0.0 area 0
Cat6509(config-ospf)#  network 10.0.77.2 0.0.0.0 area 0
Cat6509(config-ospf)#  network 10.0.128.0 0.0.127.255 area 0
Cat6509(config-ospf)# ipv6 router ospf 1
Cat6509(config-ipv6-ospf)#  log-adjacency-changes
Cat6509(config-ipv6-ospf)#  end
```

### Validation

If the HP and Cisco devices are unable to complete OSPF negotiation, routing adjacencies will remain in the ExStart state. Fully functional adjacencies will be in the Full state. To verify that an OSPF adjacency has entered OSPF Full state on the HP switches, use the **`display ospf peer`** command on the A-series switches and the **`show ipv6 ospf neighbor`** command on the HP E-series switches.

## IP multicast switching

### Objective

To verify the ability of HP Networking and Cisco Catalyst switches to correctly forward multicast traffic from a multicast routed network.

### Background

In IPv4 networks, Ethernet switches use Internet group management protocol (IGMP) snooping to determine where a switch should forward multicast traffic. With IGMP snooping enabled, a switch listens for IGMP reports from attached multicast subscribers. The switch then maps subscribed multicast group address(es) to the interface on which the subscriber is attached. When the switch receives traffic destined for one or more addresses, it will forward it only to those interfaces from which it has heard membership reports.

IGMP snooping requires the use of either an IGMP querier or an IGMP PIM router. An IGMP querier is useful if no router is available, and in this case acts as the multicast router (mrouter) for VLAN by issuing periodic membership queries. If an IGMP querier is being used, there should only be one querier per VLAN.

### Topology

In this example, a Spirent TestCenter port attached to the Cisco Catalyst 3750-E offers traffic destined to 10 multicast groups, while other test ports emulate multicast subscribers on the HP A5800 and HP E5406zl. An IGMP querier is used instead of a multicast router.

Figure 1 above illustrates the topology used to validate IP multicast switching functionality. On HP switches, all subscriber interfaces use the same VLAN for untagged traffic, and IGMP snooping is enabled. On the Cisco Catalyst 6509 and Cisco Catalyst 4506, IGMP snooping is enabled. On the Cisco Catalyst 3750-E, IGMP snooping and IGMP querier are enabled.

## HP A-series commands

In this example, all interfaces use the same VLAN for untagged traffic and IGMP snooping is enabled globally:

```
<HP5800> system-view
[HP5800] igmp-snooping
```

IGMP snooping also must be enabled on a per-VLAN basis. Only one VLAN is used in this switching example. In configurations that use additional VLANs, only one querier should be defined per VLAN.

```
[HP5800] vlan 300
[HP5800-Vlan-300] igmp-snooping enable
[HP5800-Vlan-300] igmp-snooping querier
[HP5800-Vlan-300] quit
[HP5800] quit
```

## HP E-series commands

On HP E-series switches, IGMP snooping also is enabled on a per-VLAN basis:

```
HP5406ZL# configure
HP5406ZL(config)# vlan 300
HP5406ZL(vlan-300)# ip igmp
HP5406ZL(vlan-300)# exit
```

## Cisco commands

The following commands apply to a Cisco Catalyst 6509. Except where noted, the syntax is similar for the Catalyst 3750-E switches and Cisco Catalyst 4506 switches.

First, enable IP multicast routing.

```
Cat6509# configure terminal
Cat6509(config)# ip multicast-routing
```

Cisco Catalyst 3750-E switches use a slightly different syntax.

```
Cat3750# configure terminal
Cat3750(config)# ip routing
Cat3750(config)# ip multicast-routing distributed
```

Cisco Catalyst 3750-E, Cisco Catalyst 4506, and Cisco Catalyst 6509 switches use the same commands for the remaining steps.

Enable IGMP snooping. IGMP snooping is enabled by default on Cisco Catalyst switches for all VLANs. In case it is disabled, it can be enabled with these commands:

```
Cat6509# configure terminal
Cat6509(config)# ip igmp snooping
```

Next, enable an IGMP querier. Only one querier should be defined across all switches that share a common VLAN ID.

```
Cat6509# configure terminal
Cat6509(config)# ip igmp snooping querier
Cat6509(config)# end
```

### Validation

Once subscribers attached to the HP A5800 switches and the HP E5406zl switches have joined multicast groups by sending IGMP reports with join messages, multicast traffic for these groups will be forwarded to all subscriber ports.

The HP A-series switch command **`display igmp-snooping group`** also will verify that the HP A5800 and Cisco devices see one another and can exchange IGMP membership information.

The HP E-series switch command **`show ip igmp`** also will verify that the HP E5406zl and Cisco devices see one another and can exchange IGMP membership information.

## IP multicast routing

### Objective

To verify the ability of HP switches to learn multicast routing information from a Cisco device using the protocol independent multicast-sparse mode (PIM-SM) protocol.

To verify the ability of the HP Networking and Cisco Catalyst switches to correctly forward multicast traffic based on routing information learned via PIM-SM.

## Background

PIM-SM is a popular choice for multicast routing. Devices running PIM-SM can learn topology information from other PIM-SM routers and make forwarding decisions based on that information.

## Topology

This example is similar to that used in the "IP Multicast Switching" section, with two important changes: Routing (including OSPF) is enabled on all switches, and the HP A9505 switch also acts a PIM-SM router.

In this example, a Spirent TestCenter port attached to the Cisco Catalyst 3750-E offers traffic destined to 10 multicast groups on different subnets while other test ports emulated multicast subscribers to all 10 groups on the HP A5800 and HP E5406zl. The Cisco device uses PIM-SM to propagate subnet routing information to other subnets, including the ones on the HP switches, also running PIM-SM, as attached.

The HP switches use PIM-SM and OSPF to propagate routing information. Multicast subscribers attached to VLAN-routed interfaces, each in a different VLAN with each VLAN in a different IP subnet, receive traffic from Sprirent TestCenter. The subscriber interfaces also use IGMP to build a multicast forwarding table.

Figure 1 above illustrates the topology used to validate IP multicast routing functionality. PIM-SM and OSPF routing is enabled on all Cisco and HP devices.

## HP A-series commands

First, create the necessary VLANs.

```
<HP5800> system-view
[HP5800] vlan 2 to 10
```

Next, assign IP addresses and enable IGMP on the respective VLANs.

```
[HP5800] interface Vlan-interface2
[HP5800-vlan-interface2] ip address 10.0.2.1 255.255.255.0
[HP5800-vlan-interface2]  igmp enable
[HP5800-vlan-interface2] interface Vlan-interface3
[HP5800-vlan-interface3]  ip address 10.0.3.1 255.255.255.0
[HP5800-vlan-interface3]  igmp enable
[HP5800-vlan-interface3] interface Vlan-interface4
```

```
[HP5800-vlan-interface4]  ip address 10.0.4.1 255.255.255.0
[HP5800-vlan-interface4]  igmp enable
[HP5800-vlan-interface4] interface Vlan-interface5
[HP5800-vlan-interface5]  ip address 10.0.5.1 255.255.255.0
[HP5800-vlan-interface5]  igmp enable
[HP5800-vlan-interface5] interface Vlan-interface6
[HP5800-vlan-interface6]  ip address 10.0.6.1 255.255.255.0
[HP5800-vlan-interface6]  igmp enable
[HP5800-vlan-interface6] interface Vlan-interface7
[HP5800-vlan-interface7]  ip address 10.0.7.1 255.255.255.0
[HP5800-vlan-interface7]  igmp enable
[HP5800-vlan-interface7] interface Vlan-interface8
[HP5800-vlan-interface8]  ip address 10.0.8.1 255.255.255.0
[HP5800-vlan-interface8]  igmp enable
[HP5800-vlan-interface8] interface Vlan-interface9
[HP5800-vlan-interface9]  ip address 10.0.9.1 255.255.255.0
[HP5800-vlan-interface9]  igmp enable
[HP5800-vlan-interface9]  quit
```

Then, assign the interfaces to the respective VLANs.

```
[HP5800] interface GigabitEthernet1/0/1
[HP5800-Gigabitethernet1/0/1] port link-mode bridge
[HP5800-Gigabitethernet1/0/1] port access vlan 2
[HP5800-Gigabitethernet1/0/1] interface GigabitEthernet1/0/2
[HP5800-Gigabitethernet1/0/2] port link-mode bridge
[HP5800-Gigabitethernet1/0/2] port access vlan 3
[HP5800-Gigabitethernet1/0/2] interface GigabitEthernet1/0/3
[HP5800-Gigabitethernet1/0/3] port link-mode bridge
[HP5800-Gigabitethernet1/0/3] port access vlan 4
[HP5800-Gigabitethernet1/0/3] interface GigabitEthernet1/0/4
[HP5800-Gigabitethernet1/0/4] port link-mode bridge
[HP5800-Gigabitethernet1/0/4] port access vlan 5
[HP5800-Gigabitethernet1/0/4] interface GigabitEthernet1/0/5
[HP5800-Gigabitethernet1/0/5] port link-mode bridge
[HP5800-Gigabitethernet1/0/5] port access vlan 6
[HP5800-Gigabitethernet1/0/5] interface GigabitEthernet1/0/6
[HP5800-Gigabitethernet1/0/6] port link-mode bridge
[HP5800-Gigabitethernet1/0/6] port access vlan 7
[HP5800-Gigabitethernet1/0/6] interface GigabitEthernet1/0/7
[HP5800-Gigabitethernet1/0/7] port link-mode bridge
[HP5800-Gigabitethernet1/0/7] port access vlan 8
[HP5800-Gigabitethernet1/0/7] interface GigabitEthernet1/0/8
[HP5800-Gigabitethernet1/0/8] port link-mode bridge
[HP5800-Gigabitethernet1/0/8] port access vlan 9
[HP5800-Gigabitethernet1/0/8] quit
```

Next, enable multicast routing and IGMP.

```
[HP5800] multicast routing-enable
[HP5800] igmp-snooping
```

Then, enable OSPF. Although this step is not strictly necessary for IP multicast routing, some unicast routing protocol or static routing is required.

```
[HP5800] ospf 1 router-id 10.0.0.1
[HP5800-OSPF] area 0.0.0.0
[HP5800-OSPF] network 10.0.0.0 0.0.255.255
[HP5800-OSPF] quit
```

Then, enable PIM-SM and designate a rendezvous point (RP), in this example the VLAN interface on the HP A9505 switch.

```
[HP5800] pim
[HP5800-PIM] static-rp 10.0.73.1
[HP5800-PIM] quit
```

Next, enable PIM-SM on the VLAN used for the trunk line between switches.

```
[HP5800] interface Vlan-interface41
[HP5800-vlan-interface41]  ip address 10.0.41.2 255.255.255.0
[HP5800-vlan-interface41]  igmp enable
[HP5800-vlan-interface41]  pim sm
[HP5800-vlan-interface41]  quit
```

Finally, on the HP A9505, we need to configure the rendezvous point (RP). We will also enable PIM-SM on the same VLAN interface that is being used as the rendezvous point.

```
[HP9505] interface Vlan-interface75
[HP9505-vlan-interface75]  ip address 10.0.75.1 255.255.255.0
[HP9505-vlan-interface75]  igmp enable
[HP9505-vlan-interface75]  pim sm
[HP9505] pim
[HP9505-PIM]  c-rp Vlan-interface73
[HP9505-PIM]  static-rp 10.0.73.1
[HP9505-PIM]  quit
[HP9505]  quit
```

## HP E-series commands

First, setup the VLANs that will be used, and assign interfaces to them.

```
HP5406# configure
HP5406(config)# vlan 33
HP5406(vlan-33)#    name "VLAN33"
HP5406(vlan-33)#    untagged A1
HP5406(vlan-33)#    ip address 10.0.33.1 255.255.255.0
HP5406(vlan-33)#    exit
HP5406(config)# vlan 34
HP5406(vlan-34)#    name "VLAN34"
HP5406(vlan-34)#    untagged A2
HP5406(vlan-34)#    ip address 10.0.34.1 255.255.255.0
HP5406(vlan-34)#    exit
HP5406(config)# vlan 35
HP5406(vlan-35)#    name "VLAN35"
HP5406(vlan-35)#    untagged A3
HP5406(vlan-35)#    ip address 10.0.35.1 255.255.255.0
```

```
HP5406(vlan-35)#    exit
HP5406(config)# vlan36
HP5406(vlan-36)#    name "VLAN36"
HP5406(vlan-36)#    untagged A4
HP5406(vlan-36)#    ip address 10.0.36.1 255.255.255.0
HP5406(vlan-36)#    exit
HP5406(config)# vlan 37
HP5406(vlan-37)#    name "VLAN37"
HP5406(vlan-37)#    untagged A5
HP5406(vlan-37)#    ip address 10.0.37.1 255.255.255.0
HP5406(vlan-37)#    exit
HP5406(config)# vlan 38
HP5406(vlan-38)#    name "VLAN38"
HP5406(vlan-38)#    untagged A6
HP5406(vlan-38)#    ip address 10.0.38.1 255.255.255.0
HP5406(vlan-38)#    exit
HP5406(config)# vlan 39
HP5406(vlan-39)#    name "VLAN39"
HP5406(vlan-39)#    untagged A7
HP5406(vlan-39)#    ip address 10.0.39.1 255.255.255.0
HP5406(vlan-39)#    exit
HP5406(config)# vlan 40
HP5406(vlan-40)#    name "VLAN40"
HP5406(vlan-40)#    untagged A8
HP5406(vlan-40)#    ip address 10.0.40.1 255.255.255.0
HP5406(vlan-40)#    exit
```

Next, configure OSPF routing. While OSPF is not strictly necessary, some unicast routing protocol or static routing is required.

```
HP5406(config)# ip routing
HP5406(config)# ip router-id 10.0.32.1
HP5406(config)# router ospf
HP5406(ospf)#    area backbone range 10.0.0.0 255.255.0.0 type summary
HP5406(ospf)#    exit
HP5406(config)# vlan 33
HP5406(vlan-33)#    ip ospf 10.0.33.1 area backbone
HP5406(vlan-33)#    exit
HP5406(config)# vlan 34
HP5406(vlan-34)#    ip ospf 10.0.34.1 area backbone
HP5406(vlan-34)#    exit
HP5406(config)# vlan 35
HP5406(vlan-35)#    ip ospf 10.0.35.1 area backbone
HP5406(vlan-35)#    exit
HP5406(config)# vlan 36
HP5406(vlan-36)#    ip ospf 10.0.36.1 area backbone
HP5406(vlan-36)#    exit
HP5406(config)# vlan 37
HP5406(vlan-37)#    ip ospf 10.0.37.1 area backbone
HP5406(vlan-37)#
HP5406(config)# vlan 38
HP5406(vlan-38)#    ip ospf 10.0.38.1 area backbone
HP5406(vlan-38)#    exit
HP5406(config)# vlan 39
```

```
HP5406(vlan-39)#    ip ospf 10.0.39.1 area backbone
HP5406(vlan-39)#    exit
HP5406(config)# vlan 40
HP5406(vlan-40)#    ip ospf 10.0.40.1 area backbone
HP5406(vlan-40)#    exit
```

Then, enable multicast routing and set the PIM rendezvous point (RP).

```
HP5406(config)# ip multicast-routing
HP5406(config)# router pim
HP5406(pim)#   rp-address 10.0.73.1 224.0.0.0 240.0.0.0
HP5406(pim)#   exit
```

Finally, configure a VLAN to carry traffic between switches, and enable OSPF on that VLAN.

```
HP5406(config)# vlan 43
HP5406(vlan-33)#    name "VLAN43"
HP5406(vlan-33)#    untagged A10
HP5406(vlan-33)#    ip address 10.0.43.1 255.255.255.0
HP5406(vlan-33)#    ip igmp
HP5406(vlan-33)#    exit
HP5406(vlan-33)#    ip ospf 10.0.43.1 area backbone
HP5406(vlan-33)#    ip pim-sparse
HP5406(vlan-33)#       ip-addr any
HP5406(vlan-33)#       exit
HP5406(vlan-33)#    exit
HP5406#    exit
```

## Cisco commands

The following commands apply to a Cisco Catalyst 6509. Except where noted, the syntax is similar for Cisco Catalyst 3750-E and Cisco Catalyst 4506 switches.

First, enable IP multicast routing.

```
Cat6509# configure terminal
Cat6509(config)# ip multicast-routing
```

Command syntax is slightly different on the Cisco Catalyst 3750-E.

```
Cat3750E# configure terminal
Cat3750E(config)# ip routing
Cat3750E(config)# ip multicast-routing distributed
```

Cisco Catalyst 3750-E, Cisco Catalyst 4506, and Cisco Catalyst 6509 switches use the same commands for the remaining steps.

Configure interswitch interfaces with an IP address and support for PIM-SM.

```
Cat6509(config)# interface TenGigabitEthernet5/4
Cat6509(config-if)#  ip address 10.0.201.1 255.255.255.0
```

```
Cat6509(config-if)#  ip pim sparse-mode
Cat6509(config-if)#  exit
```

Then, enable OSPF. Although OSPF is not strictly necessary for IP multicast forwarding, some unicast routing protocol or static routing is required.

```
Cat6509(config)# router ospf 1
Cat6509(config-router)#  log-adjacency-changes
Cat6509(config-router)#  network 10.0.0.0 0.0.255.255 area 0
Cat6509(config-router)#  exit
```

4. Configure a PIM rendezvous point (RP). In the case the RP will be on the HP A9505.

```
Cat6509(config)# ip pim rp-address 10.0.73.1
Cat6509(config)# end
```

### Validation

Once subscribers attached to the HP switches have joined multicast groups by sending IGMP reports with join messages, any multicast traffic for these groups offered to Interface VLAN73 on the HP9505 will be forward to all subscriber ports on the HP switches.

The HP A-series command **`display ip multicast routing-table`** will verify that the HP A5800 and Cisco devices see one another and can exchange multicast information. The HP E-series **`command show ip mrouter`** provides the same verification for HP E5406zl Ethernet switches.

## Virtual router redundancy protocol (VRRP) interoperability

### Objective

To validate failover functionality of the virtual router redundancy protocol (VRRP) between HP Networking and Cisco Catalyst switches configured as routers.

### Background

Two or more routers can make use of VRRP to add redundancy and enhance network availability. With VRRP, all routers share a single virtual IP address. One router acts as the master (active) device, while all others act as backups. If the master router fails (or if a link fails on the interfaces configured with the virtual IP address), one of the backup routers takes over as master.

## Topology

In this example, an HP A9505 switch, HP E5406zl, and Cisco Catalyst 6509 switch are all configured to route IP traffic. The interfaces connecting the switches each have unique IP addresses. A shared virtual IP address of 10.0.41.254/24 is used for VRRP, with the HP E5406zl initially acting as the master.

Figure 5 below illustrates the VRRP validation test bed. The HP switches assign an IP address to VLAN 41, and then assign interfaces to that VLAN. However, VRRP also would work if an IP address was assigned directly to the physical interface, as it is with the Cisco Catalyst 6509.

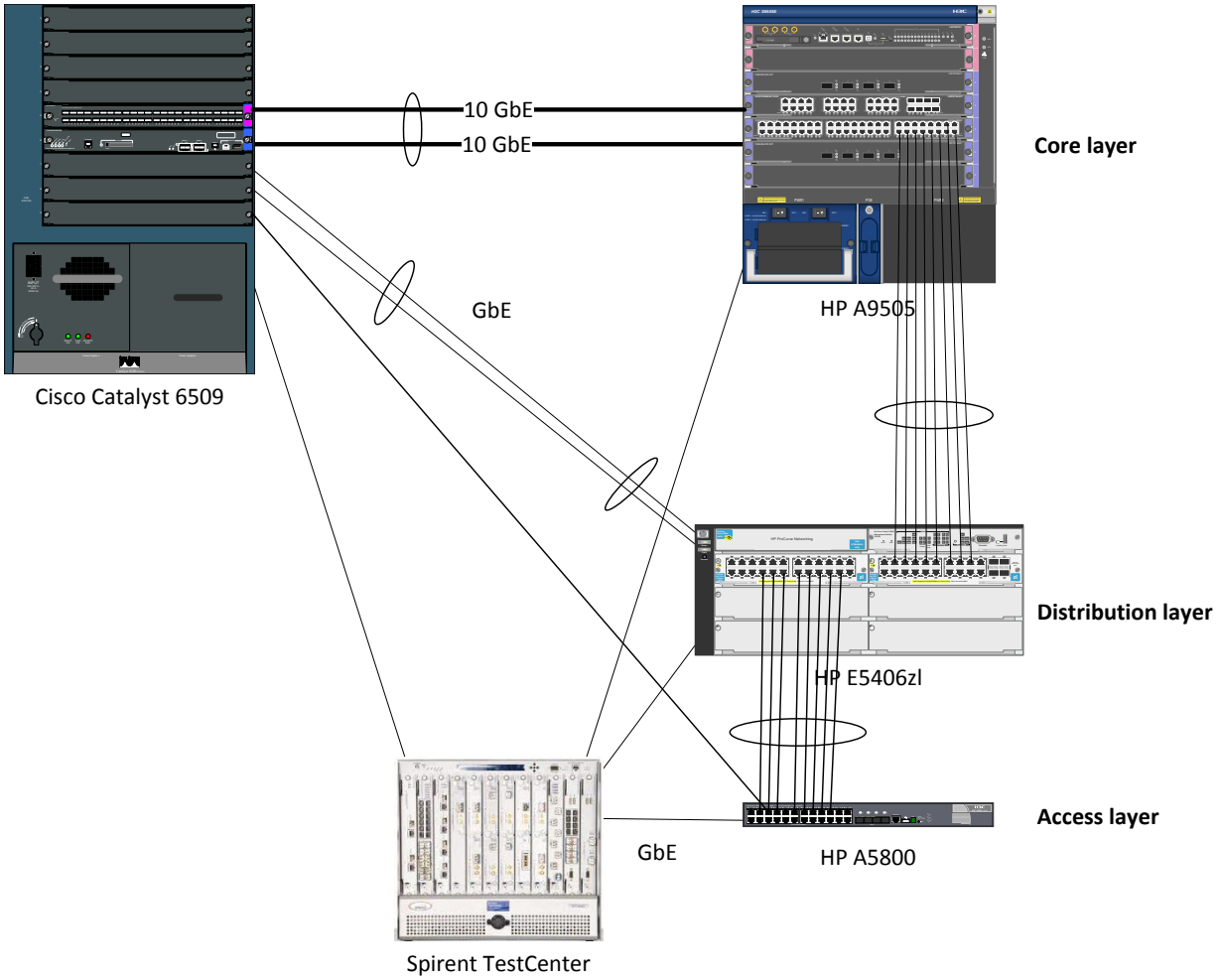


Figure 5: Virtual router redundancy protocol test bed

## HP A-series commands

VRRP configuration is done in the interface configuration context. Here, it is done on the VLAN interface.

```
<HP9505> system-view
[HP9505] interface Vlan-interface41
[HP9505-Vlan-interface41]  ip address 10.0.41.1 255.255.255.0
[HP9505-Vlan-interface41]  vrrp vrid 1 virtual-ip 10.0.41.254
[HP9505-Vlan-interface41]  vrrp vrid 1 priority 254
[HP9505-Vlan-interface41]  quit
[HP9505]  quit
```

## HP E-series commands

First, create and configure the VLAN interface.

```
HP5406ZL# configure
HP5406ZL(config)# vlan 41
HP5406ZL(vlan-41)#    name "VLAN41"
HP5406ZL(vlan-41)#    untagged A10
HP5406ZL(vlan-41)#    ip address 10.0.41.1 255.255.255.0
HP5406ZL(vlan-41)#    exit
```

Next, configure VRRP.

```
HP5406ZL(config)# router vrrp
HP5406ZL(config)# vlan 41
HP5406ZL(vlan-41)#    vrrp vrid 1
HP5406ZL(vlan-41-vrid-1)#       owner
HP5406ZL(vlan-41-vrid-1)#      virtual-ip-address 10.0.41.254 255.255.255.0
HP5406ZL(vlan-41-vrid-1)#      priority 255
HP5406ZL(vlan-41-vrid-1)#      enable
HP5406ZL(vlan-41-vrid-1)#      exit
HP5406ZL(vlan-41-vrid-1)#   exit
HP5406ZL(vlan-41)#   exit
HP5406ZL#   exit
```

## Cisco commands

The following commands apply to a Cisco Catalyst 6509. The syntax is similar for Catalyst 3750-E and Cisco Catalyst 4506 switches.

VRRP configuration is done in the interface configuration context.

```
Cat6509# configure terminal
Cat6509(config)# interface GigabitEthernet4/21
Cat6509(config-if)#  ip address 10.0.41.3 255.255.255.0
```

```
Cat6509(config-if)#  vrrp 1 description VRRP Test
Cat6509(config-if)#  vrrp 1 ip 10.0.41.254
Cat6509(config-if)#  vrrp 1 timers learn
Cat6509(config-if)#  vrrp 1 priority 90
Cat6509(config-if)#  end
```

## Validation

Both the HP E5406zl and Cisco Catalyst 6509 support the **`show vrrp`** command, which will indicate the current VRRP state on each system.

## Appendix A: About Network Test

Network Test is an independent third-party test lab and engineering services consultancy. Our core competencies are performance, security, and conformance assessment of networking equipment and live networks. Our clients include equipment manufacturers, large enterprises, service providers, industry consortia, and trade publications.

## Appendix B: Sample Configuration Files

This appendix lists URLs for the HP and Cisco switch files used to verify interoperability. These files are freely available for download from a public Network Test server.

A copy of this document, a brief interoperability report, and all HP and Cisco configuration files are available at **http://networktest.com/hpiop**.

## Appendix C: Software Releases Tested

This appendix describes the software versions used on the test bed. All tests were conducted in March 2011 at Network Test's facility in Westlake Village, CA, USA.

| Component | Version |
|---|---|
| HP A9505 | 5.20, Release 1238P08 |
| HP E5406zl | K.15.03.0007 |
| HP A5800 | 5.20, Release 1206 |
| Cisco Catalyst 6509 | 12.2(33)SXI2a |
| Cisco Catalyst 4506 | 12.2(20)EWA |
| Cisco Catalyst 3750-E | 12.2(55)SE1 |
| Spirent TestCenter | 3.55.5086.0000 |

## Appendix D: Disclaimer

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