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Configuring and Troubleshooting MPLS VPN

Vinit Jain, CCIE Security, Data Center, SP, and R&S
September 15, 2015
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Cisco Support Community Expert Series Webcast

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#22854
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Agenda

• Introduction to MPLS VPN
  • MPLS VPN Overview
  • Terminologies
  • Understanding MPLS VPN Control Plane and Data Plane
  • Basic MPLS VPN Configuration
  • Live Troubleshooting Demo
Polling Question 1

Why do we need MPLS?

A. BGP free core
B. Scalability
C. Increased Performance
D. All of the above
E. None of the above
Overlay VPN Scenarios

- Internet
- Customer 802.1q VLANs
- Hosted Content Services
- Branch/Head Office VPN Concentration Point

On-Net
- Dial-in Users

Off-Net
- Dial-in Users

Branch/Home Office
- DSL

NAS
- ISDN
- POTS

GRE Tunnel
- L2TP Tunnel
- IPSec Tunnel

Users
- On-Net
- Off-Net
Overlay VPN Model

Layer-3 Routing Adjacency

L2/L3 Virtual Circuit

Provider Edge (PE) Device

CPE (CE) Device

How to Size, or provide, Inter-Site Circuit Capacity?

Full Circuit Mesh Requirement for Optimal Routing

Layer-3 CPE Routing Adjacencies between Sites

Duplicate IP Addressing Capability

Complete Isolation Between Customers

Secure VPN Service
Peer to Peer based VPN Scenarios

- On-Net Dial-in Users
  - ISDN
  - POTS
  - NAS

- Branch/Home Office
  - DSL

- Off-Net Dial-in Users
  - L2TP
  - IPSec

- Internet

- Head Office VPN Concentration Point
- Branch Office

- Customer 802.1q VLANs
- Hosted Content Services
- VPN Client A
Peer to Peer IP-VPN Model

Layer-3 Routing Adjacency

- All VPN Routes Carried in SP IGP
- Duplicate IP Addressing Is Not an Option
- Complex Filters or Dedicated Devices
- Routing between Sites Is Optimal
- Circuit Sizing between Sites No Longer Such an Issue
- Simple Routing Scheme for Customers
RFC 2547 / 4364 MPLS VPN Model

Combined Benefits of Overlay and Peer-to-Peer VPN Models

- Routing between Sites Is Optimal
- Duplicate IP Addressing Capability
- Secure Service
- PE Routers Hold Only Relevant VPN Routes
- Complete Isolation between Customers
- No Complex Filters or Dedicated Routers
MPLS VPN Overview

• Combine benefits of overlay and network models in a scalable manner
  - Overlay (security and isolation between customers)
  - Network (simplified customer routing)

• PE routers only hold routes for attached VPNs
  - Reduces size of PE routing information
  - Proportional to number of VPNs attached

• MPLS used to forward packets (not routing)
  - Full routing within backbone no longer required
Benefits

• Operating Efficiencies – Any to Any routing between sites
• Flexibility & Scalability – Easy to add or move sites.
• Lower cost
• Security
• QoS
MPLS VPN
Terminologies
Terminologies

- Virtual Routing and Forwarding (VRF)
- Route Distinguisher (RD)
- Route Target (RT)
- Multi-Protocol BGP (MP-BGP)
VPN Routing and Forwarding Instance (VRF)

- VRF can be thought of as a virtual router with the following structures:
  - rules to control import/export of routes from/into the VPN routing table
  - set of routing protocols/peers which inject information into the VPN routing table (including static routing)
  - forwarding table based on CEF
VPN Routing and Forwarding Instance (VRF)

Multiple Routing and Forwarding Instances (VRFs) Provide the Separation
VRF and Multiple Routing Instances

- Routing processes run within specific routing contexts
- Populate specific VPN routing table and FIBs (VRF)
- PE-CE Protocols – BGP, OSPF, EIGRP, RIP, Static, (ISIS only on IOS)
Polling Question 2

Can we use VRF without MPLS VPN scenario?

A. No
B. Yes
Route Distinguisher

- Uniqueness of IPv4 prefix achieved through the use of a **Route Distinguisher**
  - RD (64 bits) identifier
  - creates a VPN-V4 Prefix = RD + IPv4 Prefix (96 bits)
  - RD Format:
    - ASN:NN
    - IP_ADDR:NN
Route Target

• Identification of route placement achieved through use of BGP Extended Community Attribute – Route Target

• Used to identify the set of sites to which a particular route should be exported to

• Do not confuse RT with RD
  - Both values can be different
Multi-protocol BGP (MP-BGP)

- Multi-protocol BGP (MP-BGP) defined in RFC 2283
- Provides the ability for BGP to carry routing information other than IPv4
  - Through the use of Address Families
- VPN-V4 Address-Family Defined
  - For use with MPLS VPN Architecture
  - AFI=1, Sub-AFI=128
MPLS VPN

Understanding MPLS VPN Control Plane
Distribution of Local VRF Routes

• PE routers distribute local VPN information across the MPLS VPN backbone
  - Through the use of MP-BGP & redistribution from VRF;
  - Receiving PE imports routes into attached VRFs
VRF Population of MP-BGP

- PE routers translate into VPN-V4 route
  - Assign a RD and RT based on configuration
  - Re-write Next-Hop attribute (to PE loopback)
  - Assign a label based on VRF and/or interface
  - Send MP-BGP update to all PE neighbors
MP-BGP Update Contents

- **VPN-V4 address**
  
  Route Distinguisher (64 bits)
  
  Makes the IPv4 route globally unique
  
  RD is configured in the PE for each VRF

- **IPv4 address (32 bits)**

- **Extended Community attribute (64 bits)**
  
  Route-target (RT): identifies the set of sites the route has to be advertised to
MP-BGP Update Contents

• Any other standard BGP attribute
  - Local Preference
  - MED
  - Next-hop
  - AS_PATH
  - Standard Community

- A Label identifying:
  - The outgoing interface or VRF where a lookup has to be performed (Aggregate / connected)
MP-BGP Update Processing

- Receiving PE routers translate to IPv4 prefix
  - Inserts the route into the relevant VRFs identified by the RT attribute
- The label associated to the VPN-V4 address will be set on packets forwarded towards the destination
Polling Question 3

Which protocols have Labeling capabilities?

A. LDP
B. BGP
C. OSPF / ISIS
D. A & B
E. A & C
MPLS VPN

Understanding MPLS VPN Data Plane
LDP & MP-BGP Label Distribution

- PE and P routers have BGP next-hop reachability through the backbone IGP
- Labels are distributed through LDP corresponding to BGP Next-Hops & through MP-BGP for VPN routes

<table>
<thead>
<tr>
<th>In Label</th>
<th>FEC</th>
<th>Out Label</th>
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<tbody>
<tr>
<td>-</td>
<td>1.1.1.1/32</td>
<td>-</td>
</tr>
</tbody>
</table>

Use label implicit-null for destination 1.1.1.1/32

<table>
<thead>
<tr>
<th>In Label</th>
<th>FEC</th>
<th>Out Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>1.1.1.1/32</td>
<td>POP</td>
</tr>
</tbody>
</table>

Use label 41 for destination 1.1.1.1/32

192.168.2.0/24

VPN-v4 update:
RD: 1:27:192.168.2.0/24, NH=1.1.1.1
RT=1:231, Label=(28)
Ingress PE Label Imposition

- Ingress PE receives normal IP packets
- PE router performs **IP Longest Match** from VPN FIB, finds iBGP next-hop and imposes a stack of labels <IGP, VPN>
MPLS VPN Forwarding

- Penultimate PE router removes the IGP label
- Egress PE router uses the VPN label to select which CE to forward the packet
- VPN label is removed and the packet is routed toward the VPN site using the relevant VRF
Configuration

MPLS VPN
Defining VRF

ip vrf ABC
  rd 1:1
  route-target import 1:1
  route-target export 1:1
  route-target import 2:2

vrf definition ABC
  rd 1:1
  address-family ipv4 unicast
    route-target import 1:1
    route-target export 1:1
    route-target import 2:2
  address-family ipv6 unicast
    . . .
Assigning VRF Interfaces

```bash
interface Gig0/1
  ip vrf forwarding ABC
  ip address 192.168.10.1 255.255.255.252
```
router bgp 100
neighbor 2.2.2.2 remote-as 100
neighbor 2.2.2.2 update-source loopback0

**address-family vpnv4 unicast**
neighbor 2.2.2.2 activate
neighbor 2.2.2.2 send-community [extended | both]

**address-family ipv4 vrf ABC**
neighbor 192.168.10.2 remote-as 65535
neighbor 192.168.10.2 activate

exit-address-family
MPLS VPN

CONFIGURATION DEMO
MPLS VPN
TROUBLESHOOTING DEMO
Resources
Resources

- RFC 4364

- CCO Documentation

- CSC Blog post on Troubleshooting MPLS VPN
  - https://supportforums.cisco.com/blog/12599296/configuring-and-troubleshooting-basic-mpls-layer3-vpn
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