Deploy Layer3 EVPN over Segment Routing MPLS in Nexus 9300

Contents

Introduction

This document describes how to deploy/configure Layer3 (L3) Ethernet VPN (EVPN) over Segment Routing (SR) Multiprotocol Label Switching (MPLS) [Open Shortest Path First (OSPF) / Internal Border Gateway Protocol (iBGP)] on Nexus 9300 products.

Prerequisites

Requirements

Cisco recommends that you have knowledge of these topics:

- Border Gateway Protocol (BGP)
- L3VPN
- EVPN
- SR

Components Used

The information in this document is based on these software and hardware versions:

- SPINE Hardware - 93360YC-FX2 that runs Release 9.3.(3)
- LEAF Hardware - 93240YC-FX2 that runs Release 9.3.(3)
- CLIENT - 93216TC-FX2

The information in this document was created from the devices in a specific lab environment. All of

the devices used in this document started with a cleared (default) configuration. If your network is live, make sure that you understand the potential impact of any command.

Background Information

MPLS L3VPN Recap

A VPN is:

- An IP-based network delivering private network services over a public infrastructure.
- A set of sites that are allowed to communicate with each other privately over the Internet or other public or private networks.

Conventional VPNs are created by configuring a full mesh of tunnels or permanent virtual circuits (PVCs) to all sites in a VPN. This type of VPN is not easy to maintain or expand, as the addition of a new site requires a change to each edge device in the VPN.

MPLS-based VPNs are created in L3 and are based on the peer model. The peer model enables the service provider and the customer to exchange L3 routing information. The service provider relays the data between the customer sites without customer involvement.

MPLS VPNs are easier to manage and expand than conventional VPNs. When a new site is added to an MPLS VPN, only the edge router of the service provider that provides services to the customer site needs to be updated.

These are the components of the MPLS VPN:

- Provider (P) router - Router in the core of the provider network. P routers run MPLS switching and do not attach VPN labels to routed packets. VPN labels are used to direct data packets to the correct private network or customer edge router.
- PE router - Router that attaches the VPN label to incoming packets based on the interface or subinterface on which they are received, and also attaches the MPLS core labels. A PE router attaches directly to a CE router.
- Customer (C) router - Router in the Internet Service Provider (ISP) or enterprise network.
- Customer edge (CE) router - Edge router on the network of the ISP that connects to the PE router on the network. A CE router must interface with a PE router.

Overview of EVPN with L3VPN (MPLS SR)

Data Center (DC) deployments have adopted VXLAN EVPN or MPLS EVPN for its benefits such as EVPN control-plane learning, multitenancy, seamless mobility, redundancy, and easier POD additions. Similarly, the CORE is either a Label Distribution Protocol (LDP)-based MPLS L3VPN network or transitioning from the traditional MPLS L3VPN LDP-based underlay to a more sophisticated solution like SR.

SR is adopted for its benefits such as:

- Unified IGP and MPLS control planes
- Simpler traffic engineering methods
- Easier configuration

- Software-Defined Networking (SDN) adoption

EVPN (RFC 7432) is BGP MPLS-based solution that has been used for next-generation Ethernet services in a virtualized data center network. It uses several building blocks such as Route Distinguisher (RD), Route Target (RT), and Virtual Routing and Forwarding (VRF) from MPLS technologies that exist.

L3 EVPN over SR which was introduced in NXOS 7.0(3)I6(1) release uses the EVPN Type-5 route with MPLS encapsulation. It offers Multi-tenant, Scalability, and High Performance for evolved data center services.

Note: In DC, the data plane can be VXLAN or MPLS.

Traditional MPLS L3 VPN
Main Build Blocks: RD, RT, and VRF
Underlay Layer for Transport: IGP, LDP, and RSVP-TE
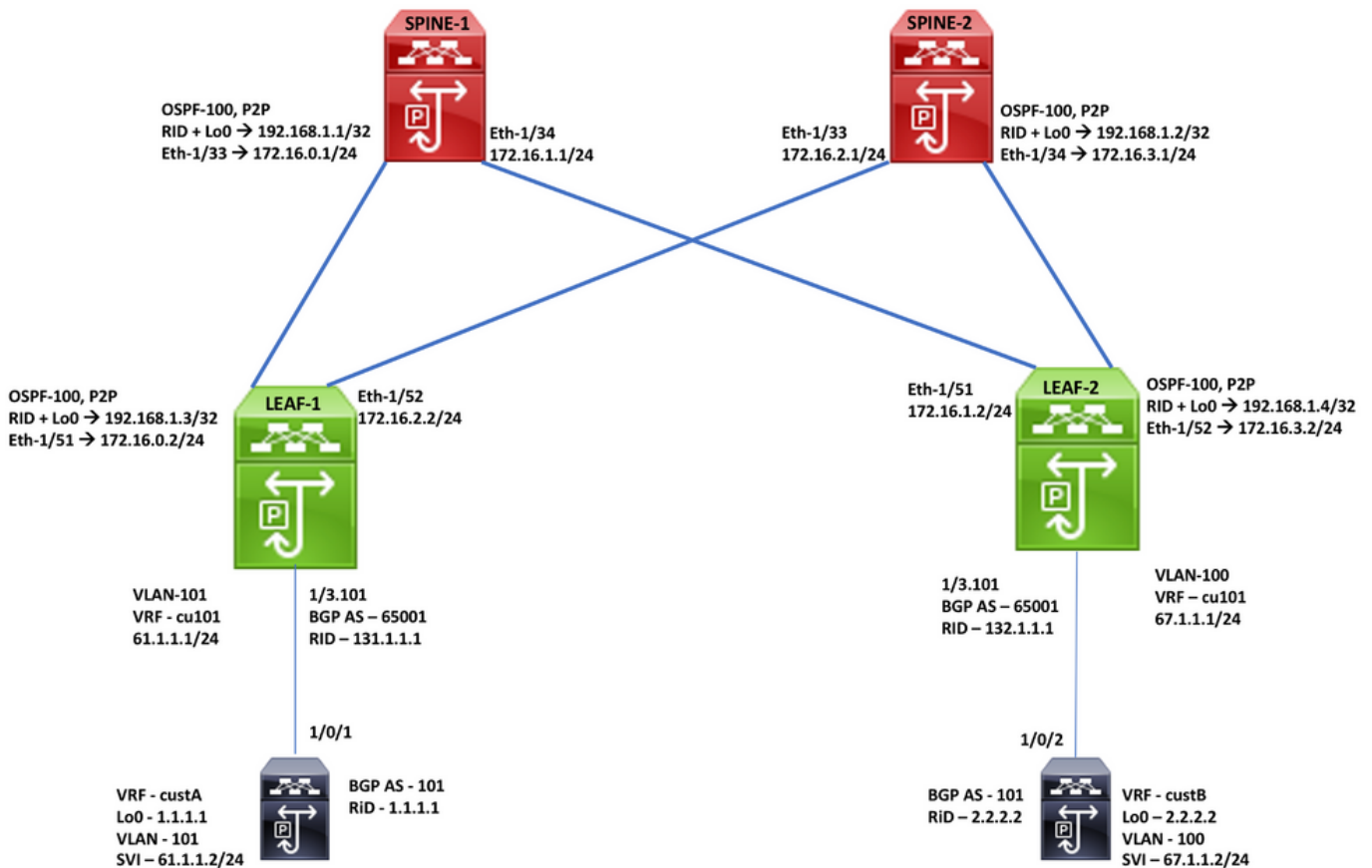Overlay Layer for Service: VPNv4 and VPNv6

MPLS L3 VPN over SR
Main Build Blocks: RD, RT, and VRF
Underlay Layer for Transport: IGP/BGP-LU and S
Overlay Layer for Service: EVPN

Configure

Topology

High-Level Configuration

1. Install Features
2. Configure IP address - Underlay

3. Configure IGP - OSPF

4. Configure MP - BGP

5. Configure VLAN and EVPN Overlay

6. Configure e-BGP between Hosts and LEAFs

SPINE-1 Configuration		
Enabling Features, Label-Range, Route-map, Label-Index	**OSPF Configuration**	**BGP/EVPN Configuration**
feature-set mpls	interface Ethernet1/33	router bgp 65001
feature ospf	ip address 172.16.0.1/24	router-id 192.168.1.1
feature bgp	ip ospf network point-to-point	address-family ipv4 unicast
feature mpls segment-routing	ip router ospf 100 area 0.0.0.0	network 192.168.1.1/32 route-map label-index-spine1
feature mpls evpn	mpls ip forwarding	allocate-label all
feature interface-vlan	no shutdown	address-family ipv4 labeled-unicast
feature mpls oam		address-family l2vpn evpn
	interface Ethernet1/34	template peer EVPN
	ip address 172.16.1.1/24	remote-as 65001
	ip ospf network point-to-point	update-source loopback0
mpls label range 5000 450000	ip router ospf 100 area 0.0.0.0	address-family l2vpn evpn
segment-routing	mpls ip forwarding	send-community extended
mpls	no shutdown	route-reflector-client
global-block 16000 25000		encapsulation mpls
connected-prefix-sid-map		template peer Labeled-unicast
address-family ipv4		remote-as 65001
192.168.1.1/32 index 211	interface loopback0	address-family ipv4 labeled-unicast
	ip address 192.168.1.1/32	send-community extended
	ip router ospf 100 area 0.0.0.0	route-reflector-client
		next-hop-self
route-map label-index-spine1 permit 10		soft-reconfiguration inbound always
set label-index 211	router ospf 100	neighbor 172.16.0.2
	segment-routing mpls	inherit peer Labeled-unicast
	router-id 192.168.1.1	neighbor 172.16.1.2
		inherit peer Labeled-unicast
		neighbor 192.168.1.3
		inherit peer EVPN
		neighbor 192.168.1.4
		inherit peer EVPN

SPINE-2 Configuration		
Enabling Features, Label-Range, Route-map, Label-Index	**OSPF Configuration**	**BGP/EVPN Configuration**
feature-set mpls	interface Ethernet1/33	router bgp 65001
feature ospf	ip address 172.16.2.1/24	router-id 192.168.1.2
feature bgp	ip ospf network point-to-point	address-family ipv4 unicast
feature mpls segment-routing	ip router ospf 100 area 0.0.0.0	network 192.168.1.2/32 route-map label-index-spine2
feature mpls evpn	mpls ip forwarding	allocate-label all
feature interface-vlan	no shutdown	address-family ipv4 labeled-unicast
feature mpls oam		address-family l2vpn evpn
		template peer EVPN
mpls label range 5000 450000	interface Ethernet1/34	remote-as 65001
	ip address 172.16.3.1/24	update-source loopback0
segment-routing	ip ospf network point-to-point	address-family l2vpn evpn
mpls	ip router ospf 100 area 0.0.0.0	send-community extended
global-block 16000 25000	mpls ip forwarding	route-reflector-client
connected-prefix-sid-map	no shutdown	encapsulation mpls
address-family ipv4		template peer Labeled-unicast
192.168.1.2/32 index 221		remote-as 65001
	interface loopback0	address-family ipv4 labeled-unicast
	ip address 192.168.1.2/32	send-community extended
route-map label-index-spine2 permit 10	ip router ospf 100 area 0.0.0.0	route-reflector-client
set label-index 221		next-hop-self
		soft-reconfiguration inbound always
		neighbor 172.16.2.2
	router ospf 100	inherit peer Labeled-unicast
	segment-routing mpls	neighbor 172.16.3.2
	router-id 192.168.1.2	inherit peer Labeled-unicast
		neighbor 192.168.1.3
		inherit peer EVPN
		neighbor 192.168.1.4
		inherit peer EVPN

LEAF-1 Configuration

Enabling Features, Label-Range, Route-map, Label-Index	OSPF Configuration	BGP/EVPN Configuration
feature-set mpls	interface Ethernet1/3.101	router bgp 65001
feature ospf	encapsulation dot1q 101	router-id 192.168.1.3
feature bgp	vrf member cu101	address-family ipv4 unicast
feature mpls segment-routing	ip address 61.1.1.1/24	network 192.168.1.3/32 route-map label-index-leaf-1
feature mpls evpn	no shutdown	allocate-label all
feature interface-vlan		address-family ipv4 labeled-unicast
feature mpls oam	interface Ethernet1/51	address-family l2vpn evpn
	ip address 172.16.0.2/24	template peer EVPN
	ip ospf network point-to-point	remote-as 65001
mpls label range 5000 450000	ip router ospf 100 area 0.0.0.0	update-source loopback0
	mpls ip forwarding	address-family l2vpn evpn
segment-routing	no shutdown	send-community extended
mpls		encapsulation mpls
global-block 16000 25000	interface Ethernet1/52	template peer Labeled-unicast
connected-prefix-sid-map	ip address 172.16.2.2/24	remote-as 65001
address-family ipv4	ip ospf network point-to-point	address-family ipv4 labeled-unicast
192.168.1.3/32 index 311	ip router ospf 100 area 0.0.0.0	send-community extended
	mpls ip forwarding	soft-reconfiguration inbound always
route-map label-index-leaf-1 permit 10	no shutdown	template peer cu1
set label-index 311		address-family ipv4 unicast
		as-override
	interface loopback0	send-community
vrf context cu101	ip address 192.168.1.3/32	soft-reconfiguration inbound always
rd auto	ip router ospf 100 area 0.0.0.0	neighbor 172.16.0.1
address-family ipv4 unicast		inherit peer Labeled-unicast
route-target import 1:101		neighbor 172.16.2.1
route-target import 1:101 evpn	router ospf 100	inherit peer Labeled-unicast
route-target export 1:101	segment-routing mpls	neighbor 192.168.1.1
route-target export 1:101 evpn	router-id 192.168.1.3	inherit peer EVPN
		neighbor 192.168.1.2
		inherit peer EVPN
		vrf cu101
		router-id 131.1.1.1
		address-family ipv4 unicast
		advertise l2vpn evpn
		neighbor 61.1.1.2
		inherit peer cu1
		remote-as 101

LEAF-2 Configuration		
Enabling Features, Label-Range, Route-map, Label-Index	**OSPF Configuration**	**BGP/EVPN Configuration**
feature-set mpls	interface Ethernet1/3.101	router bgp 65001
feature ospf	encapsulation dot1q 100	router-id 192.168.1.4
feature bgp	vrf member cu101	address-family ipv4 unicast
feature mpls segment-routing	ip address 67.1.1.1/24	network 192.168.1.4/32 route-map label-index-Leaf2
feature mpls evpn	no shutdown	allocate-label all
feature interface-vlan		address-family ipv4 labeled-unicast
feature mpls oam	interface Ethernet1/51	address-family l2vpn evpn
	ip address 172.16.1.2/24	template peer EVPN
	ip ospf network point-to-point	remote-as 65001
mpls label range 5000 450000	ip router ospf 100 area 0.0.0.0	update-source loopback0
	mpls ip forwarding	address-family l2vpn evpn
segment-routing	no shutdown	send-community extended
mpls		encapsulation mpls
global-block 16000 25000	interface Ethernet1/52	template peer Labeled-unicast
connected-prefix-sid-map	ip address 172.16.3.2/24	remote-as 65001
address-family ipv4	ip ospf network point-to-point	address-family ipv4 labeled-unicast
192.168.1.4/32 index 321	ip router ospf 100 area 0.0.0.0	send-community extended
	mpls ip forwarding	soft-reconfiguration inbound always
route-map label-index-Leaf2 permit 10	no shutdown	template peer cu1
set label-index 321		address-family ipv4 unicast
	interface loopback0	as-override
	ip address 192.168.1.4/32	send-community
	ip router ospf 100 area 0.0.0.0	soft-reconfiguration inbound always
vrf context cu101		neighbor 172.16.1.1
rd auto		inherit peer Labeled-unicast
address-family ipv4 unicast		neighbor 172.16.3.1
route-target import 1:101	router ospf 100	inherit peer Labeled-unicast
route-target import 1:101 evpn	segment-routing mpls	neighbor 192.168.1.1
route-target export 1:101	router-id 192.168.1.4	inherit peer EVPN
route-target export 1:101 evpn		neighbor 192.168.1.2
		inherit peer EVPN
		vrf cu101
		router-id 132.1.1.1
		address-family ipv4 unicast
		advertise l2vpn evpn
		neighbor 67.1.1.2
		inherit peer cu1
		remote-as 101

End-Host Configuration		
VRF, Loopback Configuration	**Interface, SVI Configuration**	**BGP Configuration**
vrf definition custA	interface GigabitEthernet1/0/1	router bgp 101
rd 101:1	switchport trunk allowed vlan 101	bgp log-neighbor-changes
!	switchport trunk encapsulation dot1q	no bgp default ipv4-unicast
address-family ipv4	switchport mode trunk	!
exit-address-family	!	address-family ipv4 vrf custA
!	interface GigabitEthernet1/0/2	bgp router-id 1.1.1.1
vrf definition custB	switchport trunk allowed vlan 100	network 1.1.1.1 mask 255.255.255.255
rd 101:2	switchport trunk encapsulation dot1q	redistribute connected
!	switchport mode trunk	neighbor 61.1.1.1 remote-as 65001
address-family ipv4		neighbor 61.1.1.1 activate
exit-address-family		neighbor 61.1.1.1 send-community
	interface Vlan100	neighbor 61.1.1.1 soft-reconfiguration inbound
interface Loopback0	vrf forwarding custB	exit-address-family
vrf forwarding custA	ip address 67.1.1.2 255.255.255.0	!
ip address 1.1.1.1 255.255.255.255	!	address-family ipv4 vrf custB
!	interface Vlan101	bgp router-id 2.2.2.2
interface Loopback1	vrf forwarding custA	network 2.2.2.2 mask 255.255.255.255
vrf forwarding custB	ip address 61.1.1.2 255.255.255.0	redistribute connected
ip address 2.2.2.2 255.255.255.255	!	neighbor 67.0.0.1 soft-reconfiguration inbound
		neighbor 67.1.1.1 remote-as 65001
		neighbor 67.1.1.1 activate
		neighbor 67.1.1.1 send-community
		neighbor 67.1.1.1 soft-reconfiguration inbound
		exit-address-family

Verify

Use this section in order to confirm that your configuration works properly.

Leaf 1 Captures : Control Plane and MPLS Data Plane:

```
Leaf1(config)# show ip bgp 1.1.1.1 vrf cu101
BGP routing table information for VRF cu101, address family IPv4 Unicast
BGP routing table entry for 1.1.1.1/32, version 4
Paths: (2 available, best #1)
Flags: (0x880c001a) (high32 0x000020) on xmit-list, is in urib, is best urib route, is in HW, exported, has label
  vpn: version 3, (0x00000000100002) on xmit-list
  local label: 492288

  Advertised path-id 1, VPN AF advertised path-id 1
  Path type: external, path is valid, is best path, no labeled nexthop, in rib
  AS-Path: 101 , path sourced external to AS
    61.1.1.2 (metric 0) from 61.1.1.2 (1.1.1.1)
      Origin IGP, MED 0, localpref 100, weight 0
      Extcommunity: RT:1:101

  Path type: external, path is valid, received only, no labeled nexthop
  AS-Path: 101 , path sourced external to AS
    61.1.1.2 (metric 0) from 61.1.1.2 (1.1.1.1)
      Origin IGP, MED 0, localpref 100, weight 0

  VRF advertise information:
  Path-id 1 not advertised to any peer

  VPN AF advertise information:
  Path-id 1 not advertised to any peer
```

```
Leaf1(config)# show bgp l2vpn evpn 1.1.1.1
BGP routing table information for VRF default, address family L2VPN EVPN
Route Distinguisher: 192.168.1.3:3
BGP routing table entry for [5]:[0]:[32]:[1.1.1.1]/224, version 6
Paths: (1 available, best #1)
Flags: (0x000002) (high32 00000000) on xmit-list, is not in l2rib/evpn, has label
  local label: 492288

  Advertised path-id 1
  Path type: local, path is valid, is best path, no labeled nexthop
  Gateway IP: 0.0.0.0
  AS-Path: 101 , path sourced external to AS
    0.0.0.0 (metric 0) from 0.0.0.0 (192.168.1.3)
      Origin IGP, MED 0, localpref 100, weight 0
      Received label 0
      Extcommunity: RT:1:101

  Path-id 1 advertised to peers:
    192.168.1.1      192.168.1.2
```

```
Leaf1(config)# show bgp ipv4 labeled-unicast 192.168.1.3
BGP routing table information for VRF default, address family IPv4 Label Unicast
BGP routing table entry for 192.168.1.3/32, version 8
Paths: (1 available, best #1)
Flags: (0x20c0002) (high32 00000000) on xmit-list, is not in urib, has label
  label af: version 11, (0x00000000100002) on xmit-list
  local label: 3

  Advertised path-id 1, Label AF advertised path-id 1
  Path type: local, path is valid, is best path, no labeled nexthop
  AS-Path: NONE, path locally originated
    0.0.0.0 (metric 0) from 0.0.0.0 (192.168.1.3)
      Origin IGP, MED not set, localpref 100, weight 32768
      Prefix-SID Attribute: Length: 10
        Label Index TLV: Length 7, Flags 0x0 Label Index 311

  Path-id 1 not advertised to any peer

  Label AF advertisement
  Path-id 1 advertised to peers:
    172.16.0.1      172.16.2.1
```

```
Leaf1(config)# show forwarding mpls 192.168.1.4/32

slot  1
======
```

Local Label	Prefix Table Id	FEC (Prefix/Tunnel id)	Next-Hop	Interface	Out Label	
16321	0x1	192.168.1.4/32	172.16.0.1	Eth1/51	16321	SWAP
"	0x1	192.168.1.4/32	172.16.2.1	Eth1/52	16321	SWAP

Leaf 2 Captures : Control Plane and MPLS Data Plane:

```
Leaf2# show forwarding 1.1.1.1/32 vrf cu101

slot  1
======

IPv4 routes for table cu101/base
```

Prefix	Next-hop	Interface	Labels	Partial Install
*1.1.1.1/32	172.16.1.1	Ethernet1/51	PUSH 16311 492288	
	172.16.3.1	Ethernet1/52	PUSH 16311 492288	

```
Leaf2#
Leaf2#
```

```
Leaf2# show forwarding 172.16.1.1/24

slot  1
======

IPv4 routes for table default/base
```

Prefix	Next-hop	Interface	Labels	Partial Install
172.16.1.0/24	Attached	Ethernet1/51		

```
Leaf2#
Leaf2#
```

```
Leaf2# show forwarding mpls 192.168.1.3/32

slot  1
======
```

Local Label	Prefix Table Id	FEC (Prefix/Tunnel id)	Next-Hop	Interface	Out Label	
16311	0x1	192.168.1.3/32	172.16.1.1	Eth1/51	16311	SWAP
"	0x1	192.168.1.3/32	172.16.3.1	Eth1/52	16311	SWAP

```
Leaf2# show forwarding 192.168.1.3/32

slot  1
======

IPv4 routes for table default/base
```

Prefix	Next-hop	Interface	Labels	Partial Install
192.168.1.3/32	172.16.1.1	Ethernet1/51	PUSH 16311	
	172.16.3.1	Ethernet1/52	PUSH 16311	

Spine 1 Captures

```
spine1# show bgp ipv4 labeled-unicast 1.1.1.1
spine1# show bgp l2vpn evpn 1.1.1.1
BGP routing table information for VRF default, address family L2VPN EVPN
Route Distinguisher: 192.168.1.3:3
BGP routing table entry for [5]:[0]:[0]:[32]:[1.1.1.1]/224, version 5
Paths: (1 available, best #1)
Flags: (0x000002) (high32 00000000) on xmit-list, is not in l2rib/evpn, is not in HW

  Advertised path-id 1
  Path type: internal, path is valid, is best path
  Gateway IP: 0.0.0.0
  AS-Path: 101 , path sourced external to AS
    192.168.1.3 (metric 0) from 192.168.1.3 (192.168.1.3)
      Origin IGP, MED 0, localpref 100, weight 0
      Received label 492288
      Extcommunity: RT:1:101

  Path-id 1 advertised to peers:
    192.168.1.4
```

```
spine1# show bgp ipv4 labeled-unicast 192.168.1.3
BGP routing table information for VRF default, address family IPv4 Label Unicast
BGP routing table entry for 192.168.1.3/32, version 5
Paths: (1 available, best #1)
Flags: (0x820c0012) (high32 00000000) on xmit-list, is in urib, is backup urib route, is in HW, has label
  label af: version 7, (0x00000000100002) on xmit-list
  local label: 16311

  Advertised path-id 1, Label AF advertised path-id 1
  Path type: internal, path is valid, received and used, is best path, no labeled nexthop, in rib
  AS-Path: NONE, path sourced internal to AS
    172.16.0.2 (metric 0) from 172.16.0.2 (192.168.1.3)
      Origin IGP, MED not set, localpref 100, weight 0
      Received label 3
      Prefix-SID Attribute: Length: 10
        Label Index TLV: Length 7, Flags 0x0 Label Index 311

  Path-id 1 not advertised to any peer

  Label AF advertisement
  Path-id 1 advertised to peers:
    172.16.1.2
```

```
spine1# show forwarding mpls 192.168.1.4/32

slot  1
======
```

Local Label	Prefix Table Id	FEC (Prefix/Tunnel id)	Next-Hop	Interface	Out Label	
16321	0x1	192.168.1.4/32	172.16.1.2	Eth1/34	0	SWAP

```
                                          End-Host Captures
endhost#show ip int brief
Interface          IP-Address    OK? Method Status         Protocol    endhost#ping vrf custB 1.1.1.1
Vlan1              unassigned    YES NVRAM  up              up          Type escape sequence to abort.
Vlan100            67.1.1.2      YES manual up              up          Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
Vlan101            61.1.1.2      YES manual up              up          !!!!!
                                                                       Success rate is 100 percent (5/5), round-trip min/avg/max = 1/7/17 ms
Loopback0          1.1.1.1       YES manual up              up
Loopback1          2.2.2.2       YES manual up              up


endhost#ping vrf custA 2.2.2.2                                          endhost#traceroute vrf custB 1.1.1.1
Type escape sequence to abort.                                         Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:       Tracing the route to 1.1.1.1
!!!!!                                                                  VRF info: (vrf in name/id, vrf out name/id)
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/8/17 ms    1 67.1.1.1 0 msec 8 msec 0 msec
                                                                        2 172.16.3.1 0 msec 0 msec 0 msec
                                                                        3 172.16.0.2 0 msec
endhost#traceroute vrf custA 2.2.2.2                                      172.16.2.2 0 msec
Type escape sequence to abort.                                           172.16.0.2 8 msec
Tracing the route to 2.2.2.2                                            4 61.1.1.2 0 msec *  0 msec
VRF info: (vrf in name/id, vrf out name/id)
 1 61.1.1.1 0 msec 17 msec 0 msec
 2 172.16.2.1 17 msec
   172.16.0.1 0 msec
   172.16.2.1 9 msec
 3 172.16.3.2 0 msec
   172.16.1.2 0 msec
   172.16.3.2 17 msec
 4 67.1.1.2 8 msec *  0 msec
endhost#
```

Troubleshoot

There is currently no specific troubleshooting information available for this configuration.

Related Information

- **Multiprotocol BGP MPLS VPN**
- **Segment Routing on Cisco Nexus 9500, 9300, 9200, 3200, and 3100 Platform Switches White paper**
- **Configuring Layer 3 EVPN and Layer 3 VPN over Segment Routing MPLS**
- **Technical Support & Documentation - Cisco Systems**