

# Verify MPLS on Catalyst 9000 Switches

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## Introduction

This document describes the how to configure and validate Multiprotocol Label Switching (MPLS) Layer 3 Virtual Private Network (VPN) on Catalyst 9000 series switches.

## Prerequisites

### Requirements

Cisco recommends that you have knowledge of these topics:

- IP Forwarding
- Border Gateway Protocol (BGP)

- MPLS

## Components Used

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

- C9500 on Cisco IOS® XE 16.12.4
- C9300 on Cisco IOS® XE 16.12.4
- C3850 on Cisco IOS® XE 16.9.6

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, ensure that you understand the potential impact of any command.

## Background Information

MPLS Layer 3 VPNs (L3VPN) use a peer-to-peer model that uses BGP to distribute VPN-related information. A MPLS VPN consists of a set of sites that are interconnected by means of a MPLS provider core network. At each customer site, one or more customer edge (CE) devices attach to one or more provide edge (PE) devices.

In conventional Layer 3 routing, as a packet traverses the network, each switch extracts all the information relevant to forward the packet from the Layer 3 header. This information is then used as an index for a routing table lookup to determine the next hop for the packet.

In the most common case, the only relevant field in the header is the destination address field, but in some cases, other header fields might also be relevant. As a result, the header analysis must be done independently at each switch through which the packet passes. In addition, a complicated table lookup must also be done at each switch.

In label switching, the analysis of the Layer 3 header is done only once. The Layer 3 header is then mapped into a fixed length, unstructured value called **alabel**.

Many different headers can map to the same label, as long as those headers always result in the same choice of next hop. In effect, a label represents **aforwarding equivalence class (FEC)** that is, a set of packets which, however different they can be indistinguishable by the forwarding function.

The initial choice of a label need not be based exclusively on the contents of the Layer 3 packet header; for example, decisions to forward packets at subsequent hops can also be based on other factors.

Once a label is assigned, a short label header is added at the front of the Layer 3 packet. This header is carried across the network as part of the packet. At subsequent hops through each MPLS switch in the network, labels are swapped and decisions are made by means of MPLS forwarding table lookup for the label carried in the packet header. Hence, the packet header does not need to be reevaluated during packet transit through the network. Because the label is of fixed length and unstructured, the MPLS forwarding table lookup process is both straightforward and fast.

Each Label Switching Router (LSR) in the network makes an independent, local decision as to which label value to use to represent a forwarding equivalence class. This association is known as a label binding. Each LSR informs its neighbors of the label bindings it has made. This awareness of label bindings by neighboring switches is facilitated by these protocols:

- Label Distribution Protocol (LDP) - Enables peer LSRs in an MPLS network to exchange label information to support hop-by-hop forwarding in an MPLS network
- Border Gateway Protocol (BGP) - Used to support MPLS Virtual Private Networks (VPNs)

When a labeled packet is sent from LSR A to LSR B, the label value carried by the IP packet is the label value that LSR B assigned to represent the forwarding equivalence class of the packet. Thus, the label value changes as the IP packet traverses the network.

## How to Use this Guide

The guide is broken into two scenarios, and a hardware scale validation section is presented at the end of the document:

- single-hop adjacency within the MPLS core
- Equal Cost Multi-Path (ECMP) adjacencies within the MPLS core
- how to check TCAM usage for scale issues

Each scenario covers verification of prefixes and labels for each MPLS device.

## Terminology

<b>MPLS</b>	Multi-Protocol Label Switching	A high-performance packet forwarding technology that integrates the performance and traffic management capabilities of data link layer (Layer 2) switching with the scalability, flexibility, and performance of network layer (Layer 3) routing.
<b>PE</b>	Provider Edge (switch/router)	The edge device of the provider network that receives IP prefixes from a customer CE, and passes them into the MPLS cloud.
<b>CE</b>	Customer Edge (switch/router)	A device at the customer premises that is connected to the provider edge of a service provider IP/MPLS network.
<b>LDP</b>	Label Discovery Protocol	LDP is a protocol that automatically generates and exchanges labels between routers. Each router locally generates labels for its prefixes and then advertises the label values to its neighbors.
<b>LSPA</b>	Label Switch Path Array	The set of labels to reach a specific MPLS destination. In a typical L3VPN, a router can have IGP + VPN label. If there is a TE tunnel, then you have TE label + IGP + VPN. Catalyst 9000 can support up to 6 labels, and this array of labels is called LSPA.
<b>Label Stack Id</b>	Label Stack Id	A unique index to identify a label stack (allows LSPA sharing).
<b>Label</b>	Label	The MPLS label used for lookup. Multiple labels make up label stack.
<b>Prefix ID</b>	Prefix Identifier	Catalyst 9000 creates a global resource for every prefix (there are as many prefix IDs as there are routes in the case of per-prefix label allocation).
<b>EM</b>	Exact Match	An entry in Hash memory that is a 1:1 match (host route, Directly Connected route).
<b>LPM</b>	Longest Prefix Match	Any route that is /31 or shorter (/32 routes are EM type).
<b>TCAM</b>	Ternary Content-Addressable Memory	A type of memory that stores and queries entries with three different inputs (0, 1, and X). This type of memory must be used in cases where there can be multiple matches for a single input.

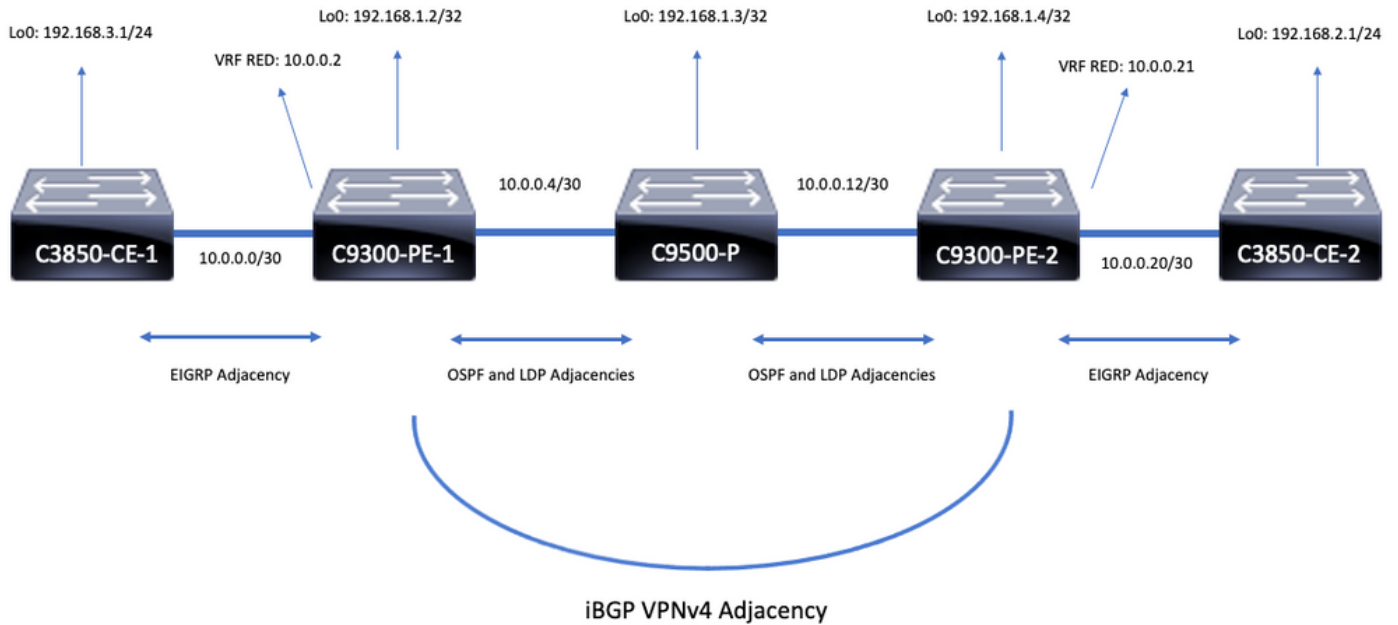
	Addressable Memory	matches to the same entry, and the resulting Hash for each would not be unique. <b>This table includes a mask or "X" value that allows it to know if matches or does not match this entry.</b>
<b>CAM</b>	Content-Addressable Memory	General term for hardware memory (Hash/TCAM).
<b>RIB</b>	Routing Information Base	the routing table seen in 'show ip route'
<b>FIB</b>	Forwarding Information Base	simplified table with prefixes added by the RIB and ARP tables with a pointer to the ADJ table
<b>Directly Connected</b>	Directly Connected Route	A locally connected host prefix (ARP adjacent)
<b>Indirectly Connected</b>	Indirectly Connected Route	A route that is via a remote next hop to reach
<b>ADJ</b>	Adjacency (table)	stores next hop information used for packet rewrite
<b>EM</b>	Exact Match Ternary	Connected hosts, indirect /32 host prefixes
<b>TCAM</b>	Content-Addressable Memory	Indirect prefixes /31 or shorter
<b>FED</b>	Forward Engine Driver	The ASIC (hardware) layer
<b>FMAN-FP</b>	Forward Manager-Forwarding Plane	FMAN-FP manages software objects that add, delete, or modify FED information
<b>SI</b>	Station Index	Station Index = packet rewrite information (RI = Rewrite Index) & outbound interface information (DI = Destination Index)
<b>RI</b>	Rewrite Index	MAC address rewrite information for layer 3 forwarding to the next hop adjacency
<b>DI</b>	Destination Index	Index that points to the outbound interface

## Configure and Verify

### Scenario 1. L3VPN with Single Hop Adjacency in MPLS Core

#### Reference Topology

For the purpose of this example, Catalyst 9300 switches function as the PE devices, Catalyst 9500 in Stackwise Virtual function as the P device, and Catalyst 3850 switches function as the CE devices.



## Configuration Details

### Configuration of C3850-CE-1

```
hostname C3850-CE-1
!
interface Loopback0
ip address 192.168.3.1 255.255.255.0
!
interface TenGigabitEthernet1/0/1
no switchport
ip address 10.0.0.1 255.255.255.252
!
router eigrp 420
network 10.0.0.0 0.0.0.3
network 192.168.3.0 0.0.0.255
eigrp stub connected summary
!
ip route 0.0.0.0 0.0.0.0 10.0.0.2
```

### Configuration of C9300-PE-1

```
hostname C9300-PE-1
!
ip vrf RED
rd 69:69
route-target export 69:69
route-target import 69:69
!
mpls ldp explicit-null
!
interface Loopback0
ip address 192.168.1.2 255.255.255.255
!
interface GigabitEthernet1/0/1
no switchport
ip vrf forwarding RED
ip address 10.0.0.2 255.255.255.252
!
```

```

interface GigabitEthernet1/0/2
no switchport
ip address 10.0.0.5 255.255.255.252
!
router eigrp 420
!
address-family ipv4 vrf RED
network 10.0.0.0 0.0.0.3
autonomous-system 420
exit-address-family
!
router ospf 420
network 0.0.0.0 255.255.255.255 area 0
mpls ldp autoconfig
!
router bgp 69420
bgp log-neighbor-changes
neighbor 192.168.1.4 remote-as 69420
neighbor 192.168.1.4 update-source Loopback0
!
address-family vpnv4
neighbor 192.168.1.4 activate
neighbor 192.168.1.4 send-community extended
exit-address-family
!
address-family ipv4 vrf RED
redistribute eigrp 420
exit-address-family

```

## Configuration of C9500-P

```

hostname C9500-P
!
interface Loopback0
ip address 192.168.1.3 255.255.255.255
!
interface TenGigabitEthernet1/0/1
no switchport
ip address 10.0.0.6 255.255.255.252
!
interface TenGigabitEthernet1/0/2
no switchport
ip address 10.0.0.13 255.255.255.252
!
router ospf 420
network 0.0.0.0 255.255.255.255 area 0
mpls ldp autoconfig

```

## Configuration of C9300-CE-2

```

hostname C9300-PE-2
!
ip vrf RED
rd 69:69
route-target export 69:69
route-target import 69:69
!
mpls ldp explicit-null
!
interface Loopback0
ip address 192.168.1.4 255.255.255.255
!

```

```

interface GigabitEthernet2/0/1
no switchport
ip vrf forwarding RED
ip address 10.0.0.21 255.255.255.252
!
interface GigabitEthernet2/0/2
no switchport
ip address 10.0.0.14 255.255.255.252
!
router eigrp 400
!
address-family ipv4 vrf RED
network 10.0.0.20 0.0.0.3
autonomous-system 400
exit-address-family
!
router ospf 420
network 0.0.0.0 255.255.255.255 area 0
mpls ldp autoconfig
!
router bgp 69420
bgp log-neighbor-changes
neighbor 192.168.1.2 remote-as 69420
neighbor 192.168.1.2 update-source Loopback0
!
address-family vpnv4
neighbor 192.168.1.2 activate
neighbor 192.168.1.2 send-community extended
exit-address-family
!
address-family ipv4 vrf RED
redistribute eigrp 400
exit-address-family

```

## Configuration of C3850-CE-2

```

hostname C3850-CE-2
!
interface Loopback0
ip address 192.168.2.1 255.255.255.0
!
interface TenGigabitEthernet2/0/1
no switchport
ip address 10.0.0.22 255.255.255.252
!
router eigrp 400
network 10.0.0.20 0.0.0.3
network 192.168.2.0 0.0.0.255
eigrp stub connected summary
!
ip route 0.0.0.0 0.0.0.0 10.0.0.21

```

## Basic Verification

Before validation of MPLS programming there are base requirements that need to be validated:

- Validate PE to PE connectivity is present
- Validate the label switched path (LSP) between the PEs
- Validate BGPv4 adjacency between PEs
- Validate VPNv4 and LDP labels
- Validate MPLS Forwarding Table

## Validate PE to PE Connectivity

You can ping the remote PE loopback and source from the local loopback, but this does not confirm the MPLS label switched path (LSP) is good, since the Loopback IP addresses are advertised in the underlay.

**Note:** The PE to PE MP-BGP VPNv4 adjacency is achieved through their respective Loopback0 interfaces.

```
C9300-PE-1#ping 192.168.1.4 source 192.168.1.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.4, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.2
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms C9300-PE-1#show ip route
192.168.1.4
Routing entry for 192.168.1.4/32
Known via "ospf 420", distance 110, metric 3, type intra area
Last update from 10.0.0.10 on GigabitEthernet1/0/3, 00:55:58 ago
Routing Descriptor Blocks:
* 10.0.0.6, from 192.168.1.4, 00:55:58 ago, via GigabitEthernet1/0/2
Route metric is 3, traffic share count is 1
```

## Validate the LSP

You can use a MPLS traceroute from PE to PE loopback to validate the LSP and all MPLS LDP labels along the path.

**Note:** This MPLS traceroute only imposes one label, the LDP label, this does not demonstrate that traffic from the CE is successful, as that traffic is imposed with 2 labels, the VPNv4 (inner) label and the LDP (outer) label.

```
C9300-PE-1#traceroute mpls ipv4 192.168.1.4/32 source 192.168.1.2
Tracing MPLS Label Switched Path to 192.168.1.4/32, timeout is 2 seconds

Codes: '.' - success, 'Q' - request not sent, '.' - timeout,
'L' - labeled output interface, 'B' - unlabeled output interface,
'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
'M' - malformed request, 'm' - unsupported tlvs, 'N' - no label entry,
'P' - no rx intf label prot, 'p' - premature termination of LSP,
'R' - transit router, 'I' - unknown upstream index,
'l' - Label switched with FEC change, 'd' - see DDMAP for return code,
'X' - unknown return code, 'x' - return code 0

Type escape sequence to abort.
 0 10.0.0.5 MRU 1500 [Labels: 17 Exp: 0]
L 1 10.0.0.6 MRU 1500 [Labels: explicit-null Exp: 0] 8 ms
! 2 10.0.0.14 2 ms
```

If you do not have access to the CE or a device behind the CE and you want to demonstrate that there is successful VPNv4 and LDP label imposition/disposition you can attempt to ping from the CE-facing interface in the VRF on a PE to the other CE-facing interface in the VRF on the remote PE.



```
C9300-PE-1#ping vrf RED 10.0.0.21 source 10.0.0.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 10.0.0.21, timeout is 2 seconds:
Packet sent with a source address of 10.0.0.2
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

## Validate BGP VPNv4 adjacency between PEs

```
C9300-PE-1#show bgp vpnv4 unicast all neighbors 192.168.1.4
BGP neighbor is 192.168.1.4, remote AS 69420, internal link
BGP version 4, remote router ID 192.168.1.4
BGP state = Established, up for 00:57:37
Last read 00:00:41, last write 00:00:41, hold time is 180, keepalive interval is 60 seconds
Neighbor sessions:
 1 active, is not multisession capable (disabled)
Neighbor capabilities:
Route refresh: advertised and received(new)
Four-octets ASN Capability: advertised and received
Address family IPv4 Unicast: advertised and received
Address family VPNv4 Unicast: advertised and received
Enhanced Refresh Capability: advertised and received
Multisession Capability:
Stateful switchover support enabled: NO for session 1
Message statistics:
InQ depth is 0
OutQ depth is 0

Sent Rcvd
Opens: 1 1
Notifications: 0 0
Updates: 6 6
Keepalives: 62 63
Route Refresh: 0 0
Total: 69 70
Do log neighbor state changes (via global configuration)
Default minimum time between advertisement runs is 0 seconds
<snip>
```

```
C9300-PE-2#show bgp vpnv4 unicast all neighbors 192.168.1.2
BGP neighbor is 192.168.1.2, remote AS 69420, internal link
BGP version 4, remote router ID 192.168.1.2
BGP state = Established, up for 01:01:00
Last read 00:00:13, last write 00:00:37, hold time is 180, keepalive interval is 60 seconds
Neighbor sessions:
 1 active, is not multisession capable (disabled)
Neighbor capabilities:
Route refresh: advertised and received(new)
Four-octets ASN Capability: advertised and received
Address family IPv4 Unicast: advertised and received
Address family VPNv4 Unicast: advertised and received
Enhanced Refresh Capability: advertised and received
Multisession Capability:
Stateful switchover support enabled: NO for session 1
Message statistics:
InQ depth is 0
OutQ depth is 0

Sent Rcvd
Opens: 1 1
```

Notifications: 0 0  
Updates: 6 6  
Keepalives: 67 66  
Route Refresh: 0 0  
Total: 74 73

Do log neighbor state changes (via global configuration)  
Default minimum time between advertisement runs is 0 seconds

## Remote PE VPNv4 adjacency is up, and a prefix has been received

### C9300-PE-1#show bgp vpnv4 unicast all summary

BGP router identifier 192.168.1.2, local AS number 69420  
BGP table version is 7, main routing table version 7  
4 network entries using 1024 bytes of memory  
4 path entries using 544 bytes of memory  
4/4 BGP path/bestpath attribute entries using 1216 bytes of memory  
4 BGP extended community entries using 1000 bytes of memory  
0 BGP route-map cache entries using 0 bytes of memory  
0 BGP filter-list cache entries using 0 bytes of memory  
BGP using 3784 total bytes of memory  
BGP activity 4/0 prefixes, 4/0 paths, scan interval 60 secs  
4 networks peaked at 16:19:10 Jun 1 2021 UTC (01:32:00.716 ago)

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
192.168.1.4	4	69420	108	108	7	0	0	01:34:52	2

### C9300-PE-2#show bgp vpnv4 unicast all summary

BGP router identifier 192.168.1.4, local AS number 69420  
BGP table version is 7, main routing table version 7  
4 network entries using 1024 bytes of memory  
4 path entries using 544 bytes of memory  
4/4 BGP path/bestpath attribute entries using 1216 bytes of memory  
4 BGP extended community entries using 1000 bytes of memory  
0 BGP route-map cache entries using 0 bytes of memory  
0 BGP filter-list cache entries using 0 bytes of memory  
BGP using 3784 total bytes of memory  
BGP activity 4/0 prefixes, 4/0 paths, scan interval 60 secs  
4 networks peaked at 16:18:31 Jun 1 2021 UTC (01:37:30.404 ago)

Neighbor	V	AS	MsgRcvd	MsgSent	TblVer	InQ	OutQ	Up/Down	State/PfxRcd
192.168.1.2	4	69420	114	114	7	0	0	01:40:22	2

## Verify what prefixes are exchanged in the particular VRF

### C9300-PE-1#show ip bgp vpnv4 vrf RED

BGP table version is 10, local router ID is 192.168.1.2  
Status codes: s suppressed, d damped, h history, \* valid, > best, i - internal,  
r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,  
x best-external, a additional-path, c RIB-compressed,  
t secondary path, L long-lived-stale,  
Origin codes: i - IGP, e - EGP, ? - incomplete  
RPKI validation codes: V valid, I invalid, N Not found

Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher: 69:69 (default for vrf RED)					
*> 10.0.0.0/30	0.0.0.0	0		32768	?
*>i 10.0.0.20/30	192.168.1.4	0	100	0	?
*> 192.168.1.0	10.0.0.1	130816		32768	?
*>i 192.168.2.0	192.168.1.4	130816	100	0	?

### C9300-PE-2#show ip bgp vpnv4 vrf RED

BGP table version is 9, local router ID is 192.168.1.4  
 Status codes: s suppressed, d damped, h history, \* valid, > best, i - internal,  
 r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,  
 x best-external, a additional-path, c RIB-compressed,  
 t secondary path, L long-lived-stale,  
 Origin codes: i - IGP, e - EGP, ? - incomplete  
 RPKI validation codes: V valid, I invalid, N Not found

	Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher:	69:69 (default for vrf RED)					
*>i	10.0.0.0/30	192.168.1.2	0	100	0	?
*>	10.0.0.20/30	0.0.0.0	0		32768	?
*>i	192.168.1.0	192.168.1.2	130816	100	0	?
*>	192.168.2.0	10.0.0.22	130816		32768	?

## Validate VPNv4 and LDP Labels:

## Verify the VPNv4 label that are used to reach the prefixes in the VRF

C9300-PE-1#show ip bgp vpnv4 vrf RED labels

	Network	Next Hop	In label/Out label
Route Distinguisher:	69:69 (RED)		
	10.0.0.0/30	0.0.0.0	20/nolabel(RED)
	10.0.0.20/30	192.168.1.4	nolabel/20
	192.168.1.0	10.0.0.1	21/nolabel
	192.168.2.1/32	192.168.1.4	nolabel/21 <-- VPNv4 label that is imposed to reach

**192.168.2.0**

C9300-PE-1#show ip route vrf RED 192.168.2.1

Routing Table: RED  
 Routing entry for 192.168.2.0/24  
 Known via "bgp 69420", distance 200, metric 130816, type internal  
 Last update from 192.168.1.4 01:31:56 ago  
 Routing Descriptor Blocks:  
 \* 192.168.1.4 (default), from 192.168.1.4, 01:31:56 ago  
 Route metric is 130816, traffic share count is 1  
 AS Hops 0  
 MPLS label: 21 <-- VPNv4 label that matches the previous output  
 MPLS Flags: MPLS Required

C9300-PE-2#show ip bgp vpnv4 vrf RED labels

	Network	Next Hop	In label/Out label
Route Distinguisher:	69:69 (RED)		
	10.0.0.0/30	192.168.1.2	nolabel/20
	10.0.0.20/30	0.0.0.0	20/nolabel(RED)
	192.168.1.0	192.168.1.2	nolabel/21
	192.168.2.0.	10.0.0.22	21/nolabel <-- VPNv4 label that is advertised to reach

**192.168.2.0**

C9300-PE-2#show ip route vrf RED 192.168.2.1

Routing Table: RED  
 Routing entry for 192.168.2.0/24  
 Known via "eigrp 400", distance 90, metric 130816, precedence routine (0), type internal  
 Redistributing via eigrp 400, bgp 69420  
 Advertised by bgp 69420  
 Last update from 10.0.0.22 on GigabitEthernet2/0/1, 01:34:42 ago  
 Routing Descriptor Blocks:  
 \* 10.0.0.22, from 10.0.0.22, 01:34:42 ago, via GigabitEthernet2/0/1 <-- CE-facing interface in  
**the VRF**  
 Route metric is 130816, traffic share count is 1  
 Total delay is 5010 microseconds, minimum bandwidth is 1000000 Kbit

Reliability 255/255, minimum MTU 1500 bytes  
Loading 1/255, Hops 1

## Verify the LDP labels that are utilized

C9300-PE-1#show mpls forwarding-table 192.168.1.4

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next Hop
19	17	192.168.1.4/32	0		Gi1/0/2	10.0.0.6 <-- 17 is the LDP label imposed to reach PE at 192.168.1.4 through Gi1/0/2

C9300-PE-2#show mpls forwarding-table 192.168.1.2

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next Hop
17	16	192.168.1.2/32	0		Gi2/0/2	10.0.0.13 <-- 16 is the LDP label imposed to reach PE at 192.168.1.4 through Gi2/0/2

## Validate the MPLS Forwarding Table

C9300-PE-1#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next Hop
16	Pop Label	192.168.1.3/32	0		Gi1/0/2	10.0.0.6
17	Pop Label	10.0.0.16/30	0		Gi1/0/2	10.0.0.6
18	Pop Label	10.0.0.12/30	0		Gi1/0/2	10.0.0.6
19	17	192.168.1.4/32	0		Gi1/0/2	10.0.0.6
20	No Label	10.0.0.0/30[V]	1982		aggregate/RED	
21	No Label	192.168.3.0/24[V]	\			
			0		Gi1/0/1	10.0.0.1

C9300-PE-2#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Label	Outgoing interface	Next Hop
16	Pop Label	192.168.1.3/32	0		Gi2/0/2	10.0.0.13
	Pop Label	192.168.1.3/32	0		Gi2/0/3	10.0.0.17
17	16	192.168.1.2/32	164		Gi2/0/2	10.0.0.13
	16	192.168.1.2/32	1224		Gi2/0/3	10.0.0.17
18	Pop Label	10.0.0.4/30	0		Gi2/0/2	10.0.0.13
	Pop Label	10.0.0.4/30	0		Gi2/0/3	10.0.0.17
20	No Label	10.0.0.20/30[V]	0		aggregate/RED	
21	No Label	192.168.2.0/24[V]	\			
			1440		Gi2/0/1	10.0.0.22

## Confirm the inner (VPNv4) and outer (LDP) labels used to reach to each given prefix in the VRF

C9300-PE-1#show ip cef vrf RED 192.168.2.0/24 detail

192.168.2.1/32, epoch 0, flags [rib defined all labels]  
recursive via 192.168.1.4 label 21 <-- VPNv4 label  
nexthop 10.0.0.6 GigabitEthernet1/0/2 label 17-(local:19) <-- 17 is the LDP label that is be imposed to reach the remote PE,  
19 is the local LDP label advertised to the P router

C9300-PE-2#show ip cef vrf RED 192.168.3.0/24 detail

192.168.1.1/32, epoch 0, flags [rib defined all labels]  
recursive via 192.168.1.2 label 22 <-- VPNv4 label  
nexthop 10.0.0.13 GigabitEthernet2/0/2 label 16-(local:17) <-- 16 is the LDP label that is be imposed to reach the remote PE,  
17 is the local LDP label advertised to the P router

## Verify Object-Manager Statistics

In ideal scenarios, there are no pending objects

```
C9300-PE-1#show platform software object-manager switch active f0 statistics
```

```
Forwarding Manager Asynchronous Object Manager Statistics
```

```
Object update: Pending-issue: 0, Pending-acknowledgement: 0
Batch begin:   Pending-issue: 0, Pending-acknowledgement: 0
Batch end:     Pending-issue: 0, Pending-acknowledgement: 0
Command:      Pending-acknowledgement: 0
Total-objects: 491
Stale-objects: 0
Resolve-objects: 0
Childless-delete-objects: 0
Error-objects: 0
Paused-types: 0
```

```
9500-P#show platform software object-manager switch active f0 statistics
```

```
Forwarding Manager Asynchronous Object Manager Statistics
```

```
Object update: Pending-issue: 0, Pending-acknowledgement: 0
Batch begin:   Pending-issue: 0, Pending-acknowledgement: 0
Batch end:     Pending-issue: 0, Pending-acknowledgement: 0
Command:      Pending-acknowledgement: 0
Total-objects: 491
Stale-objects: 0
Resolve-objects: 0
Childless-delete-objects: 0
Error-objects: 0
Paused-types: 0
```

```
C9300-PE-2#show platform software object-manager switch active f0 statistics
```

```
Forwarding Manager Asynchronous Object Manager Statistics
```

```
Object update: Pending-issue: 0, Pending-acknowledgement: 0
Batch begin:   Pending-issue: 0, Pending-acknowledgement: 0
Batch end:     Pending-issue: 0, Pending-acknowledgement: 0
Command:      Pending-acknowledgement: 0
Total-objects: 482
Stale-objects: 0
Resolve-objects: 0
Childless-delete-objects: 0
Error-objects: 0
Paused-types: 0
```

## Prefix Programming

The next section covers prefix programming on the MPLS routers, C9300-PE-1, C9500-P, and C9300-PE-2.

### C9300-PE-1 Prefix Programming

```
***Software Prefix Programming***
```

```
C9300-PE-1#show ip route vrf RED 192.168.2.1
```

```
Routing Table: RED
```

```
Routing entry for 192.168.2.0/24
```

```
Known via "bgp 69420", distance 200, metric 130816, type internal
```

Last update from 192.168.1.4 20:21:40 ago

Routing Descriptor Blocks:

\* **192.168.1.4** (default), from 192.168.1.4, 20:21:40 ago <-- **Remote PE reachable in the global routing table**

Route metric is 130816, traffic share count is 1

AS Hops 0

MPLS label: **21** <-- **VPNv4 label**

MPLS Flags: MPLS Required

C9300-PE-1#**show ip route 192.168.1.4**

Routing entry for 192.168.1.4/32

Known via "ospf 420", distance 110, metric 3, type intra area

Last update from 10.0.0.6 on GigabitEthernet1/0/2, 21:27:11 ago

Routing Descriptor Blocks:

\* **10.0.0.6**, from 192.168.1.4, 21:27:11 ago, via **GigabitEthernet1/0/2** <-- **Next-hop 10.0.0.6 via Gi1/0/2 to reach**

Route metric is 3, traffic share count is 1

**\*\*\*FMAN RP Prefix Programming\*\*\***

C9300-PE-1#**show ip vrf detail**

VRF RED (**VRF Id = 2**); default RD 69:69; default VPNID <-- **VRF ID is important in subsequent command**

Old CLI format, supports IPv4 only

Flags: 0xC

Interfaces:

Gi1/0/1

Address family ipv4 unicast (Table ID = 0x2):

Flags: 0x0

Export VPN route-target communities

RT:69:69

Import VPN route-target communities

RT:69:69

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

C9300-PE-1#**show platform software ip switch active r0 cef table index 2 prefix 192.168.2.0/24** <-  
- **Index value is the VRF ID from previous command**

Forwarding Table

Prefix/Len	Next Object	Index
192.168.2.0/24	OBJ_LABEL	<b>0x14</b>

C9300-PE-1#**show platform software mpls switch active r0 label index 0x14** <-- **Utilize the Index value from previous command**

Label OCE 0x14 -> OBJ\_LABEL (**0x17**) <-- **Utilized in next command**

Flags: Real, Number of labels in the OCE: 1

Label values: 0x15

Backup flags: Pop, UHP, backup label 0x100001

OM handle: 0x3480636fb0

C9300-PE-1#**show platform software mpls switch active r0 label index 0x17** <-- **Utilize the OBJ\_LABEL value from previous command**

Label OCE 0x17 -> OBJ\_ADJACENCY (**0x46**) <-- **Utilized in next command**

Flags: Real, Number of labels in the OCE: 1

Label values: 0x11

Backup flags: Pop, UHP, backup label 0x100001

OM handle: 0x348062f858

C9300-PE-1#show platform software adjacency switch active r0 index 0x46 <-- Utilize the OBJ\_ADJACENCY value from previous command

Number of adjacency objects: 6

Adjacency id: 0x46 (70)

Interface: **GigabitEthernet1/0/2**, IF index: 54, Link Type: MCP\_LINK\_TAG <-- **Egress interface**  
Encap: **d4:ad:71:b5:dd:e4:a0:f8:49:11:d1:d6:88:47** <-- **MAC ending in DDE4 is the DMAC, MAC ending in D1D6 is SMAC, 8847 is MPLS ETYPE**

Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500

Flags: unknown

Incomplete behavior type: None

Fixup: unknown

Fixup\_Flags\_2: unknown

Nexthop addr: **10.0.0.6** <-- **Next-hop IP address**

IP FRR MCP\_ADJ\_IPFRR\_NONE 0

OM handle: 0x3480636280

**\*\*\*FMAN FP Prefix Programming\*\*\***

C9300-PE-1#show ip vrf detail

VRF RED (**VRF Id = 2**); default RD 69:69; default VPNID <-- **VRF ID is important in subsequent command**

Old CLI format, supports IPv4 only

Flags: 0xC

Interfaces:

Gi1/0/1

Address family ipv4 unicast (Table ID = 0x2):

Flags: 0x0

Export VPN route-target communities

RT:69:69

Import VPN route-target communities

RT:69:69

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

C9300-PE-1#show platform software ip switch active f0 cef table index 2 prefix 192.168.2.0/24 detail <-- Index value is the VRF ID from previous command

Forwarding Table

192.168.2.0/24 -> OBJ\_LABEL (0x14), urpf: 15 <-- Utilized in next command

Prefix Flags: unknown

aom id: 648, HW handle: (nil) (created)

C9300-PE-1#show platform software mpls switch active f0 label index 0x14 <-- Utilize the OBJ\_LABEL value from the previous command

Label OCE 0x14 -> OBJ\_LABEL (0x17) <-- Utilized in next command

Flags: Real, Number of labels in the OCE: 1

Label values: 0x15

Backup flags: Pop, UHP, backup label 0x100001

aom id: 647, CPP handle: 0xdeadbeef (created)

C9300-PE-1#show platform software mpls switch active f0 label index 0x17 <-- Utilize the OBJ\_LABEL value from the previous command

Label OCE 0x17 -> OBJ\_ADJACENCY (0x46) <-- Utilized in next command

Flags: Real, Number of labels in the OCE: 1

Label values: 0x11

Backup flags: Pop, UHP, backup label 0x100001





C9300-PE-1#show platform hardware fed switch active fwd-asic abstraction print-resource-handle 0x7feeca12bb8 1 <-- Utilize HTM value from previous command

Handle:0x7feeca12bb8 Res-Type:ASIC\_RSC\_HASH\_TCAM Res-Switch-Num:0 Asic-Num:255 Feature-ID:AL\_FID\_L3\_UNICAST\_IPV4 Lkp-ftr-id:LKP\_FEAT\_IPV4\_L3\_UNICAST ref\_count:1  
priv\_ri/priv\_si Handle: (nil)Hardware Indices/Handles: handle [ASIC: 0]: 0x7feeca2af28  
Features sharing this resource:Cookie length: 12  
01 02 a8 c0 00 00 02 d0 07 00 00 00

Detailed Resource Information (ASIC# 0)

-----

Number of HTM Entries: 1

Entry 0: (handle 0x7feeca2af28)

Absolute Index: 66036

Time Stamp: 160003

KEY - vrf:2 mtr:0 **prefix:192.168.2.0** rcp\_redirect\_index:0x0

MASK - vrf:0 mtr:0 **prefix:0.0.0.255** rcp\_redirect\_index:0x0

FWD-AD = afd\_label\_flag:0 icmp\_redir\_enable:1 lvx\_smr\_enabled:0, dstNatType:0 priority:5

afdLabelOrDestClientId:0 SI:182 destined\_to\_us:0 hw\_stats\_idx:0 stats\_id:0

redirectSetRouterMac:0 dgtIdx:0 destModIndex:0 dstNatTypeOrVpnPrefixPtrMsb:0 vpnPrefixPtr:0x2

SRC-AD = learning\_violation:0 need\_to\_learn:0 locally\_connected:0 staticentryViolation:0

rpfValid:1 rpfLe:0 rpfLePointer:0 rpfForcePass:0 rpfForceFail:0 reachableviaSome:0

rpfCheckIncomplete:0 defaultRoute:0 ChainPtrValid:0 ChainPtrOrPortLeIndex:72 UseRpfmatchTable:0

rpfIncomplete:0 is\_src\_ce:0 sgtValid:0 sgt:0 src\_rloc\_trusted:0,sgtCacheControl1 = 0,

sgtCacheControl0 = 0

port\_label:0x0 port\_mask:0x0 vlan\_label:0x0 vlan\_mask:0x0 l3if\_label:0x0 l3if\_mask:0x0

group\_label:0x0 group\_mask:0x0

=====

C9300-PE-1#show platform hardware fed switch active fwd-asic resource asic all destination-index range 0x535f 0x535f <-- Utilize the di\_id from the previous command

ASIC#0:

index = 0x535f

pmap = 0x00000000 0x00000000

cmi = 0x0

rcp\_pmap = 0x0

al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0

ctiLo1 = 0

ctiLo2 = 0

cpuQNum0 = 0

cpuQNum1 = 0

cpuQNum2 = 0

npuIndex = 0

stripSeg = 0

copySeg = 0

ASIC#1:

index = 0x535f

pmap = 0x00000000 **0x00000002** <-- Looking at 0x00000002, in binary that is 0000 0000 0000 0000  
**0000 0000 0000 0010** = Port 1 (Zero based, count right to left)

cmi = 0x0

rcp\_pmap = 0x0

al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0

ctiLo1 = 0

ctiLo2 = 0

cpuQNum0 = 0

cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0

C9300-PE-1#show plat soft fed switch active ifm mappings

Interface	IF_ID	Inst	Asic	Core	Port	SubPort	Mac	Cntx	LPN	GPN	Type	Active
GigabitEthernet1/0/2	0x36	1	0	1	1	0	6	7	2	2	NIF	Y

- Port 1 is the egress port, Gi1/0/2

## C9500-P Prefix Programming

\*\*\*Software Prefix Programming\*\*\*

C9500-P#show ip route 192.168.1.4

Routing entry for 192.168.1.4/32

Known via "ospf 420", distance 110, metric 2, type intra area

Last update from 10.0.0.14 on TenGigabitEthernet1/0/2, 1d21h ago

Routing Descriptor Blocks:

\* 10.0.0.14, from 192.168.1.4, 1d21h ago, via TenGigabitEthernet1/0/2 <-- Next-hop to reach 192.168.1.4

Route metric is 2, traffic share count is 1

C9500-P#show ip cef 192.168.1.4 detail

192.168.1.4/32, epoch 4

dfmt local label info: global/17 [0x3]

nexthop 10.0.0.14 TenGigabitEthernet1/0/2 label explicit-null-(local:17)

\*\*\*FMAN RP Prefix Programming\*\*\*

C9500-P#show platform software ip switch active r0 cef prefix 192.168.1.4/32

Forwarding Table

Prefix/Len	Next Object	Index
192.168.1.4/32	OBJ_LABEL	0x16 <-- Value used in next command

C9500-P#show platform software mpls switch active r0 label index 0x16 <-- Utilize the OBJ\_LABEL value from previous command

Label OCE 0x16 -> OBJ\_ADJACENCY (0x49) <-- Value used in next command

Flags: Real, Number of labels in the OCE: 1

Label values: 0

Backup flags: Pop, UHP, backup label 0x100001

OM handle: 0x34806492f0

C9500-P#show platform software adjacency switch active r0 index 0x49 <-- Utilize OBJ\_ADJACENCY value from previous command

Number of adjacency objects: 8

Adjacency id: 0x49 (73)

Interface: TenGigabitEthernet1/0/2, IF index: 66, Link Type: MCP\_LINK\_TAG

Encap: 70:d3:79:be:ae:71:d4:ad:71:b5:dd:d6:88:47 <-- MAC ending in AE71 is the DMAC, MAC ending in DDD6 is the SMAC, 8847 is MPLS ETYPE

Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500

Flags: unknown

Incomplete behavior type: None

Fixup: unknown

Fixup\_Flags\_2: unknown

Nexthop addr: 10.0.0.14 <-- Next-hop IP

IP FRR MCP\_ADJ\_IPFRR\_NONE 0

OM handle: 0x3480647760

\*\*\*FMAN FP Prefix Programming\*\*\*

C9500-P#show platform software ip switch active f0 cef prefix 192.168.1.4/32 detail  
Forwarding Table

192.168.1.4/32 -> OBJ\_LABEL (0x16), urpf: 21 <-- Used in subsequent command  
Prefix Flags: unknown  
aom id: 567, HW handle: (nil) (created)

C9500-P#show platform software mpls switch active f0 label index 0x16 <-- Utilize the OBJ\_LABEL value from previous command

Label OCE 0x16 -> OBJ\_ADJACENCY (0x49) <-- Used in subsequent command  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 589, CPP handle: 0xdeadbeef (created)

C9500-P#show platform software adjacency switch active f0 index 0x49 <-- Utilize the OBJ\_ADJACENCY from previous command

Number of adjacency objects: 8

Adjacency id: 0x49 (73)

Interface: TenGigabitEthernet1/0/2, IF index: 66, Link Type: MCP\_LINK\_TAG  
Encap: 70:d3:79:be:ae:71:d4:ad:71:b5:dd:d6:88:47 <-- MAC ending in AE71 is the DMAC, MAC ending in DDD6 is the SMAC, 8847 is MPLS ETYPE  
Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500  
Flags: unknown  
Incomplete behavior type: None  
Fixup: unknown  
Fixup\_Flags\_2: unknown  
Nexthop addr: 10.0.0.14 <-- Next-hop IP  
IP FRR MCP\_ADJ\_IPFRR\_NONE 0  
aom id: 535, HW handle: (nil) (created)

\*\*\* FED Prefix Programming\*\*\*

C9500-P#show platform software fed switch active ip route 192.168.1.4/32

vrf	dest	htm	flags	SGT	DGID	MPLS	Last-
-----	------	-----	-------	-----	------	------	-------

---	----	---	-----	---	----	-----	-----
-----	------	-----	-------	-----	------	-------	-------

0	192.168.1.4/32	0x7f790c4cfd8	0x0	0	0		
---	----------------	---------------	-----	---	---	--	--

2021/06/14 22:10:54.150 <-- HTM value significant for next command

FIB: prefix\_hdl:0x6a000020, mpls\_ecr\_prefix\_hdl:0

===== OCE chain =====

LABEL:objid:22 link\_type:MPLS local\_label:17 outlabel:(0, 0) <-- Label 17 is the local transport label

flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0xb9000037

unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0

bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0

AAL: id:3103785015 lbl:0 smac:d4ad.71b5.ddd6 dmac:70d3.79be.ae71 <-- Matches the next-hop information to reach 192.168.1.4/32

sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)

vlan\_id:0 vrf\_id:0 ri:0x7f790c4cfd8, ri\_id:0x38 phdl:0x76000058, ref\_cnt:1

si:0x7f790c4c22f8, si\_id:0x400b, di\_id:0x2 <-- di\_id utilized in subsequent commands

ADJ:objid:73 {link\_type:MPLS ifnum:0x42, si:0x2d000027, }

=====

MPLS info: mpls\_ecr\_scale\_prefix\_adj:0, mpls\_lspa\_hdl:0

=====

C9500-P#show platform hardware fwd-asic abstraction print-resource-handle 0x7f790c4cfd8 1 <-- Utilize the HTM value from previous command

Handle:0x7f790c4cfd8 Res-Type:ASIC\_RSC\_HASH\_TCAM Res-Switch-Num:0 Asic-Num:255 Feature-

ID:AL\_FID\_L3\_UNICAST\_IPV4 Lkp-ftr-id:LKP\_FEAT\_IPV4\_L3\_UNICAST ref\_count:1  
priv\_r/priv\_si Handle: (nil)Hardware Indices/Handles: handle [ASIC: 0]: 0x7f790c4cf2f8  
Features sharing this resource:Cookie length: 12  
04 01 a8 c0 00 00 00 d0 07 00 00 00

Detailed Resource Information (ASIC# 0)

-----

Number of HTM Entries: 1

Entry 0: (handle 0x7f790c4cf2f8)

Absolute Index: 126650

Time Stamp: 40

KEY - vrf:0 mtr:0 **prefix:192.168.1.4** rcp\_redirect\_index:0x0

MASK - vrf:0 mtr:0 **prefix:0.0.0.0** rcp\_redirect\_index:0x0

FWD-AD = afd\_label\_flag:0 icmp\_redir\_enable:1 lvx\_smr\_enabled:0, dstNatType:0 priority:5

afdLabelOrDestClientId:0 SI:16395 destined\_to\_us:0 hw\_stats\_idx:1 stats\_id:0

redirectSetRouterMac:0 dgtIdx:0 destModIndex:0 dstNatTypeOrVpnPrefixPtrMsb:0 vpnPrefixPtr:0

SRC-AD = learning\_violation:0 need\_to\_learn:0 locally\_connected:0 staticentryViolation:0

rpfValid:1 rpfLe:38 rpfLePointer:0 rpfForcePass:0 rpfForceFail:0 reachableviaSome:1

rpfCheckIncomplete:0 defaultRoute:0 ChainPtrValid:0 ChainPtrOrPortLeIndex:72 UseRpfmatchTable:0

rpfIncomplete:0 is\_src\_ce:0 sgtValid:0 sgt:0 src\_rloc\_trusted:0,sgtCacheControl1 = 0,

sgtCacheControl0 = 0

port\_label:0x0 port\_mask:0x0 vlan\_label:0x0 vlan\_mask:0x0 l3if\_label:0x0 l3if\_mask:0x0

group\_label:0x0 group\_mask:0x0

=====

**C9500-P#show platform hardware fed switch active fwd-asic resource asic all destination-index range 0x2 0x2 <-- Utilize the di\_id value from the previous command**

ASIC#0:

index = 0x2

pmap = 0x00000000 0x00000000

cmi = 0x0

rcp\_pmap = 0x0

al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0

ctiLo1 = 0

ctiLo2 = 0

cpuQNum0 = 0

cpuQNum1 = 0

cpuQNum2 = 0

npuIndex = 0

stripSeg = 0

copySeg = 0

ASIC#1:

index = 0x2

pmap = 0x00000000 **0x00000002 <-- 0x00000002 in binary is 0000 0000 0000 0000 0000 0000 0000 =**

**Port 1 (Zero based, count right to left)**

cmi = 0x0

rcp\_pmap = 0x0

al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0

ctiLo1 = 0

ctiLo2 = 0

cpuQNum0 = 0

cpuQNum1 = 0

cpuQNum2 = 0

npuIndex = 0

stripSeg = 0  
copySeg = 0

#### C9500-P#show platform software fed switch active ifm mappings

Interface	IF_ID	Inst	Asic	Core	Port	SubPort	Mac	Cntx	LPN	GPN	Type	Active
TenGigabitEthernet1/0/2	0x42	1	0	1	1	0	10	1	2	2	NIF	Y

- Port 1 is the egress port, TenGig1/0/2

## C9300-PE-2 Prefix Programming

### \*\*\*Software Prefix Programming\*\*\*

C9300-PE-2#show ip route vrf RED 192.168.2.1

Routing Table: RED

Routing entry for 192.168.2.0/24

Known via "eigrp 400", distance 90, metric 130816, precedence routine (0), type internal

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

Last update from 10.0.0.22 on GigabitEthernet2/0/1, 1d21h ago

Routing Descriptor Blocks:

\* **10.0.0.22**, from 10.0.0.22, 1d21h ago, via GigabitEthernet2/0/1 **<-- Next-hop reachable in the VRF**

Route metric is 130816, traffic share count is 1

Total delay is 5010 microseconds, minimum bandwidth is 1000000 Kbit

Reliability 255/255, minimum MTU 1500 bytes

Loading 1/255, Hops 1

C9300-PE-2#show ip route vrf RED 10.0.0.22

Routing Table: RED

Routing entry for 10.0.0.20/30

Known via "connected", distance 0, metric 0 (connected, via interface)

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

Routing Descriptor Blocks:

\* **directly connected**, via GigabitEthernet2/0/1 **<-- Next-hop directly connected**

Route metric is 0, traffic share count is 1

C9300-PE-2#show ip cef vrf RED 192.168.2.0/24 detail

192.168.2.0/24, epoch 0

QOS: Precedence routine (0)

dfilt local label info: other/21 [0x2]

nexthop 10.0.0.22 GigabitEthernet2/0/1

### \*\*\*FMAN RP Prefix Programming\*\*\*

C9300-PE-2#show ip vrf detail

VRF RED (**VRF Id = 2**); default RD 69:69; default VPNID **<-- VRF ID is important in subsequent command**

Old CLI format, supports IPv4 only

Flags: 0xC

Interfaces:

Gi2/0/1

Address family ipv4 unicast (Table ID = 0x2):

Flags: 0x0

Export VPN route-target communities

RT:69:69

Import VPN route-target communities

RT:69:69

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

C9300-PE-2#show platform software ip switch active r0 cef table index 2 prefix 192.168.2.0/24  
Forwarding Table

Prefix/Len	Next Object	Index
192.168.2.0/24	OBJ_ADJACENCY	0x19

C9300-PE-2#show platform software adjacency switch active r0 index 0x19 <-- Utilize the Index value from previous command

Number of adjacency objects: 6

Adjacency id: 0x19 (25)

Interface: GigabitEthernet2/0/1, IF index: 53, Link Type: MCP\_LINK\_IP

Encap: 0:72:78:c8:c9:c2:70:d3:79:be:ae:42:8:0 <-- MAC ending in C9C2 is DMAC, MAC ending in AE42 is SMAC, 0x800 is the IP ETYPE

Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500

Flags: no-l3-inject

Incomplete behavior type: None

Fixup: unknown

Fixup\_Flags\_2: unknown

Nexthop addr: 10.0.0.22

IP FRR MCP\_ADJ\_IPFRR\_NONE 0

OM handle: 0x348062f118

\*\*\*FMAN FP Prefix Programming\*\*\*

C9300-PE-2#show platform software ip switch active f0 cef table index 2 prefix 192.168.2.0/24  
detail

Forwarding Table

192.168.2.0/24 -> OBJ\_ADJACENCY (0x19), urpf: 30 <-- Utilized in next command

Prefix Flags: unknown

aom id: 665, HW handle: (nil) (created)

QPPB precedence: 0

C9300-PE-2#show platform software adjacency switch active f0 index 0x19 <-- Utilize the OBJ\_ADJACENCY from previous command

Number of adjacency objects: 6

Adjacency id: 0x19 (25)

Interface: GigabitEthernet2/0/1, IF index: 53, Link Type: MCP\_LINK\_IP

Encap: 0:72:78:c8:c9:c2:70:d3:79:be:ae:42:8:0

Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500

Flags: no-l3-inject

Incomplete behavior type: None

Fixup: unknown

Fixup\_Flags\_2: unknown

Nexthop addr: 10.0.0.22

IP FRR MCP\_ADJ\_IPFRR\_NONE 0

aom id: 659, HW handle: (nil) (created)

\*\*\*FED Prefix Programming\*\*\*

C9300-PE-2#show platform software fed switch active ip route vrf-name RED 192.168.2.0/24

vrf	dest	htm	flags	SGT	DGID	MPLS	Last-
modified							

--- ---- --- ----- --- ---- -----  
-----

2 192.168.2.0/24 0x7f7fb4a25648 0x0 0 0

2021/06/14 17:04:13.460 <-- HTM value significant for next command

FIB: prefix\_hdl:0x6e00002a, mpls\_ecr\_prefix\_hdl:0

=====  
OCE chain =====

ADJ:objid:25 {link\_type:IP ifnum:0x35, si:0x3300003e, IPv4: 10.0.0.22 }

=====

MPLS info: mpls\_ecr\_scale\_prefix\_adj:0, mpls\_lsps\_hdl:0

=====

**C9300-PE-2#show platform hardware fed switch active fwd-asic abstraction print-resource-handle 0x7f7fb4a25648 1 <-- Utilize HTM value from previous command**

Handle:0x7f7fb4a25648 Res-Type:ASIC\_RSC\_HASH\_TCAM Res-Switch-Num:0 Asic-Num:255 Feature-ID:AL\_FID\_L3\_UNICAST\_IPV4 Lkp-ftr-id:LKP\_FEAT\_IPV4\_L3\_UNICAST ref\_count:1  
priv\_ri/priv\_si Handle: (nil)Hardware Indices/Handles: handle [ASIC: 0]: 0x7f7fb4a10e58  
Features sharing this resource:Cookie length: 12  
01 02 a8 c0 00 00 02 d0 07 00 00 00

Detailed Resource Information (ASIC# 0)

Number of HTM Entries: 1

Entry 0: (handle 0x7f7fb4a10e58)

Absolute Index: 66036  
Time Stamp: 164911  
KEY - vrf:2 mtr:0 prefix:192.168.2.0 rcp\_redirect\_index:0x0  
MASK - vrf:0 mtr:0 prefix:0.0.0.255 rcp\_redirect\_index:0x0  
FWD-AD = afld\_label\_flag:0 icmp\_redir\_enable:1 lvx\_smr\_enabled:0, dstNatType:0 priority:5  
afldLabelOrDestClientId:0 SI:182 destined\_to\_us:0 hw\_stats\_idx:1 stats\_id:0  
redirectSetRouterMac:0 dgtIdx:0 destModIndex:0 dstNatTypeOrVpnPrefixPtrMsb:0 vpnPrefixPtr:0  
SRC-AD = learning\_violation:0 need\_to\_learn:0 locally\_connected:0 staticentryViolation:0  
rpfValid:1 rpfLe:37 rpfLePointer:0 rpfForcePass:0 rpfForceFail:0 reachableviaSome:1  
rpfCheckIncomplete:0 defaultRoute:0 ChainPtrValid:0 ChainPtrOrPortLeIndex:72 UseRpfmatchTable:0  
rpfIncomplete:0 is\_src\_ce:0 sgtValid:0 sgt:0 src\_rloc\_trusted:0,sgtCacheControl1 = 0,  
sgtCacheControl0 = 0  
port\_label:0x0 port\_mask:0x0 vlan\_label:0x0 vlan\_mask:0x0 l3if\_label:0x0 l3if\_mask:0x0  
group\_label:0x0 group\_mask:0x0

=====

**C9300-PE-2#show platform software fed switch active ip adj**

IPV4 Adj entries

dest	if_name	dst_mac	si_hdl	ri_hdl	pd_flags
10.0.0.22	GigabitEthernet2/0/1	0072.78c8.c9c2	<b>0x7f7fb4a44048</b>	0x7f7fb4b089d8	0x0

0x19 2021/06/14 16:59:43.447 <-- **si\_hdl used in next command**

**C9300-PE-2#show platform hardware fed switch active fwd-asic abstraction print-resource-handle 0x7f7fb4a44048 1 <-- Utilize the si\_hdl value from previous command**

Handle:0x7f7fb4a44048 Res-Type:ASIC\_RSC\_SI Res-Switch-Num:255 Asic-Num:255 Feature-ID:AL\_FID\_L3\_UNICAST\_IPV4 Lkp-ftr-id:LKP\_FEAT\_INVALID ref\_count:1  
priv\_ri/priv\_si Handle: 0x7f7fb4b089d8Hardware Indices/Handles: index0:0xb6  
mtu\_index/l3u\_ri\_index0:0x0 index1:0xb6 mtu\_index/l3u\_ri\_index1:0x0  
Features sharing this resource:66 (1)]  
Cookie length: 56  
00 00 00 00 00 00 00 00 25 00 00 00 00 00 00 00 00 00 00 00 08 00 00 72 78 c8 c9 c2 00 00 00 00  
00 00

Detailed Resource Information (ASIC# 0)

Station Index (SI) [0xb6]  
RI = 0x2b  
DI = **0x5338**

stationTableGenericLabel = 0  
stationFdConstructionLabel = 0x7  
lookupSkipIdIndex = 0  
rcpServiceId = 0  
dejaVuPreCheckEn = 0  
Replication Bitmap: CD

Detailed Resource Information (ASIC# 1)

-----

Station Index (SI) [0xb6]  
RI = 0x2b  
DI = **0x5338**  
stationTableGenericLabel = 0  
stationFdConstructionLabel = 0x7  
lookupSkipIdIndex = 0  
rcpServiceId = 0  
dejaVuPreCheckEn = 0  
Replication Bitmap: LD

=====

C9300-PE-2#**show platform hardware fed switch active fwd-asic resource asic all destination-index range 0x5338 0x5338** <-- Utilize the DI value from previous command  
ASIC#0:

index = 0x5338  
pmap = 0x00000000 0x00000000  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0  
ASIC#1:

index = 0x5338  
pmap = 0x00000000 **0x00000001** <-- **0x00000001 in binary is 0000 0000 0000 0000 0000 0000 0000 0001 = Port 0 (Zero based, count right to left)**  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0

C9300-PE-2#**show platform software fed switch active ifm map**

Interface	IF_ID	Inst	Asic	Core	Port	SubPort	Mac	Cntx	LPN	GPN	Type	Active
GigabitEthernet2/0/1	0x35	1	0	1	<b>0</b>	0	26	6	1	97	NIF	Y <-



- Port 0 is the egress port, Gi2/0/1

## VPNv4 Label Programming

The next section covers VPNv4 label programming on the MPLS PE routers, C9300-PE-1 and C9300-PE-2. The C9500 does not forward on the VPNv4 label so there is no output from the C9500.

C9300-PE-1 VPNv4 Label Programming:

**Check** the local prefix to the PE, not the remote prefix.

### \*\*\*Software VPNv4 Label Programming\*\*\*

```
C9300-PE-1#show ip cef vrf RED 192.168.3.0/24 detail
192.168.3.0/24, epoch 0
  QOS: Precedence routine (0)
  dflt local label info: other/22 [0x2] <-- VPNv4 label associated with the local prefix
  nexthop 10.0.0.1 GigabitEthernet1/0/1
```

### \*\*\*FMAN RP VPNv4 Label Programming\*\*\*

```
C9300-PE-1#show platform software mpls switch active r0 eos index 24 <-- Utilize the objid from
the FED command
```

```
EOS Choice 0x18, Number of paths: 2
  Next Object Type: OBJ_ADJ_DROP,OBJ_LABEL
  Next Object Index: 0,0x17
  OM handle: 0x3480631760
```

### \*\*\*FMAN FP VPNv4 Label Programming\*\*\*

```
C9300-PE-1#show platform software mpls switch active f0 eos index 24 <-- Utilize the objid from
the FED command
```

```
EOS Choice 0x18, Number of paths: 2
  Next Object Type: OBJ_ADJ_DROP,OBJ_LABEL
  Next Object Index: 0,0x17
  aom id: 5748, CPP handle: 0xdeadbeef (created), flags: 0 <-- Utilized in subsequent command
```

```
C9300-PE-1#show platform software object-manager switch active f0 object 5748 <-- Utilize the
aom id from previous command
```

```
Object identifier: 5748
  Description: EOS Choice 0x18
  Status: Done, Epoch: 0, Client data: 0x63150908
```

```
C9300-PE-1#show platform software object-manager switch active f0 object 5748 parents <--
Utilize the aom id
```

```
Object identifier: 7
  Description: Special Object adj_drop
  Status: Done
```

```
Object identifier: 5746
  Description: label 0x17
  Status: Done
```

### \*\*\*FED VPNv4 Label Programming\*\*\*

```
C9300-PE-1#show platform software fed switch active mpls forwarding label 22 detail
LENTRY:label:22 nobj:(EOS, 24) lentry_hdl:0x800000a
  modify_cnt:1 backwalk_cnt:0
```

```

lspa_handle:0
AAL: id:134217738 lbl:22
    eos0:[adj_hdl:0, hw_hdl:0x7fa4c4d72e08]
    eos1:[adj_hdl:0x6e00003e, hw_hdl:0x7fa4c4d72c58]
    deagg_vrf_id = 0 lspa_handle:0
EOS:objid:24 local_label:0 flags:0:() pdfflags:0 <-- Utilized in previous commands
nobj0:(ADJ SPECIAL,DROP 0), nobj1:(LABEL, 23) modify:0 bwalk:0
LABEL:objid:23 link_type:IP local_label:22 outlabel:(1048577, 0)
    flags:0xc:(UHP,POP,) pdfflags:0x2:(INSTALL_HW_OK,) adj_handle:0x6e00003e
    unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
    bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
    AAL: id:1845493822 lbl:0 smac:a0f8.4911.d1e4 dmac:0072.78c8.06e4
        sub_type:0 link_type:0 adj_flags:0x2 label_type:1 rewrite_type:POP2IP(135)
        vlan_id:0 vrf_id:0 ri:0x7fa4c4a81af8, ri_id:0x44 phdl:0xf1000024, ref_cnt:1
        si:0x7fa4c4d83da8, si_id:0x4012, di_id:0x5338
    ADJ:objid:113 {link_type:IP ifnum:0x35, si:0x2000003a, IPv4:      10.0.0.1 }

```

## Verify C9300-PE-2 VPNv4 Label:

Check the local prefix to the PE, not the remote prefix

### \*\*\*Software VPNv4 Label Programming\*\*\*

```

C9300-PE-2#show ip cef vrf RED 192.168.2.0/24 detail
192.168.2.0/24, epoch 0
  QOS: Precedence routine (0)
  dflt local label info: other/21 [0x2] <-- VPNv4 label associated with local prefix
  nexthop 10.0.0.22 GigabitEthernet2/0/1

```

### \*\*\* FMAN RP VPNv4 Label Programming\*\*\*

```

C9300-PE-2#show platform software mpls switch active r0 eos index 61 <-- Use the objid from the
FED command

```

```

EOS Choice 0x3d, Number of paths: 2
  Next Object Type: OBJ_ADJ_DROP,OBJ_LABEL
  Next Object Index: 0,0x3b
  OM handle: 0x348063f2f8

```

### \*\*\* FMAN FP VPNv4 Label Programming\*\*\*

```

C9300-PE-2#show platform software mpls switch active f0 eos index 61 <-- Use the objid from the
FED command

```

```

EOS Choice 0x3d, Number of paths: 2
  Next Object Type: OBJ_ADJ_DROP,OBJ_LABEL
  Next Object Index: 0,0x3b
  aom id: 3541, CPP handle: 0xdeadbeef (created), flags: 0 <-- Utilized in subsequent command

```

```

C9300-PE-2#show platform software object-manager switch active f0 object 3541 <-- Use the aom id
from previous command

```

```

Object identifier: 3541
  Description: EOS Choice 0x3d
  Status: Done, Epoch: 0, Client data: 0x11079188

```

```

C9300-PE-2#show platform software object-manager switch active f0 object 3541 parents <-- Use
the aom id from previous command

```

```

Object identifier: 7
  Description: Special Object adj_drop
  Status: Done

```

```

Object identifier: 3540

```

Description: label 0x3b  
Status: Done

### \*\*\* FED VPNv4 Label Programming\*\*\*

```
C9300-PE-2#show platform software fed switch active mpls forwarding label 21 detail
LENTRY:label:21 nobj:(EOS, 61) lentry_hdl:0x69000009
  modify_cnt:3 backwalk_cnt:0
  lsp_handle:0
  AAL: id:1761607689 lbl:21
    eos0:[adj_hdl:0, hw_hdl:0x7fe8f8a71bd8]
    eos1:[adj_hdl:0x49000040, hw_hdl:0x7fe8f8a72458]
    deagg_vrf_id = 0 lsp_handle:0
  EOS:objid:61 local_label:0 flags:0:( ) pdflags:0 <-- Utilized in previous commands
  nobj0:(ADJ SPECIAL,DROP 0), nobj1:(LABEL, 59) modify:0 bwalk:0
  LABEL:objid:59 link_type:IP local_label:21 outlabel:(1048577, 0)
    flags:0xc:(UHP,POP,) pdflags:0x2:(INSTALL_HW_OK,) adj_handle:0x49000040
    unsupported_recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
    bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
    AAL: id:1224736832 lbl:0 smac:70d3.79be.ae42 dmac:0072.78c8.c9c2
      sub_type:0 link_type:0 adj_flags:0x2 label_type:1 rewrite_type:POP2IP(135)
      vlan_id:0 vrf_id:0 ri:0x7fe8f8a8ab98, ri_id:0x44 phdl:0xf1000024, ref_cnt:1
      si:0x7fe8f8a6ae08, si_id:0x4006, di_id:0x5338
    ADJ:objid:25 {link_type:IP ifnum:0x35, si:0x800003e, IPv4:      10.0.0.22 }
```

## LDP Label Programming

The next section covers LDP label programming on the MPLS routers, C9300-PE-1, C9500-P, and C9300-PE-2.

The LDP (outer) label is what the MPLS network label-switches the packets on. Validate the local LDP label that is advertised to the remote PE, do not validate the remote LDP label.

C9300-PE-1 LDP Label Programming:

**Validate** the local LDP label that is advertised to the remote PE, do not validate the remote LDP label. Check the label from a FED perspective and then backtrack to FMAN RP and FMAN FP.

### \*\*\*Software LDP Label Programming\*\*\*

```
C9300-PE-1#show mpls forwarding-table
Local      Outgoing   Prefix          Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id    Switched      interface
16         Pop Label  192.168.1.3/32  0             Gi1/0/2    10.0.0.6
18         Pop Label  10.0.0.12/30   0             Gi1/0/2    10.0.0.6
19        17         192.168.1.4/32  0             Gi1/0/2    10.0.0.6 <-- LDP Label 19 is
advertised to Remote PE 192.168.1.4, validate LDP label 19
20         No Label   10.0.0.0/30[V]  1890          aggregate/RED
22         No Label   192.168.3.0/24[V] \
                                         1982          Gi1/0/1    10.0.0.1
```

### \*\*\*FMAN RP LDP Label Programming\*\*\*

```
C9300-PE-1#show platform software mpls switch active r0 label index 59
```

```
Label OCE 0x3b -> OBJ_ADJACENCY (0x46)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0x11
  Backup flags: Pop, UHP, backup label 0x100001
  OM handle: 0x34805f3dc8
```

\*\*\*FMAN FP LDP Label Programming\*\*\*

C9300-PE-1#show platform software mpls switch active f0 label index 59

Label OCE 0x3b -> OBJ\_ADJACENCY (0x46)
Flags: Real, Number of labels in the OCE: 1
Label values: 0x11
Backup flags: Pop, UHP, backup label 0x100001
aom id: 7065, CPP handle: 0xdeadbeef (created)

C9300-PE-1#show platform software object-manager switch active f0 object 7065

Object identifier: 7065
Description: label 0x3b
Status: Done, Epoch: 0, Client data: 0x63152218

C9300-PE-1#show platform software object-manager switch active f0 object 7065 parents

Object identifier: 511
Description: adj 0x46, Flags None
Status: Done

\*\*\*FED LDP Label Programming\*\*\*

C9300-PE-1#show platform software fed switch active mpls forwarding label 19 detail

LENTRY:label:19 nobj:(LABEL, 59) lentry\_hdl:0xef000007
modify\_cnt:7 backwalk\_cnt:0
lspa\_handle:0
AAL: id:4009754631 lbl:19
eos0:[adj\_hdl:0x91000056, hw\_hdl:0x7fa4c4d6cae8]
eos1:[adj\_hdl:0x91000056, hw\_hdl:0x7fa4c4d6c8e8]
deagg\_vrf\_id = 0 lspa\_handle:0
LABEL:objid:59 link\_type:MPLS local\_label:19 outlabel:(17, 0)
flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0x91000056
unsupported\_recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0
AAL: id:2432696406 lbl:0 smac:a0f8.4911.d1d6 dmac:d4ad.71b5.dde4
sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)
vlan\_id:0 vrf\_id:0 ri:0x7fa4c4d75fa8, ri\_id:0x26 phdl:0x9f00004b, ref\_cnt:1
si:0x7fa4c4d5f6c8, si\_id:0x4013, di\_id:0x535f
ADJ:objid:70 {link\_type:MPLS ifnum:0x36, si:0x25000021, }

C9500 LDP Label Programming:

Validate the local LDP label that is advertised to the remote PE, do not validate the remote LDP label. Check the label from a FED perspective and then backtrack to FMAN RP and FMAN FP.

\*\*\*Software LDP Label Programming\*\*\*

C9500-P#show mpls forwarding-table

Table with 6 columns: Local Label, Outgoing Label, Prefix or Tunnel Id, Bytes Switched, Outgoing interface, Next Hop. Includes entries for 16 and 17 with explanatory text like 'LDP label 16 is advertised to reach PE 192.168.1.2'.

\*\*\*FMAN RP LDP Label Programming\*\*\*

C9500-P#show platform software mpls switch active r0 label index 23 <-- Use the obj id from the FED command

Label OCE 0x17 -> OBJ\_ADJACENCY (0x3f)
Flags: Real, Number of labels in the OCE: 1

Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x3480645150

**\*\*\*FMAN FP LDP Label Programming\*\*\***

C9500-P#show platform software mpls switch active f0 label index 23 <-- Use the obj id from the FED command

Label OCE 0x17 -> OBJ\_ADJACENCY (0x3f)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 654, CPP handle: 0xdeadbeef (created)

C9500-P#show platform software object-manager switch active f0 object 654 <-- Use the aom id from the previous command

Object identifier: 654  
Description: label 0x17  
Status: Done, Epoch: 0, Client data: 0x4b41c08

C9500-P#show platform software object-manager switch active f0 object 654 parents <-- Use the aom id from the previous command

Object identifier: 515  
Description: adj 0x3f, Flags None  
Status: Done

**\*\*\*FED LDP Label Programming\*\*\***

C9500-P#show platform software fed switch active mpls forwarding label 16 detail

LENTRY:label:16 nobj:(LABEL, 23) lentry\_hdl:0xec000004  
modify\_cnt:6 backwalk\_cnt:0  
lspa\_handle:0  
AAL: id:3959422980 lbl:16  
eos0:[adj\_hdl:0xc3000055, hw\_hdl:0x7f28944be3c8]  
eos1:[adj\_hdl:0xc3000055, hw\_hdl:0x7f28944be1b8]  
deagg\_vrf\_id = 0 lspa\_handle:0  
LABEL:objid:23 link\_type:MPLS local\_label:16 outlabel:(0, 0) <-- Utilized in previous commands  
flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0xc3000055  
unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0  
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0  
AAL: id:3271557205 lbl:0 smac:d4ad.71b5.dde4 dmac:a0f8.4911.d1d6  
sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)  
vlan\_id:0 vrf\_id:0 ri:0x7f289449bf88, ri\_id:0x44 phdl:0xe9000057, ref\_cnt:1  
si:0x7f2894489b58, si\_id:0x4009, di\_id:0x1  
ADJ:objid:63 {link\_type:MPLS ifnum:0x41, si:0x57000023, }

**\*\*\*Software LDP Label Programming\*\*\***

C9500-P#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
16	explicit-n	192.168.1.2/32	23409	Tel1/0/1	10.0.0.5
17	explicit-n	192.168.1.4/32	23345	Tel1/0/2	10.0.0.14

**\*\*\*FMAN RP LDP Label Programming\*\*\***

C9500-P#show platform software mpls switch active r0 label index 64 <-- Use the obj id from the FED command

Label OCE 0x40 -> OBJ\_ADJACENCY (0x49)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x3480641d08

\*\*\*FMAN FP LDP Label Programming\*\*\*

C9500-P#show platform software mpls switch active f0 label index 64 <-- Use the obj id from the FED command

Label OCE 0x40 -> OBJ\_ADJACENCY (0x49)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 657, CPP handle: 0xdeadbeef (created)

C9500-P#show platform software object-manager switch active f0 object 657 <-- Use the aom id value from previous command

Object identifier: 657  
Description: label 0x40  
Status: Done, Epoch: 0, Client data: 0x4b523f8

C9500-P#show platform software object-manager switch active f0 object 657 parents<-- Use the aom id value from previous command

Object identifier: 535  
Description: adj 0x49, Flags None  
Status: Done

\*\*\*FED LDP Label Programming\*\*\*

C9500-P#show platform software fed switch active mpls forwarding label 17 detail

LENTRY:label:17 nobj:(LABEL, 64) lentry\_hdl:0x8d000005  
modify\_cnt:6 backwalk\_cnt:0  
lspa\_handle:0  
AAL: id:2365587461 lbl:17  
eos0:[adj\_hdl:0xcc000037, hw\_hdl:0x7f2894480438]  
eos1:[adj\_hdl:0xcc000037, hw\_hdl:0x7f2894480228]  
deagg\_vrf\_id = 0 lspa\_handle:0  
LABEL:objid:64 link\_type:MPLS local\_label:17 outlabel:(0, 0) <-- Utilized in previous commands  
flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0xcc000037  
unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0  
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0  
AAL: id:3422552119 lbl:0 smac:d4ad.71b5.ddd6 dmac:70d3.79be.ae71  
sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)  
vlan\_id:0 vrf\_id:0 ri:0x7f2894498008, ri\_id:0x38 phdl:0x76000058, ref\_cnt:1  
si:0x7f2894498478, si\_id:0x400b, di\_id:0x2  
ADJ:objid:73 {link\_type:MPLS ifnum:0x42, si:0x3d000027, }

C9300-PE-2 LDP Label Programming:

**Validate** the local LDP label that is advertised to the remote PE, do not validate the remote LDP label. Check the label from a FED perspective and then backtrack to FMAN RP and FMAN FP.

\*\*\*Software LDP Label Programming\*\*\*

C9300-PE-2#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
16	Pop Label	192.168.1.3/32	0	Gi2/0/2	10.0.0.13
<b>17</b>	16	192.168.1.2/32	630	Gi2/0/2	10.0.0.13 <-- LDP label 17 is advertised to Remote PE 192.168.1.2
18	Pop Label	10.0.0.4/30	0	Gi2/0/2	10.0.0.13
20	No Label	10.0.0.20/30[V]	1260	aggregate/RED	
21	No Label	192.168.2.0/24[V]	\		

C9300-PE-2#**show platform software mpls switch active r0 label index 82 <-- Utilize the obj id value from the FED Command**

```
Label OCE 0x52 -> OBJ_ADJACENCY (0x46)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0x10
  Backup flags: Pop, UHP, backup label 0x100001
  OM handle: 0x348063ad00
```

C9300-PE-2#**show platform software mpls switch active f0 label index 82 <-- Utilize the obj id value from the FED Command**

```
Label OCE 0x52 -> OBJ_ADJACENCY (0x46)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0x10
  Backup flags: Pop, UHP, backup label 0x100001
  aom id: 3624, CPP handle: 0xdeadbeef (created) <-- Used in next commands
```

C9300-PE-2#**show platform software object-manager switch active f0 object 3624 <-- Utilize the aom id value**

```
Object identifier: 3624
  Description: label 0x52
  Status: Done, Epoch: 0, Client data: 0x11071668
```

C9300-PE-2#**show platform software object-manager switch active f0 object 3624 parents <-- Utilize the aom id value**

```
Object identifier: 496
  Description: adj 0x46, Flags None
  Status: Done
```

C9300-PE-2#**show platform software fed switch active mpls forwarding label 17 detail**

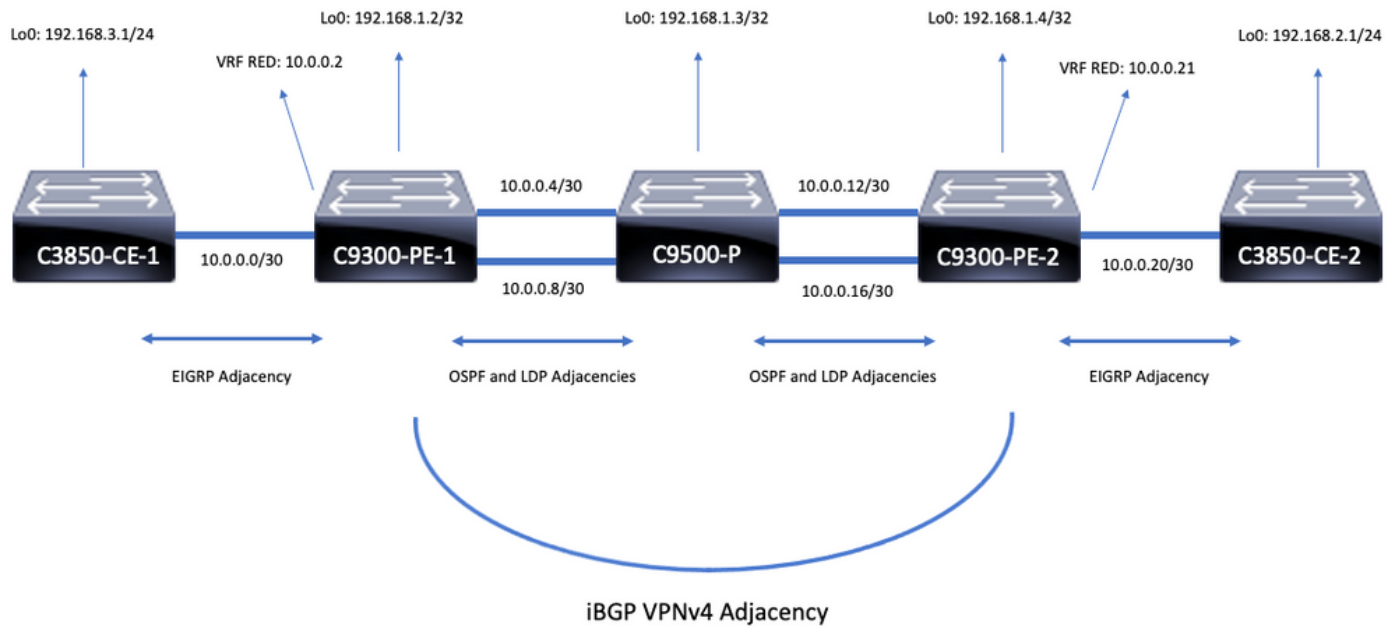
```
LENTRY:label:17 nobj:(LABEL, 82) lentry_hdl:0x44000005
  modify_cnt:6 backwalk_cnt:0
  lsp_handle:0
  AAL: id:1140850693 lbl:17
    eos0:[adj_hdl:0x5f000032, hw_hdl:0x7fe8f8a52798]
    eos1:[adj_hdl:0x5f000032, hw_hdl:0x7fe8f8a52588]
    deagg_vrf_id = 0 lsp_handle:0
  LABEL:objid:82 link_type:MPLS local_label:17 outlabel:(16, 0) <-- Used in previous commands
  flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0x5f000032
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:1593835570 lbl:0 smac:70d3.79be.ae71 dmac:d4ad.71b5.ddd6
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7fe8f8a93c78, ri_id:0x3a phdl:0x9f00004b, ref_cnt:1
    si:0x7fe8f8a91188, si_id:0x4011, di_id:0x535f
  ADJ:objid:70 {link_type:MPLS ifnum:0x36, si:0xaa000021, }
```

## Scenario 2. L3VPN with ECMP Between PEs and P Routers

### Reference Topology

For the purpose of this example, Catalyst 3850 switches function as CE devices, Catalyst 9300 switches function as PE devices, Catalyst 9500 in Stackwise Virtual function as the P device. EIGRP runs between the CE and PE devices, OSPF and LDP adjacencies in the MPLS core, with

an iBGP VPNv4 adjacency between the PE devices. Within the MPLS core, there is ECMP between the PE and P devices.



## Configuration Details

### Configuration of C3850-CE-1

```
hostname C3850-CE-1
!
interface Loopback0
ip address 192.168.3.1 255.255.255.0
!
interface TenGigabitEthernet1/0/1
no switchport
ip address 10.0.0.1 255.255.255.252
!
router eigrp 420
network 10.0.0.0 0.0.0.3
network 192.168.3.0
eigrp stub connected summary
!
ip route 0.0.0.0 0.0.0.0 10.0.0.2
```

### Configuration of C9300-PE-1

```
hostname C9300-PE-1
!
ip vrf RED
rd 69:69
route-target export 69:69
route-target import 69:69
!
mpls ldp explicit-null
!
interface Loopback0
ip address 192.168.1.2 255.255.255.255
!
interface GigabitEthernet1/0/1
```



```

no switchport
ip vrf forwarding RED
ip address 10.0.0.2 255.255.255.252
!
interface GigabitEthernet1/0/2
no switchport
ip address 10.0.0.5 255.255.255.252
!
interface GigabitEthernet1/0/3
no switchport
ip address 10.0.0.9 255.255.255.252
!
router eigrp 420
!
address-family ipv4 vrf RED
network 10.0.0.0 0.0.0.3
autonomous-system 420
exit-address-family
!
router ospf 420
network 0.0.0.0 255.255.255.255 area 0
mpls ldp autoconfig
!
router bgp 69420
bgp log-neighbor-changes
neighbor 192.168.1.4 remote-as 69420
neighbor 192.168.1.4 update-source Loopback0
!
address-family vpnv4
neighbor 192.168.1.4 activate
neighbor 192.168.1.4 send-community extended
exit-address-family
!
address-family ipv4 vrf RED
redistribute eigrp 420
exit-address-family

```

## Configuration of C9500-P

```

hostname C9500-P
!
interface Loopback0
ip address 192.168.1.3 255.255.255.255
!
interface TenGigabitEthernet1/0/1
no switchport
ip address 10.0.0.6 255.255.255.252
!
interface TenGigabitEthernet1/0/2
no switchport
ip address 10.0.0.13 255.255.255.252
!
interface TenGigabitEthernet2/0/1
no switchport
ip address 10.0.0.10 255.255.255.252
!
interface TenGigabitEthernet2/0/2
no switchport
ip address 10.0.0.17 255.255.255.252
!
router ospf 420
network 0.0.0.0 255.255.255.255 area 0
mpls ldp autoconfig

```

## Configuration of C9300-PE-2

```
hostname C9300-PE-2
!
ip vrf RED
rd 69:69
route-target export 69:69
route-target import 69:69
!
mpls ldp explicit-null
!
interface Loopback0
ip address 192.168.1.4 255.255.255.255
!
interface GigabitEthernet2/0/1
no switchport
ip vrf forwarding RED
ip address 10.0.0.21 255.255.255.252
!
interface GigabitEthernet2/0/2
no switchport
ip address 10.0.0.14 255.255.255.252
!
interface GigabitEthernet2/0/3
no switchport
ip address 10.0.0.18 255.255.255.252
!
router eigrp 400
!
address-family ipv4 vrf RED
network 10.0.0.20 0.0.0.3
autonomous-system 400
exit-address-family
!
router ospf 420
passive-interface GigabitEthernet2/0/24
network 0.0.0.0 255.255.255.255 area 0
mpls ldp autoconfig
!
router bgp 69420
bgp log-neighbor-changes
neighbor 192.168.1.2 remote-as 69420
neighbor 192.168.1.2 update-source Loopback0
!
address-family vpnv4
neighbor 192.168.1.2 activate
neighbor 192.168.1.2 send-community extended
exit-address-family
!
address-family ipv4 vrf RED
redistribute eigrp 400
exit-address-family
```

## Configuration of C3850-CE-2

```
hostname C3850-CE-2
!
interface Loopback0
ip address 192.168.2.1 255.255.255.0
!
interface TenGigabitEthernet2/0/1
```

```

no switchport
ip address 10.0.0.22 255.255.255.252
!
router eigrp 400
network 10.0.0.20 0.0.0.3
network 192.168.2.0
eigrp stub connected summary
!
ip route 0.0.0.0 0.0.0.0 10.0.0.21

```

## Basic Validation

Before validation of MPLS programming there are base requirements that need to be validated:

- Validate PE to PE connectivity is present
- Validate the label switched path (LSP) between the PEs
- Validate BGPv4 adjacency between PEs
- Validate VPNv4 and LDP labels
- Validate MPLS Forwarding Table

### Validate PE to PE Connectivity

You can ping the remote PE loopback and source from the local loopback, but this does not confirm the MPLS label switched path (LSP) is good, since the Loopback IP addresses are advertised in the underlay.

**Note:** The PE to PE MP-BGP VPNv4 adjacency is achieved through their respective Loopback0 interfaces.

```

C9300-PE-1#ping 192.168.1.4 source 192.168.1.2
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.1.4, timeout is 2 seconds:
Packet sent with a source address of 192.168.1.2
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

```

```

C9300-PE-1#show ip route 192.168.1.4
Routing entry for 192.168.1.4/32
  Known via "ospf 420", distance 110, metric 3, type intra area
  Last update from 10.0.0.10 on GigabitEthernet1/0/3, 18:39:30 ago
  Routing Descriptor Blocks:
    10.0.0.10, from 192.168.1.4, 18:39:30 ago, via GigabitEthernet1/0/3
      Route metric is 3, traffic share count is 1
    * 10.0.0.6, from 192.168.1.4, 18:39:30 ago, via GigabitEthernet1/0/2
      Route metric is 3, traffic share count is 1

```

### Validate the LSP

You can use a MPLS traceroute from PE to PE loopback to validate the LSP and all MPLS LDP labels along the path.

**Note:** This MPLS traceroute only imposes one label, the LDP label, this does not demonstrate that traffic from the CE is successful, as that traffic is imposed with 2 labels, the VPNv4 (inner) label and the LDP (outer) label.

```
C9300-PE-1#tracert mpls ipv4 192.168.1.4/32 source 192.168.1.2
Tracing MPLS Label Switched Path to 192.168.1.4/32, timeout is 2 seconds
```

```
Codes: '!' - success, 'Q' - request not sent, '.' - timeout,
'L' - labeled output interface, 'B' - unlabeled output interface,
'D' - DS Map mismatch, 'F' - no FEC mapping, 'f' - FEC mismatch,
'M' - malformed request, 'm' - unsupported tlvs, 'N' - no label entry,
'P' - no rx intf label prot, 'p' - premature termination of LSP,
'R' - transit router, 'I' - unknown upstream index,
'l' - Label switched with FEC change, 'd' - see DDMAP for return code,
'X' - unknown return code, 'x' - return code 0
```

Type escape sequence to abort.

```
0 10.0.0.5 MRU 1500 [Labels: 17 Exp: 0]
L 1 10.0.0.6 MRU 1500 [Labels: explicit-null Exp: 0] 7 ms
! 2 10.0.0.18 1 ms
```

If you do not have access to the CE or a device behind the CE and you want to demonstrate that there is successful VPNv4 and LDP label imposition/disposition you can attempt to ping from the CE-facing interface in the VRF on a PE to the other CE-facing interface in the VRF on the remote PE.

```
C9300-PE-1#ping vrf RED 10.0.0.21 source 10.0.0.2
```

Type escape sequence to abort.

```
Sending 5, 100-byte ICMP Echos to 10.0.0.21, timeout is 2 seconds:
Packet sent with a source address of 10.0.0.2
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

## Validate BGP VPNv4 adjacency between PEs

```
C9300-PE-1#show bgp vpnv4 unicast all neighbors 192.168.1.4
```

```
BGP neighbor is 192.168.1.4, remote AS 69420, internal link
  BGP version 4, remote router ID 192.168.1.4
  BGP state = Established, up for 18:40:49
  Last read 00:00:40, last write 00:00:47, hold time is 180, keepalive interval is 60 seconds
  Neighbor sessions:
    1 active, is not multisession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Address family VPNv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multisession Capability:
      Stateful switchover support enabled: NO for session 1
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

      Sent          Rcvd
  Opens:             1           1
  Notifications:    0           0
  Updates:           4           4
  Keepalives:       1237        1233
  Route Refresh:    0           0
  Total:            1242        1238

  Do log neighbor state changes (via global configuration)
  Default minimum time between advertisement runs is 0 seconds
<snip>
```

```

C9300-PE-2#show bgp vpnv4 unicast all neighbors 192.168.1.2
BGP neighbor is 192.168.1.2, remote AS 69420, internal link
  BGP version 4, remote router ID 192.168.1.2
  BGP state = Established, up for 18:41:36
  Last read 00:00:42, last write 00:00:32, hold time is 180, keepalive interval is 60 seconds
  Neighbor sessions:
    1 active, is not multiseession capable (disabled)
  Neighbor capabilities:
    Route refresh: advertised and received(new)
    Four-octets ASN Capability: advertised and received
    Address family IPv4 Unicast: advertised and received
    Address family VPNv4 Unicast: advertised and received
    Enhanced Refresh Capability: advertised and received
    Multiseession Capability:
      Stateful switchover support enabled: NO for session 1
  Message statistics:
    InQ depth is 0
    OutQ depth is 0

                Sent          Rcvd
Opens:           1            1
Notifications:   0            0
Updates:         4            4
Keepalives:     1234         1238
Route Refresh:   0            0
Total:          1239         1243
Do log neighbor state changes (via global configuration)
Default minimum time between advertisement runs is 0 seconds

```

## Remote PE VPNv4 adjacency is up, and a prefix has been received

```

C9300-PE-1#show bgp vpnv4 unicast all summary
BGP router identifier 192.168.1.2, local AS number 69420
BGP table version is 7, main routing table version 7
4 network entries using 1024 bytes of memory
4 path entries using 544 bytes of memory
4/4 BGP path/bestpath attribute entries using 1216 bytes of memory
4 BGP extended community entries using 1000 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 3784 total bytes of memory
BGP activity 4/0 prefixes, 4/0 paths, scan interval 60 secs
4 networks peaked at 18:49:56 Jun 23 2021 UTC (18:41:06.070 ago)

Neighbor      V          AS MsgRcvd MsgSent  TblVer  InQ  OutQ  Up/Down  State/PfxRcd
192.168.1.4   4          69420   1240   1244      7     0     0 18:41:59         2

```

```

C9300-PE-2#show bgp vpnv4 unicast all summary
BGP router identifier 192.168.1.4, local AS number 69420
BGP table version is 7, main routing table version 7
4 network entries using 1024 bytes of memory
4 path entries using 544 bytes of memory
4/4 BGP path/bestpath attribute entries using 1216 bytes of memory
4 BGP extended community entries using 1000 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
BGP using 3784 total bytes of memory
BGP activity 4/0 prefixes, 4/0 paths, scan interval 60 secs
4 networks peaked at 18:49:37 Jun 23 2021 UTC (18:41:06.851 ago)

Neighbor      V          AS MsgRcvd MsgSent  TblVer  InQ  OutQ  Up/Down  State/PfxRcd
192.168.1.2   4          69420   1244   1240      7     0     0 18:42:17         2

```

## Verify what prefixes are exchanged in the particular VRF

```
C9300-PE-1#show ip bgp vpnv4 vrf RED
```

```
BGP table version is 7, local router ID is 192.168.1.2
```

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
               x best-external, a additional-path, c RIB-compressed,
               t secondary path, L long-lived-stale,
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
RPKI validation codes: V valid, I invalid, N Not found
```

	Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher:	69:69 (default for vrf RED)					
*>	10.0.0.0/30	0.0.0.0	0		32768	?
*>i	10.0.0.20/30	192.168.1.4	0	100	0	?
*>i	192.168.2.0	192.168.1.4	130816	100	0	?
*>	192.168.3.0	10.0.0.1	130816		32768	?

```
C9300-PE-2#show ip bgp vpnv4 vrf RED
```

```
BGP table version is 7, local router ID is 192.168.1.4
```

```
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
               x best-external, a additional-path, c RIB-compressed,
               t secondary path, L long-lived-stale,
```

```
Origin codes: i - IGP, e - EGP, ? - incomplete
```

```
RPKI validation codes: V valid, I invalid, N Not found
```

	Network	Next Hop	Metric	LocPrf	Weight	Path
Route Distinguisher:	69:69 (default for vrf RED)					
*>i	10.0.0.0/30	192.168.1.2	0	100	0	?
*>	10.0.0.20/30	0.0.0.0	0		32768	?
*>	192.168.2.0	10.0.0.22	130816		32768	?
*>i	192.168.3.0	192.168.1.2	130816	100	0	?

## Validate VPNv4 and LDP Labels

```
C9300-PE-1#show ip bgp vpnv4 vrf RED labels
```

Network	Next Hop	In label/Out label
Route Distinguisher: 69:69 (RED)		
10.0.0.0/30	0.0.0.0	20/nolabel(RED)
10.0.0.20/30	192.168.1.4	nolabel/20
192.168.2.0	192.168.1.4	nolabel/21 <-- VPNv4 label that is be imposed to reach
<b>192.168.20</b>		
192.168.3.0	10.0.0.1	21/nolabel

```
C9300-PE-1#show ip route vrf RED 192.168.2.1
```

```
Routing Table: RED
```

```
Routing entry for 192.168.2.0/24
```

```
Known via "bgp 69420", distance 200, metric 130816, type internal
```

```
Last update from 192.168.1.4 18:41:56 ago
```

```
Routing Descriptor Blocks:
```

```
* 192.168.1.4 (default), from 192.168.1.4, 18:41:56 ago
```

```
Route metric is 130816, traffic share count is 1
```

```
AS Hops 0
```

```
MPLS label: 21 <-- VPNv4 label that matches the previous output
```

```
MPLS Flags: MPLS Required
```

C9300-PE-2#show ip bgp vpnv4 vrf RED labels

Network	Next Hop	In label/Out label
Route Distinguisher: 69:69 (RED)		
10.0.0.0/30	192.168.1.2	nolabel/20
10.0.0.20/30	0.0.0.0	20/nolabel(RED)
192.168.2.0	10.0.0.22	<b>21/nolabel &lt;-- VPNv4 label that is advertised to reach 192.168.2.0</b>
192.168.3.0	192.168.1.2	nolabel/21

C9300-PE-2#show ip route vrf RED 192.168.2.1

Routing Table: RED

Routing entry for 192.168.2.0/24

Known via "eigrp 400", distance 90, metric 130816, precedence routine (0), type internal

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

Last update from 10.0.0.22 on GigabitEthernet2/0/1, 18:45:04 ago

Routing Descriptor Blocks:

\* 10.0.0.22, from 10.0.0.22, 18:45:04 ago, via GigabitEthernet2/0/1 <-- **CE-facing interface in the VRF**

Route metric is 130816, traffic share count is 1

Total delay is 5010 microseconds, minimum bandwidth is 1000000 Kbit

Reliability 255/255, minimum MTU 1500 bytes

Loading 1/255, Hops 1

## Verify the LDP labels that are utilized

C9300-PE-1#show mpls forwarding-table 192.168.1.4

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
19	<b>17</b>	192.168.1.4/32	0	Gi1/0/2	10.0.0.6 <-- <b>17 is the LDP label imposed to reach PE at 192.168.1.4 through Gi1/0/2</b>
	<b>17</b>	192.168.1.4/32	0	Gi1/0/3	10.0.0.10 <-- <b>17 is the LDP label imposed to reach PE at 192.168.1.4 through Gi1/0/3</b>

C9300-PE-2#show mpls forwarding-table 192.168.1.2

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
17	<b>16</b>	192.168.1.2/32	0	Gi2/0/2	10.0.0.13 <-- <b>16 is the LDP label imposed to reach PE at 192.168.1.2 through Gi2/0/2</b>
	<b>16</b>	192.168.1.2/32	0	Gi2/0/3	10.0.0.17 <-- <b>16 is the LDP label imposed to reach PE at 192.168.1.2 through Gi2/0/3</b>

## Validate the MPLS Forwarding Table

C9300-PE-1#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
16	Pop Label	192.168.1.3/32	0	Gi1/0/2	10.0.0.6
	Pop Label	192.168.1.3/32	0	Gi1/0/3	10.0.0.10
17	Pop Label	10.0.0.16/30	0	Gi1/0/2	10.0.0.6
	Pop Label	10.0.0.16/30	0	Gi1/0/3	10.0.0.10
18	Pop Label	10.0.0.12/30	0	Gi1/0/2	10.0.0.6
	Pop Label	10.0.0.12/30	0	Gi1/0/3	10.0.0.10
19	17	192.168.1.4/32	0	Gi1/0/2	10.0.0.6
	17	192.168.1.4/32	0	Gi1/0/3	10.0.0.10
20	No Label	10.0.0.0/30[V]	630	aggregate/RED	
21	No Label	192.168.3.0/24[V]	\		

```

                                0                Gi1/0/1    10.0.0.1

C9300-PE-2#show mpls forwarding-table
Local      Outgoing  Prefix      Bytes Label  Outgoing  Next Hop
Label      Label     or Tunnel Id Switched     interface
16         Pop Label 192.168.1.3/32 0           Gi2/0/2    10.0.0.13
          Pop Label 192.168.1.3/32 0           Gi2/0/3    10.0.0.17
17         16        192.168.1.2/32 0           Gi2/0/2    10.0.0.13
          16        192.168.1.2/32 0           Gi2/0/3    10.0.0.17
18         Pop Label 10.0.0.4/30   0           Gi2/0/2    10.0.0.13
          Pop Label 10.0.0.4/30   0           Gi2/0/3    10.0.0.17
19         Pop Label 10.0.0.8/30   0           Gi2/0/2    10.0.0.13
          Pop Label 10.0.0.8/30   0           Gi2/0/3    10.0.0.17
20         No Label  10.0.0.20/30[V] 630        aggregate/RED
21         No Label  192.168.2.0/24[V] \
                                0                Gi2/0/1    10.0.0.22

```

**Confirm the inner (VPNv4) and outer (LDP) labels used to reach to each given prefix in the VRF**

```

C9300-PE-1#show ip cef vrf RED 192.168.2.0/24 detail
192.168.2.0/24, epoch 0, flags [rib defined all labels]
  recursive via 192.168.1.4 label 21 <-- VPNv4 label
    nexthop 10.0.0.6 GigabitEthernet1/0/2 label 17-(local:19) <-- 17 is the LDP label that is
imposed to reach the remote PE, 19 is the local LDP label advertised to the P router
    nexthop 10.0.0.10 GigabitEthernet1/0/3 label 17-(local:19) <-- 17 is the LDP label that is
imposed to reach the remote PE, 19 is the local LDP label advertised to the P router

```

```

C9300-PE-2#show ip cef vrf RED 192.168.3.0/24 detail
192.168.3.0/24, epoch 0, flags [rib defined all labels]
  recursive via 192.168.1.2 label 21 <-- VPNv4 label
    nexthop 10.0.0.13 GigabitEthernet2/0/2 label 16-(local:17) <-- 16 is the LDP label that is
imposed to reach the remote PE, 17 is the local LDP label advertised to the P router
    nexthop 10.0.0.17 GigabitEthernet2/0/3 label 16-(local:17) <-- 16 is the LDP label that is
imposed to reach the remote PE, 17 is the local LDP label advertised to the P router

```

**Verify Object-Manager Statistics:**

In ideal scenarios, there are no pending objects

```

C9300-PE-1#show platform software object-manager switch active f0 statistics
Forwarding Manager Asynchronous Object Manager Statistics

```

```

Object update: Pending-issue: 0, Pending-acknowledgement: 0
Batch begin:   Pending-issue: 0, Pending-acknowledgement: 0
Batch end:     Pending-issue: 0, Pending-acknowledgement: 0
Command:      Pending-acknowledgement: 0
Total-objects: 491
Stale-objects: 0
Resolve-objects: 0
Childless-delete-objects: 0
Error-objects: 0
Paused-types: 0

```

```

9500-P#show platform software object-manager switch active f0 statistics
Forwarding Manager Asynchronous Object Manager Statistics

```

```

Object update: Pending-issue: 0, Pending-acknowledgement: 0
Batch begin:   Pending-issue: 0, Pending-acknowledgement: 0
Batch end:     Pending-issue: 0, Pending-acknowledgement: 0
Command:      Pending-acknowledgement: 0

```



```
Total-objects: 491
Stale-objects: 0
Resolve-objects: 0
Childless-delete-objects: 0
Error-objects: 0
Paused-types: 0
C9300-PE-2#show platform software object-manager switch active f0 statistics
Forwarding Manager Asynchronous Object Manager Statistics
```

```
Object update: Pending-issue: 0, Pending-acknowledgement: 0
Batch begin: Pending-issue: 0, Pending-acknowledgement: 0
Batch end: Pending-issue: 0, Pending-acknowledgement: 0
Command: Pending-acknowledgement: 0
Total-objects: 482
Stale-objects: 0
Resolve-objects: 0
Childless-delete-objects: 0
Error-objects: 0
Paused-types: 0
```

## Prefix Programming

The next section covers prefix programming on the MPLS routers, C9300-PE-1, C9500-P, and C9300-PE-2.

### C9300-PE-1 Prefix Programming

#### \*\*\*Software Prefix Programming\*\*\*

```
C9300-PE-1#show ip route vrf RED 192.168.2.1
```

```
Routing Table: RED
Routing entry for 192.168.2.0/24
  Known via "bgp 69420", distance 200, metric 130816, type internal
  Last update from 192.168.1.4 19:21:45 ago
  Routing Descriptor Blocks:
    * 192.168.1.4 (default), from 192.168.1.4, 19:21:45 ago <-- Remote PE reachable in the global
routing table
      Route metric is 130816, traffic share count is 1
      AS Hops 0
      MPLS label: 21 <-- VPNv4 label
      MPLS Flags: MPLS Required
```

```
C9300-PE-1#show ip route 192.168.1.4
```

```
Routing entry for 192.168.1.4/32
  Known via "ospf 420", distance 110, metric 3, type intra area
  Last update from 10.0.0.10 on GigabitEthernet1/0/3, 19:23:17 ago
  Routing Descriptor Blocks:
    10.0.0.10, from 192.168.1.4, 19:23:17 ago, via GigabitEthernet1/0/3 <-- Next-hop to reach
192.168.1.4
      Route metric is 3, traffic share count is 1
    * 10.0.0.6, from 192.168.1.4, 19:23:17 ago, via GigabitEthernet1/0/2 <-- Next-hop to reach
192.168.1.4
      Route metric is 3, traffic share count is 1
```

#### \*\*\*FMAN RP Prefix Programming\*\*\*

```
C9300-PE-1#show ip vrf detail
```

```
VRF RED (VRF Id = 2); default RD 69:69; default VPNID <-- VRF ID is important in subsequent
command
  Old CLI format, supports IPv4 only
  Flags: 0xC
  Interfaces:
```

Gi1/0/1  
Address family ipv4 unicast (Table ID = 0x2):  
Flags: 0x0  
Export VPN route-target communities  
RT:69:69  
Import VPN route-target communities  
RT:69:69  
No import route-map  
No global export route-map  
No export route-map  
VRF label distribution protocol: not configured  
VRF label allocation mode: per-prefix

C9300-PE-1#show platform software ip switch active r0 cef table index 2 prefix 192.168.2.0/24 <--  
- Index value is the VRF ID from previous command

Forwarding Table

Prefix/Len	Next Object	Index
192.168.2.0/24	OBJ_LABEL	0x78

C9300-PE-1#show platform software mpls switch active r0 label index 0x78 <-- Utilize the Index  
value from previous command

Label OCE 0x78 -> OBJ\_LOADBALANCE (0x70) <-- Utilized in next command

Flags: Real, Number of labels in the OCE: 1  
Label values: 0x15  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x3480644d88

C9300-PE-1#show platform software loadinfo switch active r0 index 0x70 <-- Utilize the  
OBJ\_LOADBALANCE value from previous command

Number of loadinfo objects: 8

Index: 0x70, Flags: unknown, Hash Algorithm: , Number of Paths: 2, Number of buckets: 16  
Anti-polarising Factor: 0xf4a19ba0  
Next Object Type: OBJ\_LABEL, OBJ\_LABEL  
Next obj handle: 0x6e, 0x6f  
Hash Buckets: 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1  
Color Buckets Map: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0  
OM handle: 0x3480641fb8

C9300-PE-1#show platform software mpls switch active r0 label index 0x6e <-- Utilize the obj  
handle value from previous command

Label OCE 0x6e -> OBJ\_ADJACENCY (0x4b)

Flags: Real, Number of labels in the OCE: 1  
Label values: 0x11  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x34806420d0

C9300-PE-1#show platform software mpls switch active r0 label index 0x6f <-- Utilize the obj  
handle value from previous command

Label OCE 0x6f -> OBJ\_ADJACENCY (0x4e)

Flags: Real, Number of labels in the OCE: 1  
Label values: 0x11  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x3480642268

C9300-PE-1#show platform software adjacency switch active r0 index 0x4b <-- Utilize the OBJ\_ADJACENCY value from previous command

Number of adjacency objects: 10

Adjacency id: 0x4b (75)

Interface: GigabitEthernet1/0/2, IF index: 54, Link Type: MCP\_LINK\_TAG

Encap: d4:ad:71:b5:dd:e4:a0:f8:49:11:d1:d6:88:47 <-- MAC ending in DDE4 is the DMAC, MAC ending in D1D6 is SMAC, 8847 is MPLS ETYPE

Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500

Flags: unknown

Incomplete behavior type: None

Fixup: unknown

Fixup\_Flags\_2: unknown

Nexthop addr: 10.0.0.6 <-- Next-hop IP address

IP FRR MCP\_ADJ\_IPFRR\_NONE 0

OM handle: 0x34806375f8

C9300-PE-1#show platform software adjacency switch active r0 index 0x4e <-- Utilize the OBJ\_ADJACENCY value from previous command

Number of adjacency objects: 10

Adjacency id: 0x4e (78)

Interface: GigabitEthernet1/0/3, IF index: 55, Link Type: MCP\_LINK\_TAG

Encap: d4:ad:71:b5:dd:c2:a0:f8:49:11:d1:d8:88:47 <-- MAC ending DDC2 is the DMAC, MAC ending in D1D8 is the SMAC, 8847 is the MPLS ETYPE

Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500

Flags: unknown

Incomplete behavior type: None

Fixup: unknown

Fixup\_Flags\_2: unknown

Nexthop addr: 10.0.0.10 <-- Next-hop IP address

IP FRR MCP\_ADJ\_IPFRR\_NONE 0

OM handle: 0x3480638200

\*\*\*FMAN FP Prefix Programming\*\*\*

C9300-PE-1#show ip vrf detail

VRF RED (VRF Id = 2); default RD 69:69; default VPNID

Old CLI format, supports IPv4 only

Flags: 0xC

Interfaces:

Gi1/0/1

Address family ipv4 unicast (Table ID = 0x2):

Flags: 0x0

Export VPN route-target communities

RT:69:69

Import VPN route-target communities

RT:69:69

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

C9300-PE-1#show platform software ip switch active f0 cef table index 2 prefix 192.168.2.0/24 detail <-- Index value is the VRF ID from previous command

Forwarding Table

192.168.2.0/24 -> OBJ\_LABEL (0x78), urpf: 118

Prefix Flags: unknown

aom id: 618, HW handle: (nil) (created)

C9300-PE-1#show platform software mpls switch active f0 label index 0x78 <-- Use the OBJ\_LABEL value from previous command

Label OCE 0x78 -> OBJ\_LOADBALANCE (0x70)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0x15  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 617, CPP handle: 0xdeadbeef (created)

C9300-PE-1#show platform software object-manager switch active f0 object 617 parents <-- Use the aom id from previous command

Object identifier: 600  
Description: LB 0x70  
Status: Done

C9300-PE-1#show platform software loadinfo switch active f0 index 0x70 <-- Use the LB value from previous command

Number of loadinfo objects: 8

Index: 0x70, Flags: unknown, Hash Algorithm: , Number of Paths: 2, Number of buckets: 16  
Anti-polarising Factor: 0xf4a19ba0  
Next Object Type: OBJ\_LABEL, OBJ\_LABEL  
Next obj handle: 0x6e, 0x6f  
Hash Buckets: 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1  
Color Buckets Map: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0  
aom id: 600, HW handle: (nil)

C9300-PE-1#show platform software mpls switch active f0 label index 0x6e <-- Use the obj handle values from previous commands

Label OCE 0x6e -> OBJ\_ADJACENCY (0x4b)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0x11  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 598, CPP handle: 0xdeadbeef (created)

C9300-PE-1#show platform software mpls switch active f0 label index 0x6f <-- Use the obj handle values from previous command

Label OCE 0x6f -> OBJ\_ADJACENCY (0x4e)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0x11  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 599, CPP handle: 0xdeadbeef (created)

C9300-PE-1#show platform software adjacency switch active f0 index 0x4b <-- Use the OBJ\_ADJACENCY value from previous command

Number of adjacency objects: 10

Adjacency id: 0x4b (75)

Interface: GigabitEthernet1/0/2, IF index: 54, Link Type: MCP\_LINK\_TAG  
Encap: d4:ad:71:b5:dd:e4:a0:f8:49:11:d1:d6:88:47  
Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500  
Flags: unknown  
Incomplete behavior type: None  
Fixup: unknown  
Fixup\_Flags\_2: unknown  
Nexthop addr: 10.0.0.6  
IP FRR MCP\_ADJ\_IPFRR\_NONE 0  
aom id: 531, HW handle: (nil) (created)

C9300-PE-1#show platform software adjacency switch active f0 index 0x4e <-- Use the OBJ\_ADJACENCY value from previous command

Number of adjacency objects: 10

Adjacency id: 0x4e (78)

Interface: GigabitEthernet1/0/3, IF index: 55, Link Type: MCP\_LINK\_TAG  
Encap: d4:ad:71:b5:dd:c2:a0:f8:49:11:d1:d8:88:47  
Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500  
Flags: unknown  
Incomplete behavior type: None  
Fixup: unknown  
Fixup\_Flags\_2: unknown  
Nexthop addr: 10.0.0.10  
IP FRR MCP\_ADJ\_IPFRR\_NONE 0  
aom id: 535, HW handle: (nil) (created)

**\*\*\*FED Prefix Programming\*\*\***

C9300-PE-1#show platform software fed switch active ip route vrf-name RED 192.168.2.0/24

vrf	dest	htm	flags	SGT	DGID	MPLS	Last-
-----	------	-----	-------	-----	------	------	-------

modified	---	----	---	----	----	----	----
----------	-----	------	-----	------	------	------	------

2	192.168.2.0/24	0x7fbae8d86228	0x0	0	0	lspa0x2	
---	----------------	----------------	-----	---	---	---------	--

2021/06/23 18:50:13.079 <-- HTM value significant for next command

FIB: prefix\_hdl:0x50000026, mpls\_ecr\_prefix\_hdl:0

=====  
OCE chain  
=====

LABEL:objid:120 link\_type:IP local\_label:1048577 outlabel:(21, 0) <-- VPNv4 label

flags:0x1:(REAL,) pdflags:0x80:(INSTALL\_HW\_OK,RECIR\_ADJ,) adj\_handle:0xcb00003c <--

**adj\_handle and local\_adj\_hdl values must match**

unsupported recursion:0 olbl\_changed 0 local\_adj:1 modify\_cnt:0

bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0

AAL: id:3405774908 lbl:19 smac:0000.0000.0000 dmac:0000.0000.0000 <-- Label 19 matches the

**local transport label**

sub\_type:0 link\_type:0 adj\_flags:0x10 label\_type:0 rewrite\_type:PSH2(121)

vlan\_id:0 vrf\_id:0 ri:0x7fbae8d73648, ri\_id:0x46 phdl:0, ref\_cnt:2 <-- ri\_id and

**ri\_idx values must match**

si:0x7fbae8d834d8, si\_id:0xb6, di\_id:0x5013

LB:obj\_id:112 link\_type:IP num\_choices:2 Flags:0

mpls\_ecr:1 local\_label:19 path\_inhw:2 ecrh:0x7d000002 old\_ecrh:0

modify\_cnt:0 bwalk\_cnt:0 subwalk\_cnt:0 finish\_cnt:0

bwalk:[req:0 in\_prog:0 nested:0]

AAL: ecr:id:2097152002 af:0 ecr\_type:0 ref:7 ecrh:0x7fbae8a99268(28:2)

hwhdl:3903427176 ::0x7fbae8a98b98,0x7fbae8a9ad48,0x7fbae8a98b98,0x7fbae8a9ad48

Sw Enh ECR scale: objid:112 llabel:19 eos:1 #adjs:2 mixed\_adj:0

reprogram\_hw:0 ecrhdl:0x7d000002 ecr\_hwhdl:0x7fbae8a99268

mod\_cnt:0 prev\_npath:0 pmismatch:0 pordermatch:0

ecr\_adj: id:4278190135 is\_mpls\_adj:1 l3adj\_flags:0x100000

recirc\_adj\_id:1744830509

sih:0x7fbae8a98b98(179) di\_id:20499 rih:0x7fbae8a985d8(33)

adj\_lentry [eos0:0x7fbae8d7bf48 eos1:0x7fbae8d76e88]

ecr\_adj: id:1392508984 is\_mpls\_adj:1 l3adj\_flags:0x100000

recirc\_adj\_id:2013265966

sih:0x7fbae8a9ad48(180) di\_id:20499 rih:0x7fbae8a9a788(46)

adj\_lentry [eos0:0x7fbae8d7c1b8 eos1:0x7fbae8d77158]

ecr\_prefix\_adj: id:2164260921 (ref:1)

sih:0x7fbae8d7df08(181) di\_id:20499 rih:0x7fbae8d7db98(68)

LABEL:objid:110 link\_type:MPLS local\_label:19 outlabel:(17, 0) <-- Label 19 is the local transport label, Label 17 is the LDP label

flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0xff000037

unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0

bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0

AAL: id:4278190135 lbl:0 smac:a0f8.4911.d1d6 dmac:d4ad.71b5.dde4 <-- Matches next-hop

**information to reach 192.168.2.0/24**

sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)

vlan\_id:0 vrf\_id:0 ri:0x7fbae8d78c48, ri\_id:0x40 phdl:0x9f00004b, ref\_cnt:1

si:0x7fbae8d78fd8, si\_id:0x4013, di\_id:0x535f <-- di\_id utilized in subsequent

commands

ADJ:objid:75 {link\_type:MPLS ifnum:0x36, si:0x22000023, }

LABEL:objid:111 link\_type:MPLS local\_label:19 outlabel:(17, 0) <-- Label 19 is the local transport label, Label 17 is the LDP label

flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0x53000038
unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oe:0

AAL: id:1392508984 lbl:0 smac:a0f8.4911.d1d8 dmac:d4ad.71b5.ddc2 <-- Matches next-hop information to reach 192.168.2.0/24

sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)
vlan\_id:0 vrf\_id:0 ri:0x7fbae8d7d0a8, ri\_id:0x42 phdl:0x8400004c, ref\_cnt:1
si:0x7fbae8d7a908, si\_id:0x4014, di\_id:0x5360 <-- di\_id utilized in subsequent

commands

ADJ:objid:78 {link\_type:MPLS ifnum:0x37, si:0x74000026, }

=====

MPLS info: mpls\_ecr\_scale\_prefix\_adj:0, mpls\_lspa\_hdl:0xa7000002

AAL:LSPA: id:2801795074 num\_path:1 prefix\_id:0x2 delete\_hw\_hdl\_cnt:0

cookie[64]:

15004600000000000000000000000000000000000000 status:ok

vpn\_lbl:21 local\_adj\_hdl:0xcb00003c hw\_hdl:0x7fbae8d86018 ri\_idx:0x46 <-- vpn\_lbl matches the VPNv4 label, adj\_handle and local\_adj\_hdl values must match, ri\_id and ri\_idx must match

=====

C9300-PE-1#show platform hardware fed switch active fwd-asic abstraction print-resource-handle 0x7fbae8d86228 1 <-- Utilize the HTM value from previous command

Handle:0x7fbae8d86228 Res-Type:ASIC\_RSC\_HASH\_TCAM Res-Switch-Num:0 Asic-Num:255 Feature-ID:AL\_FID\_L3\_UNICAST\_IPV4 Lkp-ftr-id:LKP\_FEAT\_IPV4\_L3\_UNICAST ref\_count:1
priv\_ri/priv\_si Handle: (nil)Hardware Indices/Handles: handle [ASIC: 0]: 0x7fbae8d71f58

Detailed Resource Information (ASIC# 0)

-----

Number of HTM Entries: 1

Entry 0: (handle 0x7fbae8d71f58)

Absolute Index: 92181

Time Stamp: 1

KEY - vrf:2 mtr:0 prefix:192.168.2.0 rcp\_redirect\_index:0x0

MASK - vrf:255 mtr:0 prefix:255.255.255.0 rcp\_redirect\_index:0x0

FWD-AD = afd\_label\_flag:0 icmp\_redir\_enable:1 lvx\_smr\_enabled:0, dstNatType:0 priority:5

afdLabelOrDestClientId:0 SI:182 destined\_to\_us:0 hw\_stats\_idx:0 stats\_id:0

redirectSetRouterMac:0 dgtIdx:0 destModIndex:0 dstNatTypeOrVpnPrefixPtrMsb:0 vpnPrefixPtr:0x2

SRC-AD = learning\_violation:1 need\_to\_learn:1 locally\_connected:0 staticentryViolation:0

rpfValid:1 rpfLe:0 rpfLePointer:0 rpfForcePass:0 rpfForceFail:0 reachableViaSome:0

rpfCheckIncomplete:0 defaultRoute:0 ChainPtrValid:0 ChainPtrOrPortLeIndex:72 UserRpfmatchTable:0

rpfIncomplete:0 is\_src\_ce:0 sgtValid:0 sgt:0 src\_rloc\_trusted:0,sgtCacheControl1 = 0,

sgtCacheControl0 = 0

port\_label:0x0 port\_mask:0x0 vlan\_label:0x0 vlan\_mask:0x0 l3if\_label:0x0 l3if\_mask:0x0

group\_label:0x0 group\_mask:0x0

=====

C9300-PE-1#show platform hardware fed switch active fwd-asic resource ASIC all destination-index range 0x535f 0x535f <-- Utilize the di\_id from the previous command

ASIC#0:

index = 0x535f

pmap = 0x00000000 0x00000000

cmi = 0x0

rcp\_pmap = 0x0

al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0  
ASIC#1:

index = 0x535f

pmap = 0x00000000 **0x00000002** <-- Looking at 0x00000002, in binary that is 0000 0000 0000 0000  
**000 0000 0000 0010 = Port 1 (Zero based, count right to left)**

cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0

**C9300-PE-1#show platform hardware fed switch active fwd-asic resource asic all destination-index  
range 0x5360 0x5360 <-- Utilize the di\_id from the previous command ASIC#0:**

ASIC#0:

index = 0x5360

pmap = 0x00000000 0x00000000

cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0  
ASIC#1:

index = 0x5360

pmap = 0x00000000 **0x00000004** <-- Looking at 0x00000004, in binary that is 0000 0000 0000 0000  
**0000 0000 0000 0100 = Port 2 (Zero based, count right to left)**

cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0

stripSeg = 0  
copySeg = 0

C9300-PE-1#show platform software fed switch active ifm map

Interface	IF_ID	Inst	Asic	Core	Port	SubPort	Mac	Cntx	LPN	GPN	Type	Active
GigabitEthernet1/0/2	0x36	1	0	1	1	0	6	7	2	2	NIF	Y <--
<b>Port 1 is an egress port, Gi1/0/2</b>												
GigabitEthernet1/0/3	0x37	1	0	1	2	0	28	8	3	3	NIF	Y <--
<b>Port 2 is an egress port, Gi1/0/3</b>												

## C9500 Prefix Programming

### \*\*\*Software Prefix Programming\*\*\*

C9500-P#show ip route 192.168.1.4

Routing entry for 192.168.1.4/32

Known via "ospf 420", distance 110, metric 2, type intra area

Last update from 10.0.0.18 on TenGigabitEthernet2/0/2, 20:15:25 ago

Routing Descriptor Blocks:

10.0.0.18, from 192.168.1.4, 20:15:25 ago, via TenGigabitEthernet2/0/2 <-- Next-hop towards 192.168.1.4

Route metric is 2, traffic share count is 1

\* 10.0.0.14, from 192.168.1.4, 20:15:25 ago, via TenGigabitEthernet1/0/2 <-- Next-hop towards 192.168.1.4

Route metric is 2, traffic share count is 1

C9500-P#show ip cef 192.168.1.4 detail

192.168.1.4/32, epoch 4, per-destination sharing

dflt local label info: global/17 [0x3]

nexthop 10.0.0.14 TenGigabitEthernet1/0/2 label explicit-null-(local:17) <-- Explicit null to reach 192.168.1.4

nexthop 10.0.0.18 TenGigabitEthernet2/0/2 label explicit-null-(local:17) <-- Explicit null to reach 192.168.1.4

### \*\*\*FMAN RP Prefix Programming\*\*\*

C9500-P#show platform software ip switch active r0 cef prefix 192.168.1.4/32

Forwarding Table

Prefix/Len	Next Object	Index
192.168.1.4/32	OBJ_LOADBALANCE	0x6a

C9500-P#show platform software loadinfo switch active r0 index 0x6a <-- Use the OBJ\_LOADBALANCE value from previous command

Number of loadinfo objects: 4

Index: 0x6a, Flags: unknown, Hash Algorithm: , Number of Paths: 2, Number of buckets: 16

Anti-polarising Factor: 0x57a70068

Next Object Type: OBJ\_LABEL, OBJ\_LABEL

Next obj handle: 0x68, 0x69

Hash Buckets: 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1, 0, 1

Color Buckets Map: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

OM handle: 0x348064de58

C9500-P#show platform software mpls switch active r0 label index 0x68 <-- Use the obj handle values from the previous command

Label OCE 0x68 -> OBJ\_ADJACENCY (0x49)

Flags: Real, Number of labels in the OCE: 1

Label values: 0

Backup flags: Pop, UHP, backup label 0x100001

OM handle: 0x348064df70





C9500-P#show platform software mpls switch active f0 label index 0x68 <-- Use the obj handle values from previous command

Label OCE 0x68 -> OBJ\_ADJACENCY (0x49)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 576, CPP handle: 0xdeadbeef (created)

C9500-P#show platform software mpls switch active f0 label index 0x69 <-- Use the obj handle values from previous command

Label OCE 0x69 -> OBJ\_ADJACENCY (0x4e)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 577, CPP handle: 0xdeadbeef (created)

C9500-P#show platform software adjacency switch active f0 index 0x49 <-- Use the OBJ\_ADJACENCY values from previous commands

Number of adjacency objects: 16

Adjacency id: 0x49 (73)  
Interface: TenGigabitEthernet1/0/2, IF index: 66, Link Type: MCP\_LINK\_TAG  
Encap: 70:d3:79:be:ae:71:d4:ad:71:b5:dd:d6:88:47 <-- MAC ending in AE71 is the DMAC, MAC ending in DDD6 is the SMAC, 8847 is the MPLS ETYPE  
Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500  
Flags: unknown  
Incomplete behavior type: None  
Fixup: unknown  
Fixup\_Flags\_2: unknown  
Nexthop addr: 10.0.0.14 <-- Next-hop IP address  
IP FRR MCP\_ADJ\_IPFRR\_NONE 0  
aom id: 536, HW handle: (nil) (created)

C9500-P#show platform software adjacency switch active f0 index 0x4e <-- Use the OBJ\_ADJACENCY values from previous commands

Number of adjacency objects: 16

Adjacency id: 0x4e (78)  
Interface: TenGigabitEthernet2/0/2, IF index: 68, Link Type: MCP\_LINK\_TAG  
Encap: 70:d3:79:be:ae:61:d4:ad:71:b5:dd:f1:88:47 <-- MAC ending in AE61 is the DMAC, MAC ending in DDF1 is the SMAC, 8847 is the MPLS ETYPE  
Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500  
Flags: unknown  
Incomplete behavior type: None  
Fixup: unknown  
Fixup\_Flags\_2: unknown  
Nexthop addr: 10.0.0.18 <-- Next-hop IP address  
IP FRR MCP\_ADJ\_IPFRR\_NONE 0  
aom id: 545, HW handle: (nil) (created)

\*\*\*FED Prefix Programming\*\*\*

C9500-P#show platform software fed switch active ip route 192.168.1.4/32

vrf	dest	htm	flags	SGT	DGID	MPLS	Last-
---	----	---	-----	---	----	-----	-----
0	192.168.1.4/32	0x7f0b284c1118	0x0	0	0		

2021/06/23 18:47:01.761 <-- HTM value important for subsequent command  
FIB: prefix\_hdl:0x9b000020, mpls\_ecr\_prefix\_hdl:0xdd00003a

```

===== OCE chain =====
LB:obj_id:106 link_type:IP num_choices:2 Flags:0
  mpls_ecr:1 local_label:17 path_inhw:2 ecrh:0x44000002 old_ecrh:0
  modify_cnt:0 bwalk_cnt:0 subwalk_cnt:0 finish_cnt:0
  bwalk:[req:0 in_prog:0 nested:0]
AAL: ecr:id:1140850690 af:0 ecr_type:0 ref:2 ecrh:0x7f0b284a3998(28:2)
hwhdl:675953048 ::0x7f0b284b4268,0x7f0b284a1d78,0x7f0b284b4268,0x7f0b284a1d78
Sw Enh ECR scale: objid:106 llabel:17 eos:1 #adjs:2 mixed_adj:0
reprogram_hw:0 ecrhdl:0x44000002 ecr_hwhdl:0x7f0b284a3998
mod_cnt:0 prev_npath:0 pmismatch:0 pordermatch:0
ecr_adj: id:4127195192 is_mpls_adj:1 l3adj_flags:0x100000
  recirc_adj_id:1207959601
    sih:0x7f0b284b4268(181) di_id:23709 rih:0x7f0b284b3ca8(31)
  adj_lentry [eos0:0x7f0b284c38e8 eos1:0x7f0b284cd858]
ecr_adj: id:1157627961 is_mpls_adj:1 l3adj_flags:0x100000
  recirc_adj_id:67108914
    sih:0x7f0b284a1d78(182) di_id:23709 rih:0x7f0b284b47d8(44)
  adj_lentry [eos0:0x7f0b284c3af8 eos1:0x7f0b284cdb28]
ecr_prefix_adj: id:3707764794 (ref:1)
  sih:0x7f0b284c5028(184) di_id:23709 rih:0x7f0b284c4c48(60)
LABEL:objid:104 link_type:MPLS local_label:17 outlabel:(0, 0) <-- Label 17 is the local
transport label, 0 is the LDP label
  flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0xf6000038
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:4127195192 lbl:0 smac:d4ad.71b5.ddd6 dmac:70d3.79be.ae71 <-- Matches the next-
hop information to reach 192.168.1.4/32
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7f0b284ceaa8, ri_id:0x38 phdl:0x76000058, ref_cnt:1
    si:0x7f0b284ceeb8, si_id:0x400b, di_id:0x2 <-- Used in subsequent commands
  ADJ:objid:73 {link_type:MPLS ifnum:0x42, si:0x1f000028, }
  LABEL:objid:105 link_type:MPLS local_label:17 outlabel:(0, 0) <-- Label 17 is the local
transport label, 0 is the LDP label
  flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0x45000039
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:1157627961 lbl:0 smac:d4ad.71b5.ddf1 dmac:70d3.79be.ae61 <-- Matches the next-
hop information to reach 192.168.1.4/32
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7f0b284c4588, ri_id:0x3a phdl:0x5500005a, ref_cnt:1
    si:0x7f0b284d0548, si_id:0x400c, di_id:0x62 <-- Used in subsequent commands
  ADJ:objid:78 {link_type:MPLS ifnum:0x44, si:0x4900002a, }
=====
MPLS info: mpls_ecr_scale_prefix_adj:0xdd00003a, mpls_lspa_hdl:0
=====

```

```

C9500-P#show platform hardware fed switch active fwd-asic abstraction print-resource-handle
0x7f0b284c1118 1 <-- Use the HTM value from previous command

```

```

Handle:0x7f0b284c1118 Res-Type:ASIC_RSC_HASH_TCAM Res-Switch-Num:0 Asic-Num:255 Feature-
ID:AL_FID_L3_UNICAST_IPV4 Lkp-ftr-id:LKP_FEAT_IPV4_L3_UNICAST ref_count:1
priv_ri/priv_si Handle: (nil)Hardware Indices/Handles: handle [ASIC: 0]: 0x7f0b284c1328
Features sharing this resource:Cookie length: 12
04 01 a8 c0 00 00 00 d0 07 00 00 00

```

```

Detailed Resource Information (ASIC# 0)
-----

```

```

Number of HTM Entries: 1

```

```

Entry 0: (handle 0x7f0b284c1328)

```

```

Absolute Index: 126650

```

```

Time Stamp: 1

```

```

KEY - vrf:0 mtr:0 prefix:192.168.1.4 rcp_redirect_index:0x0

```

```

MASK - vrf:0 mtr:0 prefix:0.0.0.0 rcp_redirect_index:0x0

```

FWD-AD = afd\_label\_flag:0 icmp\_redir\_enable:1 lvx\_smr\_enabled:0, dstNatType:0 priority:5  
afdLabelOrDestClientId:0 SI:184 destined\_to\_us:0 hw\_stats\_idx:1 stats\_id:0  
redirectSetRouterMac:0 dgtIdx:0 destModIndex:0 dstNatTypeOrVpnPrefixPtrMsb:0 vpnPrefixPtr:0  
SRC-AD = learning\_violation:0 need\_to\_learn:0 locally\_connected:0 staticentryViolation:0  
rpfValid:1 rpfLe:2 rpfLePointer:0 rpfForcePass:0 rpfForceFail:0 reachableviaSome:1  
rpfCheckIncomplete:0 defaultRoute:0 ChainPtrValid:0 ChainPtrOrPortLeIndex:72 UseRpfmatchTable:1  
rpfIncomplete:0 is\_src\_ce:0 sgtValid:0 sgt:0 src\_rloc\_trusted:0,sgtCacheControl1 = 0,  
sgtCacheControl0 = 0  
port\_label:0x0 port\_mask:0x0 vlan\_label:0x0 vlan\_mask:0x0 l3if\_label:0x0 l3if\_mask:0x0  
group\_label:0x0 group\_mask:0x0

=====

C9500-P#**show platform hardware fed switch active fwd-asic resource asic all destination-index range 0x2 0x2** <-- Use the di\_id values from previous command

ASIC#0:

index = 0x2  
pmap = 0x00000000 0x00000000  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0  
ASIC#1:

index = 0x2  
pmap = 0x00000000 **0x00000002** <-- Looking at 0x00000002, in binary that is 0000 0000 0000 0000  
**0000 0000 0000 0010** = Port 1 (Zero based, count right to left)  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0

C9500-P#**show platform hardware fed switch active fwd-asic resource asic all destination-index range 0x62 0x62**

ASIC#0:

index = 0x62  
pmap = 0x00000000 **0x00008000** <-- Looking at 0x00008000, in binary that is 0000 0000 0000 0000  
**1000 0000 0000 0000** = Port 15 (Zero based, count right to left)  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0

ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0  
ASIC#1:

index = 0x62  
pmap = 0x00000000 0x00000000  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0

C9500-P#show platform software fed switch standby ip route 192.168.1.4/32

vrf	dest	htm	flags	SGT	DGID	MPLS	Last-
---	----	---	-----	---	---	-----	-----

0 192.168.1.4/32 0x7f57c0545938 0x0 0 0

2021/06/23 18:46:51.399 <-- HTM value used in subsequent command

FIB: prefix\_hdl:0x29000020, mpls\_ecr\_prefix\_hdl:0x8f000039  
===== OCE chain =====

LB:obj\_id:106 link\_type:IP num\_choices:2 Flags:0  
mpls\_ecr:1 local\_label:17 path\_inhw:2 ecrh:0xf1000002 old\_ecrh:0  
modify\_cnt:0 bwalk\_cnt:0 subwalk\_cnt:0 finish\_cnt:0  
bwalk:[req:0 in\_prog:0 nested:0]

AAL: ecr:id:4043309058 af:0 ecr\_type:0 ref:2 ecrh:0x7f57c04d2148(28:2)  
hwhdl:3226280264 ::0x7f57c0547538,0x7f57c05497d8,0x7f57c0547538,0x7f57c05497d8

Sw Enh ECR scale: objid:106 llabel:17 eos:1 #adjs:2 mixed\_adj:0

reprogram\_hw:0 ecrhdl:0xf1000002 ecr\_hwhdl:0x7f57c04d2148  
mod\_cnt:0 prev\_npath:0 pmismatch:0 pordermatch:0  
ecr\_adj: id:201326647 is\_mpls\_adj:1 l3adj\_flags:0x100000  
recirc\_adj\_id:3925868592

sih:0x7f57c0547538(181) di\_id:23717 rih:0x7f57c0546f18(31)

adj\_lentry [eos0:0x7f57c04c8a08 eos1:0x7f57c04d07f8]

ecr\_adj: id:738197560 is\_mpls\_adj:1 l3adj\_flags:0x100000

recirc\_adj\_id:3070230577

sih:0x7f57c05497d8(182) di\_id:23717 rih:0x7f57c0547838(44)

adj\_lentry [eos0:0x7f57c04c8c18 eos1:0x7f57c04d0ac8]

ecr\_prefix\_adj: id:2399141945 (ref:1)

sih:0x7f57c04c8788(184) di\_id:23717 rih:0x7f57c04c8508(60)

LABEL:objid:104 link\_type:MPLS local\_label:17 outlabel:(0, 0) <-- Label 17 is the local transport label, 0 is the LDP label

flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0xc000037

unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0

bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0

AAL: id:201326647 lbl:0 smac:d4ad.71b5.ddd6 dmac:70d3.79be.ae71 <-- Matches next-hop information to reach 192.168.1.4/32

sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)

vlan\_id:0 vrf\_id:0 ri:0x7f57c04d18e8, ri\_id:0x38 phdl:0x76000058, ref\_cnt:1

si:0x7f57c04d1b18, si\_id:0x400b, di\_id:0x2 <-- di\_id utilized in subsequent

**commands**

ADJ:objid:73 {link\_type:MPLS ifnum:0x42, si:0xdf000027, }

LABEL:objid:105 link\_type:MPLS local\_label:17 outlabel:(0, 0) <-- Label 17 is the local transport label, 0 is the LDP label

flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0x2c000038

unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0

bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0

AAL: id:738197560 lbl:0 smac:d4ad.71b5.ddf1 dmac:70d3.79be.ae61 <-- Matches next-hop information to reach 192.168.1.4/32

sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)

vlan\_id:0 vrf\_id:0 ri:0x7f57c04da418, ri\_id:0x3a phdl:0x5500005a, ref\_cnt:1

si:0x7f57c04da838, si\_id:0x400c, di\_id:0x62 <-- di\_id utilized in subsequent

**commands**

ADJ:objid:78 {link\_type:MPLS ifnum:0x44, si:0xfa000029, }

=====

MPLS info: mpls\_ecr\_scale\_prefix\_adj:0x8f000039, mpls\_lsps\_hdl:0

=====

C9500-P#show platform hardware fed switch standby fwd-asic resource asic all destination-index range 0x62 0x62

ASIC#0:

index = 0x62

pmap = 0x00000000 0x00000000

cmi = 0x0

rcp\_pmap = 0x0

al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0

ctiLo1 = 0

ctiLo2 = 0

cpuQNum0 = 0

cpuQNum1 = 0

cpuQNum2 = 0

npuIndex = 0

stripSeg = 0

copySeg = 0

ASIC#1:

index = 0x62

pmap = 0x00000000 0x00000002 <-- Looking at 0x00000002, in binary that is 0000 0000 0000 0000 0000 0000 0000 0010 = Port 1 (Zero based, count right to left)

cmi = 0x0

rcp\_pmap = 0x0

al\_rsc\_cmi

CPU Map Index (CMI) [0]

ctiLo0 = 0

ctiLo1 = 0

ctiLo2 = 0

cpuQNum0 = 0

cpuQNum1 = 0

cpuQNum2 = 0

npuIndex = 0

stripSeg = 0

copySeg = 0

C9500-P#show platform hardware fed switch standby fwd-asic resource asic all destination-index range 0x2 0x2

ASIC#0:

index = 0x2

pmap = 0x00000000 0x00008000 <-- Looking at 0x00008000, in binary that is 0000 0000 0000 0000 1000 0000 0000 0000 = Port 15 (Zero based, count right to left)

cmi = 0x0

```
rcp_pmap = 0x0
al_rsc_cmi
CPU Map Index (CMI) [0]
ctiLo0 = 0
ctiLo1 = 0
ctiLo2 = 0
cpuQNum0 = 0
cpuQNum1 = 0
cpuQNum2 = 0
npuIndex = 0
stripSeg = 0
copySeg = 0
ASIC#1:
```

```
index = 0x2
pmap = 0x00000000 0x00000000
cmi = 0x0
rcp_pmap = 0x0
al_rsc_cmi
CPU Map Index (CMI) [0]
ctiLo0 = 0
ctiLo1 = 0
ctiLo2 = 0
cpuQNum0 = 0
cpuQNum1 = 0
cpuQNum2 = 0
npuIndex = 0
stripSeg = 0
copySeg = 0
```

**C9500-P#show platform software fed switch active ifm mappings**

Interface	IF_ID	Inst	Asic	Core	Port	SubPort	Mac	Cntx	LPN	GPN	Type	Active
TenGigabitEthernet1/0/2	0x42	1	0	1	<b>1</b>	0	10	1	2	2	NIF	Y <--
<b>Port 1 is an egress port, TenGi1/0/2</b>												
TenGigabitEthernet1/0/16	0x18	0	0	0	<b>15</b>	0	8	11	16	2360	NIF	Y <--
<b>Port 15 is the SVL</b>												

**C9500-P#show platform software fed switch standby ifm mappings**

Interface	IF_ID	Inst	Asic	Core	Port	SubPort	Mac	Cntx	LPN	GPN	Type	Active
TenGigabitEthernet2/0/2	0x44	1	0	1	<b>1</b>	0	10	1	2	98	NIF	Y <--
<b>Port 1 is an egress port, TenGi2/0/2</b>												
TenGigabitEthernet2/0/16	0x33	0	0	0	<b>15</b>	0	8	11	16	2360	NIF	Y <--
<b>Port 15 is the SVL</b>												

## Verify C9300-PE-2 Prefixes

**\*\*\*Software Prefix Programming\*\*\***

C9300-PE-2#show ip route vrf RED 192.168.2.0

Routing Table: RED

Routing entry for 192.168.2.0/24

Known via "eigrp 400", distance 90, metric 130816, precedence routine (0), type internal

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

Last update from 10.0.0.22 on GigabitEthernet2/0/1, 21:35:22 ago

Routing Descriptor Blocks:

\* **10.0.0.22**, from 10.0.0.22, 21:35:22 ago, via GigabitEthernet2/0/1 <-- Next-hop to reach

**192.168.2.0/24**

Route metric is 130816, traffic share count is 1

Total delay is 5010 microseconds, minimum bandwidth is 1000000 Kbit

Reliability 255/255, minimum MTU 1500 bytes

Loading 1/255, Hops 1

C9300-PE-2#show ip route vrf RED 10.0.0.22

Routing Table: RED

Routing entry for 10.0.0.20/30

Known via "connected", distance 0, metric 0 (connected, via interface)

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

Routing Descriptor Blocks:

\* directly connected, via GigabitEthernet2/0/1

Route metric is 0, traffic share count is 1

C9300-PE-2#show ip cef vrf RED 192.168.2.0/24 detail

192.168.2.0/24, epoch 0

QOS: Precedence routine (0)

dflt local label info: other/21 [0x2] <-- VPNv4 Label

nexthop 10.0.0.22 GigabitEthernet2/0/1

\*\*\*FMAN RP Prefix Programming\*\*\*

C9300-PE-2#show ip vrf detail

VRF RED (VRF Id = 2); default RD 69:69; default VPNID <-- VRF ID used in next command

Old CLI format, supports IPv4 only

Flags: 0xC

Interfaces:

Gi2/0/1

Address family ipv4 unicast (Table ID = 0x2):

Flags: 0x0

Export VPN route-target communities

RT:69:69

Import VPN route-target communities

RT:69:69

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

C9300-PE-2#show platform software ip switch active r0 cef table index 2 prefix 192.168.2.0/24 <-

- Use the VRF ID from previous command

Forwarding Table

Prefix/Len	Next Object	Index
192.168.2.0/24	OBJ_ADJACENCY	0x3a

C9300-PE-2#show platform software adjacency switch active r0 index 0x3a <-- Use the

OBJ\_ADJACENCY value from previous command

Number of adjacency objects: 10

Adjacency id: 0x3a (58)

Interface: GigabitEthernet2/0/1, IF index: 53, Link Type: MCP\_LINK\_IP

Encap: 0:72:78:c8:c9:c2:70:d3:79:be:ae:42:8:0 <-- MAC ending in C9C2 is the DMAC, MAC ending in AE42 is SMAC, 0800 is IP ETYPE

Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500

Flags: no-l3-inject

Incomplete behavior type: None

Fixup: unknown

Fixup\_Flags\_2: unknown

Nexthop addr: 10.0.0.22 <-- Next-hop IP address

IP FRR MCP\_ADJ\_IPFRR\_NONE 0

OM handle: 0x348062b578

\*\*\*FMAN FP Prefix Programming\*\*\*

C9300-PE-2#show platform software ip switch active f0 cef table index 2 prefix 192.168.2.0/24



Forwarding Table

Prefix/Len	Next Object	Index
192.168.2.0/24	OBJ_ADJACENCY	0x3a

C9300-PE-2#show platform software adjacency switch active f0 index 0x3a <-- Use the OBJ\_ADJACENCY value from previous command  
 Number of adjacency objects: 10

Adjacency id: 0x3a (58)  
 Interface: GigabitEthernet2/0/1, IF index: 53, Link Type: MCP\_LINK\_IP  
 Encap: 0:72:78:c8:c9:c2:70:d3:79:be:ae:42:8:0 <-- MAC ending in C9C2 is the DMAC, MAC ending in AE42 is SMAC, 0800 is IP ETYPE  
 Encap Length: 14, Encap Type: MCP\_ET\_ARPA, MTU: 1500  
 Flags: no-l3-inject  
 Incomplete behavior type: None  
 Fixup: unknown  
 Fixup\_Flags\_2: unknown  
 Nexthop addr: 10.0.0.22 <-- Next-hop IP address  
 IP FRR MCP\_ADJ\_IPFRR\_NONE 0  
 aom id: 477, HW handle: (nil) (created)

\*\*\*FED Prefix Programming\*\*\*

C9300-PE-2#show platform hardware fed switch active ip route vrf-name RED 192.168.2.0/24

vrf	dest	htm	flags	SGT	DGID	MPLS	Last-
modified							
2	192.168.2.0/24	0x7f0650a7e3e8	0x0	0	0		

2021/06/23 18:46:56.801 <-- HTM value used in subsequent command  
 FIB: prefix\_hdl:0x38000016, mpls\_ecr\_prefix\_hdl:0  
 ===== OCE chain =====  
 ADJ:objid:58 {link\_type:IP ifnum:0x35, si:0x9700001b, IPv4: 10.0.0.22 } <-- objid relevant in subsequent command, 10.0.0.22 is the next-hop IP  
 =====  
 MPLS info: mpls\_ecr\_scale\_prefix\_adj:0, mpls\_lsapa\_hdl:0  
 =====

C9300-PE-2#show platform hardware fed switch active fwd-asic abstraction print-resource-handle 0x7f0650a7e3e8 1 <-- Use the HTM value from previous command  
 Handle:0x7f0650a7e3e8 Res-Type:ASIC\_RSC\_HASH\_TCAM Res-Switch-Num:0 Asic-Num:255 Feature-ID:AL\_FID\_L3\_UNICAST\_IPV4 Lkp-ftr-id:LKP\_FEAT\_IPV4\_L3\_UNICAST ref\_count:1  
 priv\_ri/priv\_si Handle: (nil)Hardware Indices/Handles: handle [ASIC: 0]: 0x7f0650ba4028

Detailed Resource Information (ASIC# 0)

Number of HTM Entries: 1

Entry 0: (handle 0x7f0650ba4028)

Absolute Index: 92180

Time Stamp: 1

KEY - vrf:2 mtr:0 prefix:192.168.2.0 rcp\_redirect\_index:0x0  
 MASK - vrf:255 mtr:0 prefix:255.255.255.0 rcp\_redirect\_index:0x0  
 (SI value used later)

FWD-AD = afld\_label\_flag:0 icmp\_redir\_enable:1 lvx\_smr\_enabled:0, dstNatType:0 priority:5  
 afldLabelOrDestClientId:0 SI:173 destined\_to\_us:0 hw\_stats\_idx:1 stats\_id:0  
 redirectSetRouterMac:0 dgtIdx:0 destModIndex:0 dstNatTypeOrVpnPrefixPtrMsb:0 vpnPrefixPtr:0  
 SRC-AD = learning\_violation:1 need\_to\_learn:1 locally\_connected:0 staticentryViolation:0  
 rpfValid:1 rpfLe:37 rpfLePointer:0 rpfForcePass:0 rpfForceFail:0 reachableviaSome:1  
 rpfCheckIncomplete:0 defaultRoute:0 ChainPtrValid:0 ChainPtrOrPortLeIndex:72 UserRpfmatchTable:0  
 rpfIncomplete:0 is\_src\_ce:0 sgtValid:0 sgt:0 src\_rloc\_trusted:0,sgtCacheControl1 = 0,  
 sgtCacheControl0 = 0

port\_label:0x0 port\_mask:0x0 vlan\_label:0x0 vlan\_mask:0x0 l3if\_label:0x0 l3if\_mask:0x0  
group\_label:0x0 group\_mask:0x0

=====

C9300-PE-2#show platform software fed switch active ip adj

IPV4 Adj entries

dest	if_name	dst_mac	si_hdl	ri_hdl	pd_flags
adj_id	Last-modified				
----	-----	-----	-----	-----	-----
10.0.0.22	GigabitEthernet2/0/1	0072.78c8.c9c2	0x7f0650a32858	0x7f0650a1af48	0x0
0x3a	2021/06/23 18:46:52.956				

C9300-PE-2#show ip arp vrf RED 10.0.0.22

Protocol	Address	Age (min)	Hardware Addr	Type	Interface
Internet	10.0.0.22	131	0072.78c8.c9c2	ARPA	GigabitEthernet2/0/1

<-- dst\_mac matches the ARP entry

C9300-PE-2#show platform hardware fed fwd-asic abstraction print-resource-handle 0x7f0650a32858  
1 <-- Use the HTM value from previous command

Handle:0x7f0650a32858 Res-Type:ASIC\_RSC\_SI Res-Switch-Num:255 Asic-Num:255 Feature-ID:AL\_FID\_L3\_UNICAST\_IPV4 Lkp-ftr-id:LKP\_FEAT\_INVALID ref\_count:1  
priv\_ri/priv\_si Handle: 0x7f0650a1af48Hardware Indices/Handles: index0:0xad  
mtu\_index/l3u\_ri\_index0:0x0 index1:0xad mtu\_index/l3u\_ri\_index1:0x0  
Features sharing this resource:66 (1)]  
Cookie length: 56  
00 00 00 00 00 00 00 00 25 00 00 00 00 00 00 00 00 00 00 00 08 00 00 72 78 c8 c9 c2 00 00 00 00  
00 00

Detailed Resource Information (ASIC# 0)

-----

Station Index (SI) [0xad]

RI = 0x18

DI = 0x5338

stationTableGenericLabel = 0

stationFdConstructionLabel = 0x7

lookupSkipIdIndex = 0

rcpServiceId = 0

dejaVuPreCheckEn = 0

Replication Bitmap: CD

Detailed Resource Information (ASIC# 1)

-----

Station Index (SI) [0xad]

RI = 0x18

DI = 0x5338

stationTableGenericLabel = 0

stationFdConstructionLabel = 0x7

lookupSkipIdIndex = 0

rcpServiceId = 0

dejaVuPreCheckEn = 0

Replication Bitmap: LD

=====

C9300-PE-2#show platform hardware fed switch active fwd-asic resource asic all destination-index  
range 0x5338 0x5338 <-- Use the DI value from previous command

ASIC#0:

```

index = 0x5338
pmap = 0x00000000 0x00000000
cmi = 0x0
rcp_pmap = 0x0
al_rsc_cmi
CPU Map Index (CMI) [0]
ctiLo0 = 0
ctiLo1 = 0
ctiLo2 = 0
cpuQNum0 = 0
cpuQNum1 = 0
cpuQNum2 = 0
npuIndex = 0
stripSeg = 0
copySeg = 0
ASIC#1:

```

```

index = 0x5338
pmap = 0x00000000 0x00000001 <-- Looking at 0x00000001, in binary that is 0000 0000 0000 0000
0000 0000 0000 0001 = Port 0 (Zero based, count right to left)
cmi = 0x0
rcp_pmap = 0x0
al_rsc_cmi
CPU Map Index (CMI) [0]
ctiLo0 = 0
ctiLo1 = 0
ctiLo2 = 0
cpuQNum0 = 0
cpuQNum1 = 0
cpuQNum2 = 0
npuIndex = 0
stripSeg = 0
copySeg = 0

```

C9300-PE-2#show platform software fed switch active ifm mappings

Interface	IF_ID	Inst	Asic	Core	Port	SubPort	Mac	Cntx	LPN	GPN	Type	Active
GigabitEthernet2/0/1	0x35	1	0	1	0	0	26	6	1	97	NIF	Y

- Port 0 is the egress port, Gi2/0/1

## VPNv4 Label Programming

The next section covers VPNv4 label programming on the MPLS PE routers, C9300-PE-1 and C9300-PE-2. The C9500=P does not forward on the VPNv4 label so there is no output from C9500-P.

C9300-PE-1 VPNv4 Label Programming:

**Check** the local prefix to the PE, not the remote prefix. Check the label from a FED perspective and then backtrack to FMAN RP and FMAN FP.

\*\*\*Software VPNv4 Label Programming\*\*\*

C9300-PE-1#show ip cef vrf RED 192.168.3.0/24 detail

192.168.3.0/24, epoch 0

QOS: Precedence routine (0)

dflt local label info: other/21 [0x2] <-- VPNv4 label associated with the local prefix

nexthop 10.0.0.1 GigabitEthernet1/0/1

\*\*\*FMAN RP VPNv4 Label Programming\*\*\*

C9300-PE-1#show platform software mpls switch active r0 eos index 117 <-- Utilize the objid from the FED command

EOS Choice 0x75, Number of paths: 2  
Next Object Type: OBJ\_ADJ\_DROP,OBJ\_LABEL  
Next Object Index: 0,0x74  
OM handle: 0x3480644470

**\*\*\*FMAN FP VPNv4 Label Programming\*\*\***

C9300-PE-1#show platform software mpls switch active f0 eos index 117 <-- Utilize the objid from the FED command

EOS Choice 0x75, Number of paths: 2  
Next Object Type: OBJ\_ADJ\_DROP,OBJ\_LABEL  
Next Object Index: 0,0x74  
**aom id: 612**, CPP handle: 0xdeadbeef (created), flags: 0

C9300-PE-1#show platform software object-manager switch active f0 object 612 <-- Use the aom id from previous command

Object identifier: 612  
Description: EOS Choice 0x75  
Status: Done, Epoch: 0, Client data: 0xe05e9318

C9300-PE-1#show platform software object-manager switch active f0 object 612 parents <-- Use the aom id from previous command

Object identifier: 7  
Description: Special Object adj\_drop  
Status: Done

Object identifier: 611  
Description: label 0x74  
Status: Done

**\*\*\*FED VPNv4 Label Programming\*\*\***

C9300-PE-1#show platform software fed switch active mpls forwarding label 21 detail

LENTRY:label:21 nobj:(EOS, 117) lentry\_hdl:0x8b000009  
modify\_cnt:0 backwalk\_cnt:0  
lspa\_handle:0  
AAL: id:2332033033 lbl:21  
eos0:[adj\_hdl:0, hw\_hdl:0x7fbae8d87428]  
eos1:[adj\_hdl:0x4300003b, hw\_hdl:0x7fbae8d87278]  
deagg\_vrf\_id = 0 lspa\_handle:0  
EOS:**objid:117** local\_label:0 flags:0:( ) pdflags:0 <-- Utilized in previous commands  
nobj0:(ADJ SPECIAL,DROP 0), nobj1:(LABEL, 116) modify:0 bwalk:0  
LABEL:objid:116 link\_type:IP local\_label:21 outlabel:(1048577, 0)  
flags:0xc:(UHP,POP,) pdflags:0x2:(INSTALL\_HW\_OK,) adj\_handle:0x4300003b  
unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0  
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0  
AAL: id:1124073531 lbl:0 smac:a0f8.4911.d1e4 dmac:0072.78c8.06e4  
sub\_type:0 link\_type:0 adj\_flags:0x2 label\_type:1 rewrite\_type:POP2IP(135)  
vlan\_id:0 vrf\_id:0 ri:0x7fbae8d811b8, ri\_id:0x3e phdl:0xf1000024, ref\_cnt:1  
si:0x7fbae8d72078, si\_id:0x4012, di\_id:0x5338  
ADJ:objid:58 {link\_type:IP ifnum:0x35, si:0x1900001b, IPv4: 10.0.0.1 }

## Verify C9300-PE-2 VPNv4 Labels

Check the local prefix to the PE, not the remote prefix. Check the label from a FED perspective and then backtrack to FMAN RP and FMAN FP.

C9300-PE-2#show ip cef vrf RED 192.168.2.0/24 detail

192.168.2.0/24, epoch 0

QOS: Precedence routine (0)

dflt local label info: other/21 [0x2] <-- VPNv4 label associated with the local prefix

nexthop 10.0.0.22 GigabitEthernet2/0/1

C9300-PE-2#show platform software mpls switch active r0 eos index 118 <-- Utilize the objid value from the FED command

EOS Choice 0x76, Number of paths: 2

Next Object Type: OBJ\_ADJ\_DROP,OBJ\_LABEL

Next Object Index: 0,0x75

OM handle: 0x34806402d0

C9300-PE-2#show platform software mpls switch active f0 eos index 118 <-- Utilize the objid value from the FED command

EOS Choice 0x76, Number of paths: 2

Next Object Type: OBJ\_ADJ\_DROP,OBJ\_LABEL

Next Object Index: 0,0x75

aom id: 589, CPP handle: 0xdeadbeef (created), flags: 0

C9300-PE-2#show platform software object-manager switch active f0 object 589 <-- Utilize the aom id from the previous command

Object identifier: 589

Description: EOS Choice 0x76

Status: Done, Epoch: 0, Client data: 0x248cac8

C9300-PE-2#show platform software object-manager switch active f0 object 589 parents <-- Utilize the aom id from the previous command

Object identifier: 7

Description: Special Object adj\_drop

Status: Done

Object identifier: 588

Description: label 0x75

Status: Done

C9300-PE-2#show platform software fed switch active mpls forwarding label 21 detail

LENTY:label:21 nobj:(EOS, 118) lentry\_hdl:0x63000009

modify\_cnt:0 backwalk\_cnt:0

lspa\_handle:0

AAL: id:1660944393 lbl:21

eos0:[adj\_hdl:0, hw\_hdl:0x7f0650a40408]

eos1:[adj\_hdl:0xcb00003a, hw\_hdl:0x7f0650a401f8]

deagg\_vrf\_id = 0 lspa\_handle:0

EOS:objid:118 local\_label:0 flags:0:( ) pdfflags:0

nobj0:(ADJ SPECIAL,DROP 0), nobj1:(LABEL, 117) modify:0 bwalk:0

LABEL:objid:117 link\_type:IP local\_label:21 outlabel:(1048577, 0)

flags:0xc:(UHP,POP,) pdfflags:0x2:(INSTALL\_HW\_OK,) adj\_handle:0xcb00003a

unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0

bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0

AAL: id:3405774906 lbl:0 smac:70d3.79be.ae42 dmac:0072.78c8.c9c2

sub\_type:0 link\_type:0 adj\_flags:0x2 label\_type:1 rewrite\_type:POP2IP(135)

vlan\_id:0 vrf\_id:0 ri:0x7f0650a3f2a8, ri\_id:0x48 phdl:0xf1000024, ref\_cnt:1

si:0x7f0650a3d5e8, si\_id:0x400a, di\_id:0x5338

ADJ:objid:58 {link\_type:IP ifnum:0x35, si:0x9700001b, IPv4: 10.0.0.22 }

## LDP Label Programming

The next section covers LDP label programming on the MPLS routers, C9300-PE-1, C9500-P, and C9300-PE-2.

The LDP (outer) label is what the MPLS network label-switches the packets on. Validate the local LDP label that is advertised to the remote PE, do not validate the remote LDP label.

C9300-PE-1 LDP Label Programming:

**Validate** the local LDP label that is advertised to the remote PE, do not validate the remote LDP label. Check the label from a FED perspective and then backtrack to FMAN RP and FMAN FP.

**\*\*\*Software LDP Label Programming\*\*\***

C9300-PE-1#**show mpls forwarding-table**

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
16	Pop Label	192.168.1.3/32	0	Gi1/0/2	10.0.0.6
	Pop Label	192.168.1.3/32	0	Gi1/0/3	10.0.0.10
17	Pop Label	10.0.0.16/30	0	Gi1/0/2	10.0.0.6
	Pop Label	10.0.0.16/30	0	Gi1/0/3	10.0.0.10
18	Pop Label	10.0.0.12/30	0	Gi1/0/2	10.0.0.6
	Pop Label	10.0.0.12/30	0	Gi1/0/3	10.0.0.10
<b>19</b>	17	192.168.1.4/32	0	Gi1/0/2	10.0.0.6 <-- LDP label 19 is advertised to reach PE 192.168.1.4
	17	192.168.1.4/32	0	Gi1/0/3	10.0.0.10
20	No Label	10.0.0.0/30[V]	630	aggregate/RED	
21	No Label	192.168.3.0/24[V]	\		
			0	Gi1/0/1	10.0.0.1

**\*\*\*FMAN RP LDP Label Programming\*\*\***

C9300-PE-1#**show platform software mpls switch active r0 label index 110 <-- Use the objid value from the FED commands**

```
Label OCE 0x6e -> OBJ_ADJACENCY (0x4b)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0x11
  Backup flags: Pop, UHP, backup label 0x100001
  OM handle: 0x34806420d0
```

C9300-PE-1#**show platform software mpls switch active r0 label index 111 <-- Use the objid value from the FED commands**

```
Label OCE 0x6f -> OBJ_ADJACENCY (0x4e)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0x11
  Backup flags: Pop, UHP, backup label 0x100001
  OM handle: 0x3480642268
```

**\*\*\*FMAN FP LDP Label Programming\*\*\***

C9300-PE-1#**show platform software mpls switch active f0 label index 110 <-- Use the objid value from the FED commands**

```
Label OCE 0x6e -> OBJ_ADJACENCY (0x4b)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0x11
  Backup flags: Pop, UHP, backup label 0x100001
  aom id: 598, CPP handle: 0xdeadbeef (created)
```

C9300-PE-1#show platform software mpls switch active f0 label index 111 <-- Use the objid value from the FED commands

Label OCE 0x6f -> OBJ\_ADJACENCY (0x4e)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0x11  
Backup flags: Pop, UHP, backup label 0x100001  
**aom id: 599**, CPP handle: 0xdeadbeef (created)

C9300-PE-1#show platform software object-manager switch active f0 object 598 <-- Utilize the aom id from previous commands

Object identifier: 598  
Description: label 0x6e  
Status: Done, Epoch: 0, Client data: 0xe05e6d78

C9300-PE-1#show platform software object-manager switch active f0 object 598 parents <-- Utilize the aom id from previous commands

Object identifier: 531  
Description: adj 0x4b, Flags None  
Status: Done

C9300-PE-1#show platform software object-manager switch active f0 object 599 <-- Utilize the aom id from previous commands

Object identifier: 599  
Description: label 0x6f  
Status: Done, Epoch: 0, Client data: 0xe05e6f78

C9300-PE-1#show platform software object-manager switch active f0 object 599 parents <-- Utilize the aom id from previous commands

Object identifier: 535  
Description: adj 0x4e, Flags None  
Status: Done

C9300-PE-1#show platform software fed switch active mpls forwarding label 19 detail

LENTRY:label:19 nobj:(LB, 112) lentry\_hdl:0x9000007  
modify\_cnt:1 backwalk\_cnt:0  
lspa\_handle:0  
AAL: id:150994951 lbl:19  
eos0:[adj\_hdl:0x7d000002, hw\_hdl:0x7fbae8d778b8]  
eos1:[adj\_hdl:0x7d000002, hw\_hdl:0x7fbae8d776a8]  
deagg\_vrf\_id = 0 lspa\_handle:0  
LB:obj\_id:112 link\_type:IP num\_choices:2 Flags:0  
mpls\_ecr:1 local\_label:19 path\_inhw:2 ecrh:0x7d000002 old\_ecrh:0  
modify\_cnt:0 bwalk\_cnt:0 subwalk\_cnt:0 finish\_cnt:0  
bwalk:[req:0 in\_prog:0 nested:0]  
AAL: ecr:id:2097152002 af:0 ecr\_type:0 ref:7 ecrh:0x7fbae8a99268(28:2)  
hwhdl:3903427176 ::0x7fbae8a98b98,0x7fbae8a9ad48,0x7fbae8a98b98,0x7fbae8a9ad48  
Sw Enh ECR scale: objid:112 llabel:19 eos:1 #adjs:2 mixed\_adj:0  
reprogram\_hw:0 ecrhdl:0x7d000002 ecr\_hwhdl:0x7fbae8a99268  
mod\_cnt:0 prev\_npath:0 pmismatch:0 pordermatch:0  
ecr\_adj: id:4278190135 is\_mpls\_adj:1 l3adj\_flags:0x100000  
recirc\_adj\_id:1744830509  
sih:0x7fbae8a98b98(179) di\_id:20499 rih:0x7fbae8a985d8(33)  
adj\_lentry [eos0:0x7fbae8d7bf48 eos1:0x7fbae8d76e88]  
ecr\_adj: id:1392508984 is\_mpls\_adj:1 l3adj\_flags:0x100000  
recirc\_adj\_id:2013265966  
sih:0x7fbae8a9ad48(180) di\_id:20499 rih:0x7fbae8a9a788(46)  
adj\_lentry [eos0:0x7fbae8d7c1b8 eos1:0x7fbae8d77158]  
ecr\_prefix\_adj: id:2164260921 (ref:1)  
sih:0x7fbae8d7df08(181) di\_id:20499 rih:0x7fbae8d7db98(68)  
LABEL:objid:110 link\_type:MPLS local\_label:19 outlabel:(17, 0) <-- Used in previous commands

```

flags:0x1:(REAL,) pdfflags:0:(INSTALL_HW_OK,) adj_handle:0xff000037
unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
AAL: id:4278190135 lbl:0 smac:a0f8.4911.d1d6 dmac:d4ad.71b5.dde4
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7fbae8d78c48, ri_id:0x40 phdl:0x9f00004b, ref_cnt:1
    si:0x7fbae8d78fd8, si_id:0x4013, di_id:0x535f
ADJ:objid:75 {link_type:MPLS ifnum:0x36, si:0x22000023, }
LABEL:objid:111 link_type:MPLS local_label:19 outlabel:(17, 0) <-- Used in previous

```

**commands**

```

flags:0x1:(REAL,) pdfflags:0:(INSTALL_HW_OK,) adj_handle:0x53000038
unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
AAL: id:1392508984 lbl:0 smac:a0f8.4911.d1d8 dmac:d4ad.71b5.ddc2
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7fbae8d7d0a8, ri_id:0x42 phdl:0x8400004c, ref_cnt:1
    si:0x7fbae8d7a908, si_id:0x4014, di_id:0x5360
ADJ:objid:78 {link_type:MPLS ifnum:0x37, si:0x74000026, }

```

### C9500-P LDP Label Programming:

**Validate** the local LDP label that is advertised to the remote PE, do not validate the remote LDP label. Check the label from a FED perspective and then backtrack to FMAN RP and FMAN FP.

**\*\*\*Software LDP Label Programming\*\*\***

C9500-P#**show mpls forwarding-table**

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
<b>16</b>	explicit-n	192.168.1.2/32	1240	Te1/0/1	10.0.0.5 <-- LDP Label 16
<b>advertised to reach PE 192.168.1.2</b>					
	explicit-n	192.168.1.2/32	226537	Te2/0/1	10.0.0.9
<b>17</b>	explicit-n	192.168.1.4/32	610	Te1/0/2	10.0.0.14 <-- LDP Label 17
<b>advertised to reach PE 192.168.1.4</b>					
	explicit-n	192.168.1.4/32	227592	Te2/0/2	10.0.0.18

**\*\*\*FMAN RP LDP Label Programming\*\*\***

C9500-P#**show platform software mpls switch active r0 label index 94**

```

Label OCE 0x5e -> OBJ_ADJACENCY (0x3f)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0
  Backup flags: Pop, UHP, backup label 0x100001
  OM handle: 0x348064c530

```

C9500-P#**show platform software mpls switch active r0 label index 95**

```

Label OCE 0x5f -> OBJ_ADJACENCY (0x44)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0
  Backup flags: Pop, UHP, backup label 0x100001
  OM handle: 0x348064c6c8

```

C9500-P#**show platform software mpls switch active r0 label index 104**

```

Label OCE 0x68 -> OBJ_ADJACENCY (0x49)
  Flags: Real, Number of labels in the OCE: 1
  Label values: 0
  Backup flags: Pop, UHP, backup label 0x100001

```



OM handle: 0x348064df70

C9500-P#**show platform software mpls switch active r0 label index 105**

Label OCE 0x69 -> OBJ\_ADJACENCY (0x4e)

Flags: Real, Number of labels in the OCE: 1

Label values: 0

Backup flags: Pop, UHP, backup label 0x100001

OM handle: 0x348064e108

**\*\*\*FMAN FP LDP Label Programming\*\*\***

C9500-P#**show platform software mpls switch active f0 label index 94**

Label OCE 0x5e -> OBJ\_ADJACENCY (0x3f)

Flags: Real, Number of labels in the OCE: 1

Label values: 0

Backup flags: Pop, UHP, backup label 0x100001

aom id: 564, CPP handle: 0xdeadbeef (created)

C9500-P#**show platform software mpls switch active f0 label index 95**

Label OCE 0x5f -> OBJ\_ADJACENCY (0x44)

Flags: Real, Number of labels in the OCE: 1

Label values: 0

Backup flags: Pop, UHP, backup label 0x100001

aom id: 565, CPP handle: 0xdeadbeef (created)

C9500-P#**show platform software mpls switch active f0 label index 104**

Label OCE 0x68 -> OBJ\_ADJACENCY (0x49)

Flags: Real, Number of labels in the OCE: 1

Label values: 0

Backup flags: Pop, UHP, backup label 0x100001

aom id: 576, CPP handle: 0xdeadbeef (created)

C9500-P#**show platform software mpls switch active f0 label index 105**

Label OCE 0x69 -> OBJ\_ADJACENCY (0x4e)

Flags: Real, Number of labels in the OCE: 1

Label values: 0

Backup flags: Pop, UHP, backup label 0x100001

aom id: 577, CPP handle: 0xdeadbeef (created)

C9500-P#**show platform software object-manager switch active f0 object 564**

Object identifier: 564

Description: label 0x5e

Status: Done, Epoch: 0, Client data: 0x4f737108

C9500-P#**show platform software object-manager switch active f0 object 564 parents**

Object identifier: 515

Description: adj 0x3f, Flags None

Status: Done

C9500-P#**show platform software object-manager switch active f0 object 565**

Object identifier: 565

Description: label 0x5f

Status: Done, Epoch: 0, Client data: 0x4f737448

C9500-P#show platform software object-manager switch active f0 object 565 parents

Object identifier: 525  
Description: adj 0x44, Flags None  
Status: Done

C9500-P#show platform software object-manager switch active f0 object 576

Object identifier: 576  
Description: label 0x68  
Status: Done, Epoch: 0, Client data: 0x4f6d4bf8

C9500-P#show platform software object-manager switch active f0 object 576 parents

Object identifier: 536  
Description: adj 0x49, Flags None  
Status: Done

C9500-P#show platform software object-manager switch active f0 object 577

Object identifier: 577  
Description: label 0x69  
Status: Done, Epoch: 0, Client data: 0x4f737f78

C9500-P#show platform software object-manager switch active f0 object 577 parents

Object identifier: 545  
Description: adj 0x4e, Flags None  
Status: Done

**\*\*\*FED LDP Label Programming\*\*\***

C9500-P#show platform software fed switch active mpls forwarding label 16 detail

LENTRY:label:16 nobj:(LB, 96) lentry\_hdl:0xeb000004  
modify\_cnt:2 backwalk\_cnt:0  
lspa\_handle:0  
AAL: id:3942645764 lbl:16  
eos0:[adj\_hdl:0x44000002, hw\_hdl:0x7f0b284b4d98]  
eos1:[adj\_hdl:0x44000002, hw\_hdl:0x7f0b284b4be8]  
deagg\_vrf\_id = 0 lspa\_handle:0  
LB:obj\_id:96 link\_type:IP num\_choices:2 Flags:0  
mpls\_ecr:1 local\_label:16 path\_inhw:2 ecrh:0x44000002 old\_ecrh:0  
modify\_cnt:0 bwalk\_cnt:0 subwalk\_cnt:0 finish\_cnt:0  
bwalk:[req:0 in\_prog:0 nested:0]  
AAL: ecr:id:1140850690 af:0 ecr\_type:0 ref:2 ecrh:0x7f0b284a3998(28:2)  
hwhdl:675953048 ::0x7f0b284b4268,0x7f0b284a1d78,0x7f0b284b4268,0x7f0b284a1d78  
Sw Enh ECR scale: objid:96 llabel:16 eos:1 #adjs:2 mixed\_adj:0  
reprogram\_hw:0 ecrhdl:0x44000002 ecr\_hwhdl:0x7f0b284a3998  
mod\_cnt:0 prev\_npath:0 pmismatch:0 pordermatch:0  
ecr\_adj: id:1610612787 is\_mpls\_adj:1 l3adj\_flags:0x100000  
recirc\_adj\_id:1207959601  
sih:0x7f0b284b4268(181) di\_id:23709 rih:0x7f0b284b3ca8(31)  
adj\_lentry [eos0:0x7f0b284a32d8 eos1:0x7f0b284a3cc8]  
ecr\_adj: id:805306420 is\_mpls\_adj:1 l3adj\_flags:0x100000  
recirc\_adj\_id:67108914  
sih:0x7f0b284a1d78(182) di\_id:23709 rih:0x7f0b284b47d8(44)  
adj\_lentry [eos0:0x7f0b284c1608 eos1:0x7f0b284a2138]  
ecr\_prefix\_adj: id:3976200245 (ref:1)  
sih:0x7f0b284c2bf8(183) di\_id:23709 rih:0x7f0b284c2888(50)  
LABEL:objid:94 link\_type:MPLS local\_label:16 outlabel:(0, 0)  
flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0x60000033  
unsupported\_recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0  
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0  
AAL: id:1610612787 lbl:0 smac:d4ad.71b5.dde4 dmac:a0f8.4911.d1d6  
sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)  
vlan\_id:0 vrf\_id:0 ri:0x7f0b284a2cd8, ri\_id:0x2e phdl:0xe9000057, ref\_cnt:1  
si:0x7f0b284a3048, si\_id:0x4009, di\_id:0x1

```

ADJ:objid:63 {link_type:MPLS ifnum:0x41, si:0x2d000023, }
LABEL:objid:95 link_type:MPLS local_label:16 outlabel:(0, 0)
  flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0x30000034
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:805306420 lbl:0 smac:d4ad.71b5.ddc2 dmac:a0f8.4911.d1d8
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7f0b284a57c8, ri_id:0x30 phdl:0x67000059, ref_cnt:1
    si:0x7f0b284a6008, si_id:0x400a, di_id:0x61
  ADJ:objid:68 {link_type:MPLS ifnum:0x43, si:0xef000026, }

```

#### C9500-P#show platform software fed switch active mpls forwarding label 17 detail

```

LENTRY:label:17 nobj:(LB, 106) lentry_hdl:0xf6000005
  modify_cnt:1 backwalk_cnt:0
  lsp_handle:0
  AAL: id:4127195141 lbl:17
    eos0:[adj_hdl:0x44000002, hw_hdl:0x7f0b284ce2f8]
    eos1:[adj_hdl:0x44000002, hw_hdl:0x7f0b284ce0e8]
    deagg_vrf_id = 0 lsp_handle:0
  LB:obj_id:106 link_type:IP num_choices:2 Flags:0
    mpls_ecr:1 local_label:17 path_inhw:2 ecrh:0x44000002 old_ecrh:0
    modify_cnt:0 bwalk_cnt:0 subwalk_cnt:0 finish_cnt:0
    bwalk:[req:0 in_prog:0 nested:0]
  AAL: ecr:id:1140850690 af:0 ecr_type:0 ref:2 ecrh:0x7f0b284a3998(28:2)
  hwhdl:675953048 ::0x7f0b284b4268,0x7f0b284a1d78,0x7f0b284b4268,0x7f0b284a1d78
  Sw Enh ECR scale: objid:106 llabel:17 eos:1 #adjs:2 mixed_adj:0
  reprogram_hw:0 ecrhdl:0x44000002 ecr_hwhdl:0x7f0b284a3998
  mod_cnt:0 prev_npath:0 pmismatch:0 pordermatch:0
  ecr_adj: id:4127195192 is_mpls_adj:1 l3adj_flags:0x100000
    recirc_adj_id:1207959601
    sih:0x7f0b284b4268(181) di_id:23709 rih:0x7f0b284b3ca8(31)
    adj_lentry [eos0:0x7f0b284c38e8 eos1:0x7f0b284cd858]
  ecr_adj: id:1157627961 is_mpls_adj:1 l3adj_flags:0x100000
    recirc_adj_id:67108914
    sih:0x7f0b284a1d78(182) di_id:23709 rih:0x7f0b284b47d8(44)
    adj_lentry [eos0:0x7f0b284c3af8 eos1:0x7f0b284cdb28]
  ecr_prefix_adj: id:3707764794 (ref:1)
    sih:0x7f0b284c5028(184) di_id:23709 rih:0x7f0b284c4c48(60)
  LABEL:objid:104 link_type:MPLS local_label:17 outlabel:(0, 0)
    flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0xf6000038
    unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
    bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
    AAL: id:4127195192 lbl:0 smac:d4ad.71b5.ddd6 dmac:70d3.79be.ae71
      sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
      vlan_id:0 vrf_id:0 ri:0x7f0b284ceaa8, ri_id:0x38 phdl:0x76000058, ref_cnt:1
      si:0x7f0b284ceeb8, si_id:0x400b, di_id:0x2
    ADJ:objid:73 {link_type:MPLS ifnum:0x42, si:0x1f000028, }
  LABEL:objid:105 link_type:MPLS local_label:17 outlabel:(0, 0)
    flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0x45000039
    unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
    bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
    AAL: id:1157627961 lbl:0 smac:d4ad.71b5.ddf1 dmac:70d3.79be.ae61
      sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
      vlan_id:0 vrf_id:0 ri:0x7f0b284c4588, ri_id:0x3a phdl:0x5500005a, ref_cnt:1
      si:0x7f0b284d0548, si_id:0x400c, di_id:0x62
    ADJ:objid:78 {link_type:MPLS ifnum:0x44, si:0x4900002a, }

```

#### C9300-PE-2 LDP Label Programming:

**Validate** the local LDP label that is advertised to the remote PE, do not validate the remote LDP label. Start by checking the label from a FED perspective and then backtrack to FMAN RP and FMAN FP.

**\*\*\*Software LDP Label Programming\*\*\***

C9300-PE-2#show mpls forwarding-table

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
16	Pop Label	192.168.1.3/32	0	Gi2/0/2	10.0.0.13
	Pop Label	192.168.1.3/32	0	Gi2/0/3	10.0.0.17
<b>17</b>	16	192.168.1.2/32	0	Gi2/0/2	10.0.0.13 <-- LDP Label 17 is advertised to Remote PE 192.168.1.2
	16	192.168.1.2/32	0	Gi2/0/3	10.0.0.17
18	Pop Label	10.0.0.4/30	0	Gi2/0/2	10.0.0.13
	Pop Label	10.0.0.4/30	0	Gi2/0/3	10.0.0.17
19	Pop Label	10.0.0.8/30	0	Gi2/0/2	10.0.0.13
	Pop Label	10.0.0.8/30	0	Gi2/0/3	10.0.0.17
20	No Label	10.0.0.20/30[V]	630	aggregate/RED	
21	No Label	192.168.2.0/24[V] \	0	Gi2/0/1	10.0.0.22

**\*\*\*FMAN RP Label Programming\*\*\***

C9300-PE-2#show platform software mpls switch active r0 label index 106 <-- Use the objid values from the FED commands

Label OCE 0x6a -> OBJ\_ADJACENCY (0x4b)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0x10  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x3480637358

C9300-PE-2#show platform software mpls switch active r0 label index 107 <-- Use the objid values from the FED commands

Label OCE 0x6b -> OBJ\_ADJACENCY (0x4e)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0x10  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x3480638c10

**\*\*\*FMAN FP LDP Label Programming\*\*\***

C9300-PE-2#show platform software mpls switch active f0 label index 106

Label OCE 0x6a -> OBJ\_ADJACENCY (0x4b)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0x10  
Backup flags: Pop, UHP, backup label 0x100001  
**aom id: 548**, CPP handle: 0xdeadbeef (created)

C9300-PE-2#show platform software mpls switch active f0 label index 107

Label OCE 0x6b -> OBJ\_ADJACENCY (0x4e)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0x10  
Backup flags: Pop, UHP, backup label 0x100001  
**aom id: 549**, CPP handle: 0xdeadbeef (created)

C9300-PE-2#show platform software object-manager switch active f0 object 548 <-- Use the aom id value from the previous commands

Object identifier: 548  
Description: label 0x6a  
Status: Done, Epoch: 0, Client data: 0x24843d8

C9300-PE-2#show platform software object-manager switch active f0 object 548 parents <-- Use the aom id value from the previous commands

Object identifier: 509  
Description: adj 0x4b, Flags None  
Status: Done

C9300-PE-2#show platform software object-manager switch active f0 object 549 <-- Use the aom id value from the previous commands

Object identifier: 549  
Description: label 0x6b  
Status: Done, Epoch: 0, Client data: 0x2484518

C9300-PE-2#show platform software object-manager switch active f0 object 549 parents <-- Use the aom id value from the previous commands

Object identifier: 513  
Description: adj 0x4e, Flags None  
Status: Done

**\*\*\*FED LDP Label Programming\*\*\***

C9300-PE-2#show platform software fed switch active mpls forwarding label 17 detail

LENTRY:label:17 nobj:(LB, 108) lentry\_hdl:0x64000005  
modify\_cnt:1 backwalk\_cnt:0  
lspa\_handle:0  
AAL: id:1677721605 lbl:17  
eos0:[adj\_hdl:0xa0000002, hw\_hdl:0x7f0650a5c8e8]  
eos1:[adj\_hdl:0xa0000002, hw\_hdl:0x7f0650a5b908]  
deagg\_vrf\_id = 0 lspa\_handle:0  
LB:obj\_id:108 link\_type:IP num\_choices:2 Flags:0  
mpls\_ecr:1 local\_label:17 path\_inhw:2 ecrh:0xa0000002 old\_ecrh:0  
modify\_cnt:0 bwalk\_cnt:0 subwalk\_cnt:0 finish\_cnt:0  
bwalk:[req:0 in\_prog:0 nested:0]  
AAL: ecr:id:2684354562 af:0 ecr\_type:0 ref:7 ecrh:0x7f0650a62888(28:2)  
hwhdl:1353066632 ::0x7f0650a60998,0x7f0650a630d8,0x7f0650a60998,0x7f0650a630d8  
Sw Enh ECR scale: objid:108 llabel:17 eos:1 #adjs:2 mixed\_adj:0  
reprogram\_hw:0 ecrhdl:0xa0000002 ecr\_hwhdl:0x7f0650a62888  
mod\_cnt:0 prev\_npath:0 pmismatch:0 pordermatch:0  
ecr\_adj: id:436207667 is\_mpls\_adj:1 l3adj\_flags:0x100000  
recirc\_adj\_id:2113929262  
sih:0x7f0650a60998(178) di\_id:20507 rih:0x7f0650a60378(50)  
adj\_lentry [eos0:0x7f0650a877d8 eos1:0x7f0650a1cf78]  
ecr\_adj: id:3976200246 is\_mpls\_adj:1 l3adj\_flags:0x100000  
recirc\_adj\_id:1509949487  
sih:0x7f0650a630d8(179) di\_id:20507 rih:0x7f0650a62b18(51)  
adj\_lentry [eos0:0x7f0650a87a48 eos1:0x7f0650a1d188]  
ecr\_prefix\_adj: id:2919235640 (ref:1)  
sih:0x7f0650a87558(180) di\_id:20507 rih:0x7f0650a871d8(68)  
LABEL:objid:106 link\_type:MPLS local\_label:17 outlabel:(16, 0) <-- Used in previous commands  
flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0x1a000033  
unsupported\_recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0  
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0  
AAL: id:436207667 lbl:0 smac:70d3.79be.ae71 dmac:d4ad.71b5.ddd6  
sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)  
vlan\_id:0 vrf\_id:0 ri:0x7f0650a67d48, ri\_id:0x3a phdl:0x9f00004b, ref\_cnt:1  
si:0x7f0650a65408, si\_id:0x4010, di\_id:0x535f  
ADJ:objid:75 {link\_type:MPLS ifnum:0x36, si:0x35000023, }  
LABEL:objid:107 link\_type:MPLS local\_label:17 outlabel:(16, 0) <-- Used in previous commands  
flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0xed000036  
unsupported\_recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0  
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0  
AAL: id:3976200246 lbl:0 smac:70d3.79be.ae61 dmac:d4ad.71b5.ddf1

```

sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
vlan_id:0 vrf_id:0 ri:0x7f0650a6f4f8, ri_id:0x40 phdl:0x8400004c, ref_cnt:1
si:0x7f0650a73088, si_id:0x4013, di_id:0x5360
ADJ:objid:78 {link_type:MPLS ifnum:0x37, si:0xa2000025, }

```

## Troubleshoot Hardware Scale

This section provides information you can use in order to troubleshoot your configuration.

### MPLS Hardware Syslogs

If you run out of a particular resource, such as MPLS labels, SYSLOG message are generated by the system.

#### Key points to remember

- MPLS LABEL is used for **label disposition**. (This resource is consumed when prefixes are learnt from a local CE)
- LSPA is used for **label imposition**. (This resource is consumed when prefixes are learnt from a remote PE)

#### MPLS Log Message

%FED\_L3\_ERRMSG-3-RSRC\_ERR:  
Switch 1 R0/0: fed: Failed to allocate hardware resource for **fib entry due to hardware resource exhaustion**

#### Definition

Hardware reserved for IP prefixes has run out of space (EM or TCAM)

#### Recovery Action

Take one of these actions to reduce the number of prefixes learned on the **local or remote PE**:

1. Summarize prefixes at CE
2. Change label allocation mode from per-prefix to per-vrf

Take one of these actions to reduce number of lables used on **local PE**:

1. Summarize prefixes at local PE or local PE
2. Change label allocation mode from per-prefix to per-vrf on the PE

%FED\_L3\_ERRMSG-3-  
**mpls\_out\_of\_resource**: Switch 1 R0/0: fed: **Out of resource for MPLS LABEL ENTRY**. Failed to program local label:8205 (8192/8192) in hardware

#### Local label

**Allocation:** Hardware reserved for MPLS local labels has run out of space (EM or TCAM)

Take one of these actions to reduce number of lables used on **local PE**:

1. Summarize prefixes at local PE or local PE
2. Change label allocation mode from per-prefix to per-vrf on the PE

%FED\_L3\_ERRMSG-3-  
MPLS\_LENTRY\_PAUSE: Switch 1 R0/0: fed: **Critical limit reached for MPLS LABEL ENTRY resource. Lentry Create PAUSED.**

#### Local label Allocation:

Hardware reserved for MPLS local labels has run out of space (EM or TCAM)

Take one of these actions to reduce number of lables used on **remote PE**:

1. Summarize prefixes at remote PE or remote PE
2. Change label allocation mode from per-prefix to per-vrf on the remote PE

%FED\_L3\_ERRMSG-3-  
**mpls\_out\_of\_resource**: Switch 1 R0/0: fed: **Out of resource for MPLS LSPA. Failed to program in hardware**

#### Remote label allocation:

Hardware reserved for LSPA remote labels has run out of space

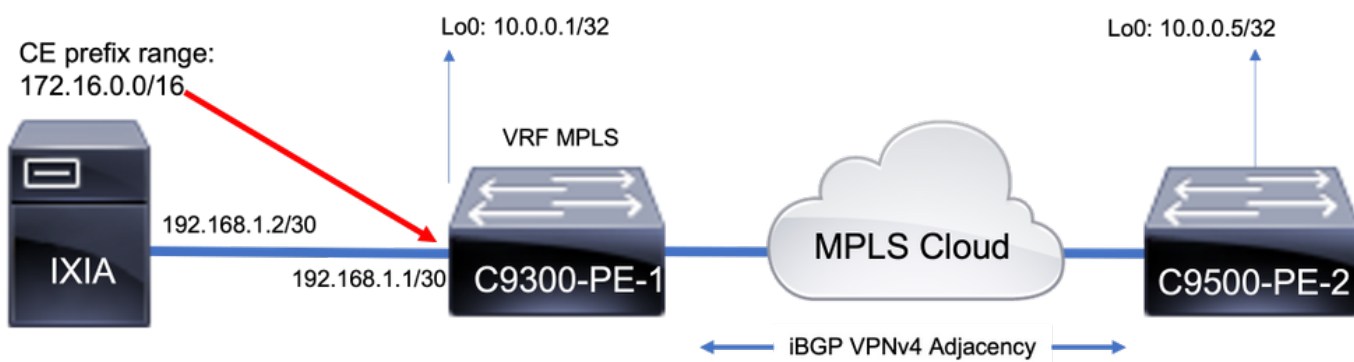
### Hardware Validation Commands

**show platform hardware fed active fwd-asic resource tcam utilization** command is the first place you want to look to evaluate if you have a hardware scale issue. It displays information on a per-ASIC basis.

This section shows a PE learning prefixes from BGP in vrf MPLS with the parameters described here:

- The default per-prefix label allocation is used
- PE is C9300-48U with Cisco IOS-XE 17.3.4
- CE is Ixia as a BGP neighbor that advertises prefixes to an interface in vrf MPLS
- Prefix length used is /28. Thus platform uses TCAM for prefix lengths /31 or shorter
- This platform uses EM memory for MPLS/BGP labels first, then overflows to TCAM if EM becomes full

### Topology



### Baseline Resource Usage

Prior to the addition of any prefixes, there is some base usage:

- This baseline was taken after MPLS LDP neighbors were formed in global table
- From this baseline, VPNv4 prefixes are added in VRF MPLS
- Your baseline numbers can vary. It depends on what is already programmed on the switch

**Note:** In this example, prefixes are added from one CE-PE side, which results in resources such as LSPA only allocated on the remote PE that needs to use a label stack for reachability. In real world scenarios, the resource would be allocated at both PE devices.

```
C9300-48U#show version | inc IOS
Cisco IOS XE Software, Version 17.03.04
Cisco IOS Software [Amsterdam], Catalyst L3 Switch Software (CAT9K_IOSXE), Version 17.3.4,
RELEASE SOFTWARE (fc3)
```

```
C9300-48U#show platform hardware fed switch active fwd-asic resource tcam utilization
Codes: EM - Exact_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable
```

```
CAM Utilization for ASIC [0]
```

Table	Subtype	Dir	Max	Used	%Used	V4	V6	MPLS
Other								
Mac Address Table	EM	I	32768	20	0.06%	0	0	0
Mac Address Table	TCAM	I	1024	21	2.05%	0	0	0

```

21
L3 Multicast      EM      I      8192      0      0.00%      0      0      0
0
L3 Multicast      TCAM    I      512      9      1.76%      3      6      0
0
L2 Multicast      EM      I      8192      0      0.00%      0      0      0
0
L2 Multicast      TCAM    I      512      11     2.15%      3      8      0
0
IP Route Table    EM      I      24576     23     0.09%     14      0      9
0 <-- 23 EM (hash) base usage
IP Route Table    TCAM    I      8192     25     0.31%     12      10     2
1 <-- 25 TCAM base usage

```

**C9300-48U#show platform software fed switch active mpls summary | b Resource shar**

Resource sharing info:

SI: 4/65536

RI: 10/65536

Well Known Index: 49/2048

Tcam: 21/57344

lv1\_ecr: 0/64

lv2\_ecr: 0/256

lspa: 0/16385

label\_stack\_id: 2/65537

vpn\_spoke\_id: 0/255

indirect\_si: 0/255

**RSM resource database stats:**

Num of (L3+mpls) ADJ entries allocated: 36/131072

**Num of LABEL entries allocated: 4/8192** <-- Baseline label usage = 4 (label entries allocated on local PE-CE side)

**Num of LSPA entries allocated: 0/8192** <-- LSPA resource used when prefix learnt from another PE, not from a local CE (The SDM template determines max value)

Num of local adjs in mpls adjs: 3

Num of SI stats allocated: 6/49152

Adjs stats allocated by MPLS:

Num of mpls adjs: 11

Num of L3 adjs: 0

Num of VPN prefix\_id: 0

<...snip...>

**Other MPLS resource alloc error stats:** <-- reported resource allocation issues shown here

LENTY out-of-resource errors: 0

LENTY general errors: 0

LSPA out-of-resource errors: 0

LSPA general errors: 0

ADJ out-of-resource errors: 0

SI stats alloc error: 0

MPLS ADJ stats error: 0

MPLS ADJ stats last error rc: 0

**Note:** SI/RI/DI are resources required for packet rewrite, destination port, and so on. To troubleshoot problems with SI/DI/RI see article [Understand Hardware Resources on Catalyst 9000 Switches](#)

## Add 1000 BGP VPNv4 Prefixes

Neighbor (Ixia) brought up with 1000 prefixes added to VRF MPLS from CE

9300 Local PE (connected to CE)



```
C9300-48U#show bgp vpnv4 unicast all summary
BGP router identifier 10.0.0.1, local AS number 65000
<...snip...> Neighbor V AS MsgRcvd MsgSent TblVer InQ OutQ Up/Down State/PfxRcd 10.0.0.5 4 65000
102 304 3001 0 0 01:28:23 0 192.168.1.2 4 65005 102 5 3001 0 0
00:00:58 1000 <-- PE learns 1000 prefixes from CE device
```

```
C9300-48U#show bgp vpnv4 unicast all | count /28
Number of lines which match regexp = 1000 <-- All 1000 prefixes are /28
C9300-48U#show platform hardware fed switch active fwd-asic resource tcam utilization
Codes: EM - Exact_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable
```

CAM Utilization for ASIC [0]

Table	Subtype	Dir	Max	Used	%Used	V4	V6	MPLS
Other								
-----								
Mac Address Table	EM	I	32768	20	0.06%	0	0	0
20								
Mac Address Table	TCAM	I	1024	21	2.05%	0	0	0
21								
L3 Multicast	EM	I	8192	0	0.00%	0	0	0
0								
L3 Multicast	TCAM	I	512	9	1.76%	3	6	0
0								
L2 Multicast	EM	I	8192	0	0.00%	0	0	0
0								
L2 Multicast	TCAM	I	512	11	2.15%	3	8	0
0								
IP Route Table	EM	I	24576	2023	8.23%	14	0	2009
0								
<b>IP Route Table</b>	<b>TCAM</b>	<b>I</b>	<b>8192</b>	<b>1025</b>	<b>12.51%</b>	<b>1012</b>	<b>10</b>	<b>2</b>
<b>1</b>								

```
<-- 25 base + 1000 /28 prefixes = 1025 TCAM entries
<-- MPLS labels are added to EM, and each MPLS label uses 2 entries (one IPv4 prefix, and one
MPLS label results in 3 entries used in hardware)
```

```
C9300-48U#show platform software fed switch active mpls summary | b Resource shar
Resource sharing info:
SI: 4/65536
RI: 1010/65536
Well Known Index: 49/2048
Tcam: 1021/57344
lv1_ecr: 0/64
lv2_ecr: 0/256
lspa: 0/16385
label_stack_id: 1002/65537
vpn_spoke_id: 0/255
indirect_si: 0/255
RSM resource database stats:
Num of (L3+mpls) ADJ entries allocated: 1036/131072
Num of LABEL entries allocated: 1004/8192 <-- Increased by 1000 on local PE
Num of LSPA entries allocated: 0/8192 <-- No prefixes learnt from remote
PE, no LSPA allocated
Num of local adjs in mpls adjs: 3
Num of SI stats allocated: 1006/49152
Adjs stats allocated by MPLS:
Num of mpls adjs: 1011
Num of L3 adjs: 0
Num of VPN prefix_id: 0
<...snip...>
Other MPLS resource alloc error stats: <-- no resource allocation issues
LENTRY out-of-resource errors: 0
```

LENTRY general errors: 0  
 LSPA out-of-resource errors: 0  
 LSPA general errors: 0  
 ADJ out-of-resource errors: 0  
 SI stats alloc error: 0  
 MPLS ADJ stats error: 0  
 MPLS ADJ stats last error rc: 0

<-- Resources shown in baseline outputs are now increased by 1000

**9500H Remote PE (Learned over MPLS)**

C9500-24Y4C#show platform hardware fed active fwd-asic resource tcam utilization

Codes: EM - Exact\_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable

CAM Utilization for ASIC [0]

Table	Subtype	Dir	Max	Used	%Used	V4	V6	MPLS
Other								
-----								
Mac Address Table	EM	I	32768	19	0.06%	0	0	0
19								
Mac Address Table	TCAM	I	768	21	2.73%	0	0	0
21								
L3 Multicast	EM	I	32768	0	0.00%	0	0	0
0								
L3 Multicast	TCAM	I	768	6	0.78%	3	3	0
0								
L2 Multicast	TCAM	I	2304	7	0.30%	3	4	0
0								
<b>IP Route Table</b>	<b>EM/LPM</b>	<b>I</b>	<b>212992</b>	<b>1012</b>	<b>0.48%</b>	<b>1003</b>	<b>0</b>	<b>9</b>
0								
IP Route Table	TCAM	I	1536	28	1.82%	23	3	2
0								
<b>CTS Cell Matrix/VPN</b>								
<b>Label</b>	<b>EM</b>	<b>O</b>	<b>32768</b>	<b>992</b>	<b>3.03%</b>	<b>0</b>	<b>0</b>	<b>992</b>
0								
<b>&lt;-- MPLS VPN used 992 entries</b>								
CTS Cell Matrix/VPN								
Label TCAM 0 768 9 1.17% 0 0 8 1								

<-- 1000 /28 IPv4 prefixes learned from remote PE (On the 9500HP these /28 prefixes are be stored in EM/LPM memory, not TCAM)

<-- Hardware shared between CTS and VPN (resource is used when prefixes learned PE-PE, label imposition)

C9500-24Y4C#show platform software fed active mpls summary | b Resource shar

Resource sharing info:

SI: 4/131072  
 RI: 11/98304  
 Well Known Index: 48/2048  
 Tcam: 20/245760  
 lv1\_ecr: 0/64  
 lv2\_ecr: 0/256  
 lspas: 1000/65536  
 label\_stack\_id: 2/65537  
 vpn\_spoke\_id: 0/255  
 indirect\_si: 0/255

**RSM resource database stats:**

Num of (L3+mpls) ADJ entries allocated: 37/196608

**Num of LABEL entries allocated: 4/45056**

**prefixes learnt from a local CE)**

**Num of LSPA entries allocated: 1000/32768**

**(these prefixes require label stack to reach)**

Num of local adjs in mpls adjs: 4

<-- LABEL does not increase (no

<-- LSPA usage increased by 1000

```

Num of SI stats allocated: 6/49152
Adjs stats allocated by MPLS:
  Num of mpls adjs: 12
  Num of L3 adjs: 0
Num of VPN prefix_id: 1000
AL MPLS SI/RI resource alloc stats:
SI allocated: 1
RI allocated: 6
SI_STATS allocated: 6
Unknowns allocs: 0
Alloc no resource: 0
Alloc errors: 0
Free errors: 0
Invalid free: 0
Free unknown: 0

```

```

Other MPLS resource alloc error stats:                <-- no resource allocation issues
LENTRY out-of-resource errors: 0
LENTRY general errors: 0
LSPA out-of-resource errors: 0
LSPA general errors: 0
ADJ out-of-resource errors: 0
SI stats alloc error: 0
MPLS ADJ stats error: 0
MPLS ADJ stats last error rc: 0

```

<-- Different resources are allocated to reach a local prefix (LABEL) versus a remote prefix (LSPA)

**Note:** For general Catalyst 9000 TCAM information, or details on how to check TCAM for other features see article [Understand Hardware Resources on Catalyst 9000 Switches](#).

**Note:** ADJ (adjacencies) are a shared resource. To troubleshoot problems with ADJ see article [Understand Hardware Resources on Catalyst 9000 Switches](#).

## MPLS Label and IPv4 Scale Limit and Remediation

In most cases when the MPLS feature is used, and too many hardware resources are consumed, a change to the label allocation from (default) per-prefix to per-vrf can help. In this example consider the resource allocation before and after (**in this case, the 9500 is the CE-PE device**).

### ### Usage with per-prefix label allocation ###

C9500-24Y4C#show platform hardware fed active fwd-asic resource tcam utilization

Codes: EM - Exact\_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable

CAM Utilization for ASIC [0]

Table	Subtype	Dir	Max	Used	%Used	V4	V6	MPLS
Other								
-----								
Mac Address Table	EM	I	32768	19	0.06%	0	0	0
19								
Mac Address Table	TCAM	I	768	21	2.73%	0	0	0
21								
L3 Multicast	EM	I	32768	0	0.00%	0	0	0
0								
L3 Multicast	TCAM	I	768	6	0.78%	3	3	0

```

0
L2 Multicast          TCAM          I          2304          7          0.30%          3          4          0
0
IP Route Table      EM/LPM      I      212992      3023      1.42%      1014      0      2009
0 <-- 1 IPv4 prefix entry + 2 entries for labels (2 labels created per every 1 IPv4 prefix)
IP Route Table      TCAM          I          1536          17          1.11%          12          3          2
0

```

### New usage after change to per-vrf lable allocation ###

```

C9500-24Y4C(config)#mpls label mode vrf MPLS protocol all-afs per-vrf
C9500-24Y4C#show bgp vpnv4 unicast all BGP table version is 164901, local router ID is 10.0.0.5
  Network          Next Hop          Metric LocPrf Weight Path
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
               x best-external, a additional-path, c RIB-compressed,
               t secondary path, L long-lived-stale,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found
Network Next Hop Metric LocPrf Weight Path
Route Distinguisher: 1:1 (default for vrf MPLS) *> 172.30.0.0/24 192.168.3.2 2219
0 65100 65101 65102 65103 {65104} e
<...snip...>

```

```

C9500-24Y4C#show bgp vpnv4 unicast all 172.30.0.0
BGP routing table entry for 1:1:172.30.0.0/24, version 163902
Paths: (1 available, best #1, table MPLS)
  Advertised to update-groups:
    8
  Refresh Epoch 1
  65100 65101 65102 65103 {65104}
    192.168.3.2 (via vrf MPLS) from 192.168.3.2 (192.168.3.2)
      Origin EGP, metric 2219, localpref 100, valid, external, best
      Extended Community: RT:1:1
      mpls labels in/out IPv4 VRF Aggr:18116/nolabel <-- Verify you see a 'VRF Aggr' label
type
  rx pathid: 0, tx pathid: 0x0
  Updated on Dec 9 2021 19:50:22 UTC

```

### Usage with per-vrf label allocation ###

Allocation on both local and remote PE is dramatically reduced via change to label allocation mode

local switch (PE-CE)

```

C9500-24Y4C#show platform hardware fed active fwd-asic resource tcam utilization
Codes: EM - Exact_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable

CAM Utilization for ASIC [0]
  Table          Subtype      Dir      Max      Used      %Used      V4      V6      MPLS
Other
-----
-----
  Mac Address Table  EM          I      32768      19      0.06%      0      0      0
19
  Mac Address Table  TCAM        I       768       21      2.73%      0      0      0
21
  L3 Multicast      EM          I      32768      0      0.00%      0      0      0
0
  L3 Multicast      TCAM        I       768       6      0.78%      3      3      0
0
  L2 Multicast      TCAM        I      2304       7      0.30%      3      4      0
0
IP Route Table      EM/LPM      I      212992      1025      0.48%      1014      0      11

```

```

0 <-- one local LABEL used to reach the CE learnt prefixes
IP Route Table          TCAM          I          1536        17        1.11%        12         3         2
0
QOS ACL                 TCAM          I          1024        45        4.39%        15        20         0
10

```

#### remote switch (PE-PE)

```
C9300-48U#show platform hardware fed switch active fwd-asic resource tcam utilization
```

Codes: EM - Exact\_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable

```
CAM Utilization for ASIC [0]
```

Table	Subtype	Dir	Max	Used	%Used	V4	V6	MPLS
Other								

```
-----
```

```
<...snip...>
```

IP Route Table	EM	I	24576	23	0.09%	14	0	9
----------------	----	---	-------	----	-------	----	---	---

<b>IP Route Table</b>	<b>TCAM</b>	<b>I</b>	<b>8192</b>	<b>1025</b>	<b>12.51%</b>	<b>1012</b>	<b>10</b>	<b>2</b>
-----------------------	-------------	----------	-------------	-------------	---------------	-------------	-----------	----------

```
<...snip...>
```

```
CTS Cell Matrix/VPN
```

Label	EM	O	8192	1	0.01%	0	0	1
0 <-- one remote LSPA used to reach the PE learnt prefixes								

**Note:** The resource usage in **show platform software fed switch active mpls summary** also shows this reduction in LABEL or LSPA (whichever is applicable).

## Commands to Collect for TAC

The most common hardware resource problems related to MPLS are covered in this guide, with appropriate remediation steps. However, in the event that this guide did not resolve your issue please collect the command list shown and attach them to the service request.

```

show ip route summary
show ip bgp vpnv4 all | redirect flash:bgp_vpnv4_all
show ip bgp vpnv4 all summary
show ip route vrf <vrf-name> summary
show mpls forwarding-table summary
show ip cef vrf <name> | redirect flash:sh_ip_cef_vrf_<name>
show ip cef vrf <name> summary
show platform software fed switch active ip route summary
show platform software mpls switch <all switches> f0 forwarding-table
show platform software mpls switch <all switches> f0 label
show platform software mpls switch <all switches> f0 eos
show platform software object-manager switch <all switches> f0 error-object
show platform software object-manager switch <all switches> f0 pending-issue-update
show platform software fed switch <all switches> mpls label_oce all detail
show platform software fed switch <all switches> mpls eos all det
show platform software fed switch <all switches> mpls summary
show platform software fed switch active mpls forwarding all detail
show platform software object-manager switch 1 f0 statistics
show tech-support mpls | redirect flash:sh_tech_mpls
show logging | redirect flash:sh_logging_console
show platform hard fed switch active fwd resource tcam table sghash ASIC 0 format 0 | redirect
flash:vpn_lspa

```

request platform software trace archive last 30 days target flash

## Related Information

[Technical Support & Documentation - Cisco Systems](#)

[Multiprotocol Label Switching \(MPLS\) Configuration Guide, Cisco IOS XE Cupertino 17.7.x \(Catalyst 9300 Switches\)](#)

[Multiprotocol Label Switching \(MPLS\) Configuration Guide, Cisco IOS XE Cupertino 17.7.x \(Catalyst 9500 Switches\)](#)

[Understand Hardware Resources on Catalyst 9000 Switches](#)