

验证Catalyst 9000交换机上的MPLS

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简介

本文档介绍如何在Catalyst 9000系列交换机上配置和验证多协议标签交换(MPLS)第3层虚拟专用网络(VPN)。

先决条件

要求

Cisco 建议您了解以下主题：

- IP转发
- 边界网关协议 (BGP)

- MPLS

使用的组件

本文档中的信息基于以下软件和硬件版本：

- C9500在Cisco IOS® XE 16.12.4上
- C9300在Cisco IOS® XE 16.12.4上
- Cisco IOS® XE 16.9.6上的C3850

本文档中的信息都是基于特定实验室环境中的设备编写的。本文档中使用的所有设备最初均采用原始（默认）配置。如果您的网络处于活动状态，请确保您了解所有命令的潜在影响。

背景信息

MPLS第3层VPN(L3VPN)使用使用BGP分发VPN相关信息的对等模型。MPLS VPN由一组通过MPLS提供商核心网络互连的站点组成。在每个客户站点，一个或多个客户边缘(CE)设备连接到一个或多个提供边缘(PE)设备。

在常规第3层路由中，当数据包通过网络时，每台交换机都会从第3层报头中提取与转发数据包相关的所有信息。然后，此信息将用作路由表查找的索引，以确定数据包的下一跳。

在最常见的情况下，报头中唯一相关的字段是目标地址字段，但在某些情况下，其他报头字段也可能相关。因此，报头分析必须在数据包通过的每台交换机上独立完成。此外，每台交换机还必须执行复杂的表查找。

在标签交换中，第3层报头的分析只完成一次。然后，第3层报头将映射到一个称为“alabel”的固定长度的非结构化值。

许多不同的报头可以映射到同一标签，只要这些报头总是导致选择相同的下一跳。实际上，标签表示转发等效类(FEC)，即一组数据包，无论它们有何不同，都可以通过转发功能不区分。

标签的初始选择不必完全基于第3层数据包报头的内容；例如，在后续跳处转发数据包的决定也可能基于其他因素。

分配标签后，第3层数据包的前面会添加一个短标签报头。此报头作为数据包的一部分在网络中传输。在通过网络中每个MPLS交换机的后续跳数中，标签交换并通过MPLS转发表查找数据包报头中携带的标签来做出决策。因此，在通过网络的数据包传输过程中不需要重新评估数据包报头。由于标签的长度是固定的，而且是非结构化的，因此MPLS转发表查找过程既简单又快速。

网络中的每个标签交换路由器(LSR)会独立地做出本地决定，决定使用哪个标签值来表示转发等价类。此关联称为标签绑定。每个LSR都会通知其邻居其已进行的标签绑定。以下协议有助于邻居交换机对标签绑定的感知：

- 标签分发协议(LDP) — 使MPLS网络中的对等LSR能够交换标签信息，以支持MPLS网络中逐跳转发
- 边界网关协议(BGP) — 用于支持MPLS虚拟专用网络(VPN)

当从LSR A向LSR B发送带标签的数据包时，IP数据包所携带的标签值是LSR B分配的用于表示数据包的转发等价类的标签值。因此，标签值会随着IP数据包通过网络而改变。

如何使用本指南

本指南分为两个场景，文档末尾提供了硬件扩展验证部分：

- MPLS核心内的单跳邻接
- MPLS核心内的等价多路径(ECMP)邻接
- 如何检查TCAM的使用情况以解决规模问题

每个场景都包括验证每个MPLS设备的前缀和标签。

术语

MPLS	多协议标签交换	一种高性能数据包转发技术，将数据链路层（第2层）交换的性能和流量管理与网络层（第3层）路由的可扩展性、灵活性和性能相集成。
PE	提供商边缘（交换机/路由器）	提供商网络的边缘设备，从客户CE接收IP前缀，并将其传送到MPLS云。
CE	客户边缘（交换机/路由器）	连接到服务提供商IP/MPLS网络的提供商边缘路由器的客户驻地设备。
LDP	标签发现协议	LDP是一种协议，可自动生成和交换路由器之间的标签。每台路由器在本地前缀生成标签，然后将标签值通告给其邻居。
LSPA	标签交换机路径阵列	到达特定MPLS目标的一组标签。在典型的L3VPN中 — 您可以有IGP + VPN。如果有TE隧道，则您有TE标签+ IGP + VPN。 Catalyst 9000最多可支持签，这组标签称为LSPA。
标签堆栈ID	标签堆栈ID	A 标识标签堆栈的唯一索引(允许LSPA共享)。
标签	标签	用于查找的MPLS标签。多个标签组成标签堆栈。
前缀ID	前缀标识符	Catalyst 9000为每个前缀创建全局资源（在分配每个前缀标签的情况下，前ID的数量与路由的数量一样多）。
EM	精确匹配	哈希内存中匹配1:1的条目（主机路由，直连主机）。
LPM	最长前缀匹配	任何/31或更短的路由（/32路由是EM类型）。
TCAM	三态内容可寻址存储器	一种内存，它存储和查询具有三种不同输入的条目：0、1和X。在同一条目有多个匹配时，必须使用此类内存，并且每个条目的哈希值不唯一。此表包或“X”值，使其能够知道它是否匹配该条目或与该条目不匹配。
CAM	内容可寻址存储器	硬件内存（散列/TCAM）的一般术语。
RIB	路由信息库	在“show ip route”中看到的路由表
FIB	转发信息库	简化表，其前缀由RIB和ARP表添加，并带有指向ADJ表的指针
直接连接	直接连接的路由	本地连接的主机前缀（ARP邻接）
间接连接	间接连接路由	通过远程下一跳到达的路由
ADJ	邻接（表）	存储用于数据包重写的下一跳信息
EM	精确匹配	已连接主机，间接/32主机前缀
TCAM	三态内容可寻址存储器	间接前缀/31或更短
美联储	转发引擎驱动程序	ASIC（硬件）层
FMAN-FP	转发管理器 —	FMAN-FP管理添加、删除或修改FED信息的软件对象

转发平面

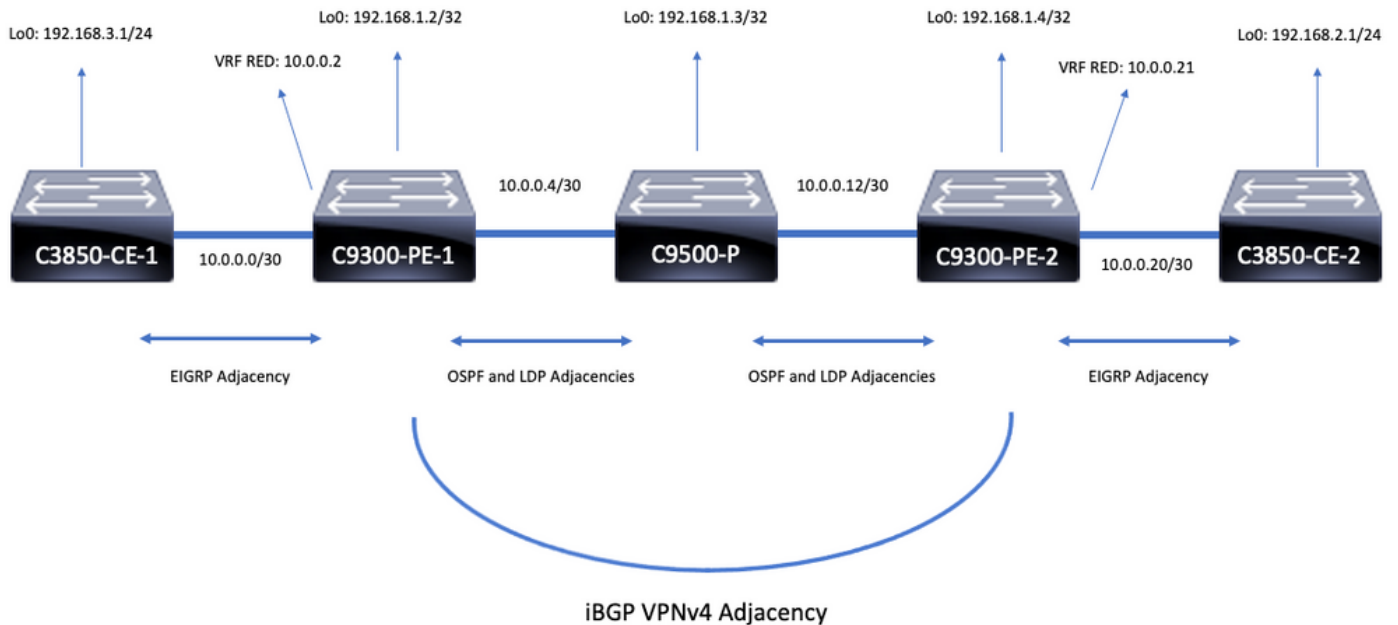
SI	站索引	站索引 = 数据包重写信息 (RI =重写索引) 和出站接口信息 (DI =目标索引)
RI	重写索引	第3层转发到下一跳邻接的MAC地址重写信息
DI	目标索引	指向出站接口的索引

配置和验证

场景1.在MPLS核心中具有单跳邻接的L3VPN

参考拓扑

在本例中，Catalyst 9300交换机用作PE设备，Stackwise虚拟中的Catalyst 9500用作P设备，Catalyst 3850交换机用作CE设备。



配置 细节

C3850-CE-1的配置

```
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
```

C9300-PE-1的配置

```
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
```

C9500-P的配置

```
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
```

C9300-CE-2的配置

```
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
```

C3850-CE-2的配置

```
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

```

基本验证

在验证MPLS编程之前，需要验证的基本要求有：

- 验证PE到PE的连接是否存在
- 验证PE之间的标签交换路径(LSP)
- 验证PE之间的BGPv4邻接
- 验证VPNv4和LDP标签
- 验证MPLS转发表

验证PE到PE的连接

您可以从本地环回对远程PE环回和源执行ping操作，但这不会确认MPLS标签交换路径(LSP)是否良好，因为环回IP地址在底层通告。

注意: PE到PE MP-BGP VPNv4邻接通过各自的Loopback0接口实现。

```

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

```

验证LSP

您可以使用从PE到PE环回的MPLS跟踪路由来验证LSP和沿路径的所有MPLS LDP标签。

注意:此MPLS跟踪路由仅强加一个标签 (LDP标签)，这并不表明来自CE的流量是成功的，因为该流量强加了2个标签，即VPNv4 (内部) 标签和LDP (外部) 标签。

```

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
```

如果您无权访问CE或CE后面的设备，并且想要证明VPNv4和LDP标签实施/处置成功，则可以尝试从PE上VRF中面向CE的接口ping远程PE上VRF中面向CE的接口。

```
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
```

验证PE之间的BGP VPNv4邻接

```
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

```

远程PE VPNv4邻接关系已启用，且已收到前缀

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

验证特定VRF中交换的前缀

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	?

验证VPNv4和LDP标签：

验证用于到达VRF中前缀的VPNv4标签

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

验证使用的LDP标签

```
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

验证MPLS转发表

```
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

确认用于到达VRF中每个给定前缀的内部(VPNv4)和外部(LDP)标签

```
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

验证Object-Manager统计信息

在理想情况下，没有挂起的对象

```
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
```

前缀编程

下一节介绍MPLS路由器、C9300-PE-1、C9500-P和C9300-PE-2上的前缀编程。

C9300-PE-1前缀编程

*****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	0x14

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
aom id: 664, CPP handle: 0xdeadbeef (created)

C9300-PE-1#show platform software adjacency switch active f0 index 0x46 <-- Utilize the OBJ_ADJACENCY value from the 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
aom id: 522, 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	0x7feeeeca12bb8	0x0	0	0	lspa0x2	

2021/06/14 17:13:59.644 <-- HTM value significant for next command

FIB: prefix_hdl:0x5000002a, mpls_ecr_prefix_hdl:0
===== OCE chain =====

LABEL:objid:20 link_type:MPLS local_label:1048577 outlabel:(21, 0) <-- VPNv4 Label
flags:0x1:(REAL,) pdflags:0x80:(INSTALL_HW_OK,RECIR_ADJ,) adj_handle:0x5100003d <--

adj_handle and local_adj_hdl values must match

unsupported recursion:0 olbl_changed 0 local_adj:1 modify_cnt:1
bwalk_cnt:0 subwalk_cnt:1 collapsed_oce:0

AAL: id:1358954557 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:0x7feeeeca9acf8, ri_id:0x46 phdl:0, ref_cnt:2 <-- ri_id and

ri_idx values must match

si:0x7feeeeca6ab98, si_id:0xb6, di_id:0x5013

LABEL:objid:23 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:0x50000034
unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0

bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0

AAL: id:1342177332 lbl:0 smac:a0f8.4911.d1d6 dmac:d4ad.71b5.dde4 <-- Matches the 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:0x7feeeecd6d238, ri_id:0x3e phdl:0x9f00004b, ref_cnt:1


```

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前缀编程

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
  dflt 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	0x7f790c4cf0e8	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:0x7f790c4cdfd8, 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 0x7f790c4cf0e8 1 <--
Utilize the HTM value from previous command
```

```
Handle:0x7f790c4cf0e8 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]: 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前缀编程

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)

dflt 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_lspa_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 = 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: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 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 0x7f7fb4a44048 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  0  0  26  6  1  97  NIF  Y  <-
- Port 0 is the egress port, Gi2/0/1
```

VPNv4标签编程

下一节介绍MPLS PE路由器C9300-PE-1和C9300-PE-2上的VPNv4标签编程。C9500不会在VPNv4标签上转发，因此C9500没有输出。

C9300-PE-1 VPNv4标签编程：

检查PE的本地前缀，而不是远程前缀。

```
***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)
```

```
dfilt 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
  lsp_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 lsp_handle:0
  EOS:objid:24 local_label:0 flags:0:( ) pdflags: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,) pdflags: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 }
```

验证C9300-PE-2 VPNv4标签：

检查PE的本地前缀，而不是远程前缀

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:( ) pdfflags: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,) pdfflags: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标签编程

下一节介绍MPLS路由器、C9300-PE-1、C9500-P和C9300-PE-2上的LDP标签编程。

LDP (外部) 标签是MPLS网络标签交换数据包的方式。验证通告给远程PE的本地LDP标签，不验证远程LDP标签。

C9300-PE-1 LDP标签编程：

验证通告到远程PE的本地LDP标签，不验证远程LDP标签。从FED的角度检查标签，然后返回到FMAN RP和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
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标签编程：

验证通告到远程PE的本地LDP标签，不验证远程LDP标签。从FED的角度检查标签，然后返回到FMAN RP和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
16	explicit-n	192.168.1.2/32	23409	Tel1/0/1	10.0.0.5 <-- LDP label 16 is

advertised to reach PE 192.168.1.2
17 explicit-n 192.168.1.4/32 23345 Te1/0/2 10.0.0.14 <-- LDP label 17 is
advertised to reach PE 192.168.1.4

*****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	Outgoing	Prefix	Bytes Label	Outgoing	Next Hop
Label	Label	or Tunnel Id	Switched	interface	
16	explicit-n	192.168.1.2/32	23409	Te1/0/1	10.0.0.5
17	explicit-n	192.168.1.4/32	23345	Te1/0/2	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
  lsp_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 lsp_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标签编程：

验证通告到远程PE的本地LDP标签，不验证远程LDP标签。从FED的角度检查标签，然后返回到FMAN RP和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
17	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]	\		
			2070	Gi2/0/1	10.0.0.22

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

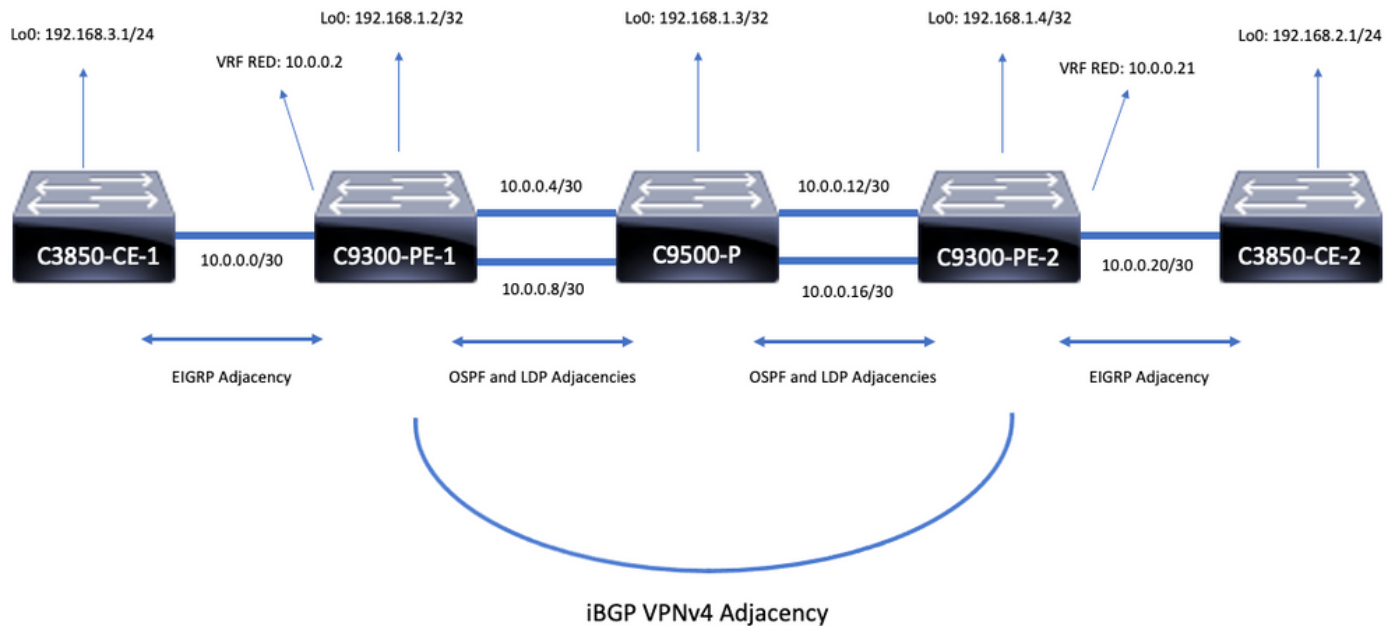
C9300-PE-2#show platform software fed switch active mpls forwarding label 17 detail

LENTRY:label:17 nobj:(LABEL, 82) lentry_hdl:0x44000005
modify_cnt:6 backwalk_cnt:0
lspa_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 lspa_handle:0
LABEL:**objid:82** link_type:MPLS local_label:17 outlabel:(16, 0) <-- Used in previous commands
flags:0x1:(REAL,) pflags: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

场景2.在PE和P路由器之间使用ECMP的L3VPN

参考拓扑

在本例中，Catalyst 3850交换机用作CE设备，Catalyst 9300交换机用作PE设备，Stackwise虚拟中的Catalyst 9500用作P设备。EIGRP在CE和PE设备、OSPF和MPLS核心中的LDP邻接关系之间运行，PE设备之间具有iBGP VPNv4邻接关系。在MPLS核心内，PE和P设备之间有ECMP。



配置 细节

C3850-CE-1的配置

```
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
```

C9300-PE-1的配置

```
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

```

C9500-P的配置

```

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
```

C9300-PE-2的配置

```
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
```

C3850-CE-2的配置

```
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
```

基本验证

在验证MPLS编程之前，需要验证的基本要求有：

- 验证PE到PE的连接是否存在
- 验证PE之间的标签交换路径(LSP)
- 验证PE之间的BGPv4邻接
- 验证VPNv4和LDP标签
- 验证MPLS转发表

验证PE到PE的连接

您可以从本地环回对远程PE环回和源执行ping操作，但这不会确认MPLS标签交换路径(LSP)是否良好，因为环回IP地址在底层通告。

注意: PE到PE MP-BGP VPNv4邻接通过各自的Loopback0接口实现。

```
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
```

验证LSP

您可以使用从PE到PE环回的MPLS跟踪路由来验证LSP和沿路径的所有MPLS LDP标签。

注意:此MPLS跟踪路由仅强加一个标签 (LDP标签)，这并不表明来自CE的流量是成功的，因为该流量强加了2个标签，即VPNv4 (内部) 标签和LDP (外部) 标签。

```
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
```

如果您无权访问CE或CE后面的设备，并且想要证明VPNv4和LDP标签实施/处置成功，则可以尝试从PE上VRF中面向CE的接口ping远程PE上VRF中面向CE的接口。

```
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
```

验证PE之间的BGP VPNv4邻接

```
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 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:          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

```

远程PE VPNv4邻接关系已启用，且已收到前缀

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

验证特定VRF中交换的前缀

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	?

验证VPNv4和LDP标签

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
192.168.20		
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	21/nolabel <-- VPNv4 label that is advertised to reach 192.168.2.0
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

验证使用的LDP标签

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	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
	17	192.168.1.4/32	0	Gi1/0/3	10.0.0.10 <-- 17 is the LDP label imposed to reach PE at 192.168.1.4 through Gi1/0/3

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	16	192.168.1.2/32	0	Gi2/0/2	10.0.0.13 <-- 16 is the LDP label imposed to reach PE at 192.168.1.2 through Gi2/0/2
	16	192.168.1.2/32	0	Gi2/0/3	10.0.0.17 <-- 16 is the LDP label imposed to reach PE at 192.168.1.2 through Gi2/0/3

验证MPLS转发表

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

```

确认用于到达VRF中每个给定前缀的内部(VPNv4)和外部(LDP)标签

```

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

```

验证Object-Manager统计信息：

在理想情况下，没有挂起的对象

```

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
```

前缀编程

下一节介绍MPLS路由器、C9300-PE-1、C9500-P和C9300-PE-2上的前缀编程。

C9300-PE-1前缀编程

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, }
```



```
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 <--
Port 1 is an egress port, Gi1/0/2
GigabitEthernet1/0/3  0x37      1  0  1  2  0  28  8  3  3  NIF  Y <--
Port 2 is an egress port, Gi1/0/3
```

C9500前缀编程

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 r0 label index 0x69
```

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

C9500-P#show platform software adjacency switch active r0 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 is B5DD 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: 10.0.0.14 <-- Next-hop IP address
IP FRR MCP_ADJ_IPFRR_NONE 0
OM handle: 0x3480647700

C9500-P#show platform software adjacency switch active r0 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 DMAC, MAC ending in B5DD 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: 10.0.0.18 <-- Next-hop IP address
IP FRR MCP_ADJ_IPFRR_NONE 0
OM handle: 0x3480648f68

FMAN FP Prefix Programming

C9500-P#show platform software ip switch active f0 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 f0 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
aom id: 578, HW handle: (nil)

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	1	0	10	1	2	2	NIF	Y <--
Port 1 is an egress port, TenGi1/0/2												
TenGigabitEthernet1/0/16	0x18	0	0	0	15	0	8	11	16	2360	NIF	Y <--
Port 15 is the SVL												

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	1	0	10	1	2	98	NIF	Y <--
Port 1 is an egress port, TenGi2/0/2												
TenGigabitEthernet2/0/16	0x33	0	0	0	15	0	8	11	16	2360	NIF	Y <--
Port 15 is the SVL												

验证C9300-PE-2前缀

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_lsps_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 = afd_label_flag:0 icmp_redir_enable:1 lvx_smr_enabled:0, dstNatType:0 priority:5
afdLabelOrDestClientId: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标签编程

下一节介绍MPLS PE路由器C9300-PE-1和C9300-PE-2上的VPNv4标签编程。C9500=P不会在VPNv4标签上转发，因此没有来自C9500的输出 — P。

C9300-PE-1 VPNv4标签编程：

检查PE的本地前缀，而不是远程前缀。从FED的角度检查标签，然后返回到FMAN RP和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 }
```

验证C9300-PE-2 VPNv4标签

检查PE的本地前缀，而不是远程前缀。从FED的角度检查标签，然后返回到FMAN RP和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
```

```
LENTRY: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:( ) pdflags: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,) pdflags: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标签编程

下一节介绍MPLS路由器、C9300-PE-1、C9500-P和C9300-PE-2上的LDP标签编程。

LDP (外部) 标签是MPLS网络标签交换数据包的方式。验证通告给远程PE的本地LDP标签，不验证远程LDP标签。

C9300-PE-1 LDP标签编程：

验证通告到远程PE的本地LDP标签，不验证远程LDP标签。从FED的角度检查标签，然后返回到FMAN RP和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
19	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,) 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

```

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标签编程：

验证通告到远程PE的本地LDP标签，不验证远程LDP标签。从FED的角度检查标签，然后返回到FMAN RP和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
16	explicit-n	192.168.1.2/32	1240	Te1/0/1	10.0.0.5 <-- LDP Label 16
advertised to reach PE 192.168.1.2					
	explicit-n	192.168.1.2/32	226537	Te2/0/1	10.0.0.9
17	explicit-n	192.168.1.4/32	610	Te1/0/2	10.0.0.14 <-- LDP Label 17
advertised to reach PE 192.168.1.4					
	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_a_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_a_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标签编程：

验证通告到远程PE的本地LDP标签，不验证远程LDP标签。首先从FED的角度检查标签，然后回溯到FMAN RP和FMAN FP。

Software LDP Label Programming

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 <-- 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, }

硬件扩展故障排除

本部分提供了可用于对配置进行故障排除的信息。

MPLS硬件系统日志

如果用完特定资源（如MPLS标签），系统将生成SYSLOG消息。

要记住的要点

- MPLS LABEL用于**标签处置**。（当从本地CE获取前缀时，会消耗此资源）
- LSPA用于**标签实施**。（当从远程PE获取前缀时，会消耗此资源）

MPLS日志消息	定义	恢复操作
%FED_L3_ERRMSG-3-RSRC_ERR:交换机1 R0/0:fed：由于硬件资源耗尽，无法为fib条目分配硬件资源	为IP前缀保留的硬件空间已用尽（EM或TCAM）	执行以下操作之一以减少本地PE获知的前缀数： 1.在CE汇总前缀 2.将标签分配模式从每前缀更改为每VRF
%FED_L3_ERRMSG-3-mpls_out_of_resource:交换机1 R0/0:美联储：MPLS标签条目资源不足。无法在硬件中对本地标签：8205(8192/8192)进行编程	本地标签分配：为MPLS本地标签保留的硬件空间已用尽（EM或TCAM）	执行以下操作之一以减少本地PE使用的线路数： 1.总结本地CE或本地PE的前缀 2.在本地PE上将标签分配模式更改为每vrf
%FED_L3_ERRMSG-3-MPLS_LENTRY_PAUSE:交换机1 R0/0:美联储：已达到MPLS标签条目资源的严重限制。重试创建暂停。	本地标签分配：为MPLS本地标签保留的硬件空间已用尽（EM或TCAM）	执行以下操作之一以减少本地PE使用的线路数： 1.总结本地CE或本地PE的前缀 2.在本地PE上将标签分配模式更改为每vrf
%FED_L3_ERRMSG-3-mpls_out_of_resource:交换机1 R0/0:美联储：MPLS LSPA资源不足。无法在硬件中编程	远程标签分配：为LSPA远程标签保留的硬件空间已用尽	执行以下操作之一以减少远程PE使用的线路数： 1.在远程CE或远程PE上汇总前缀 2.在远程PE上将标签分配模式更改为每vrf

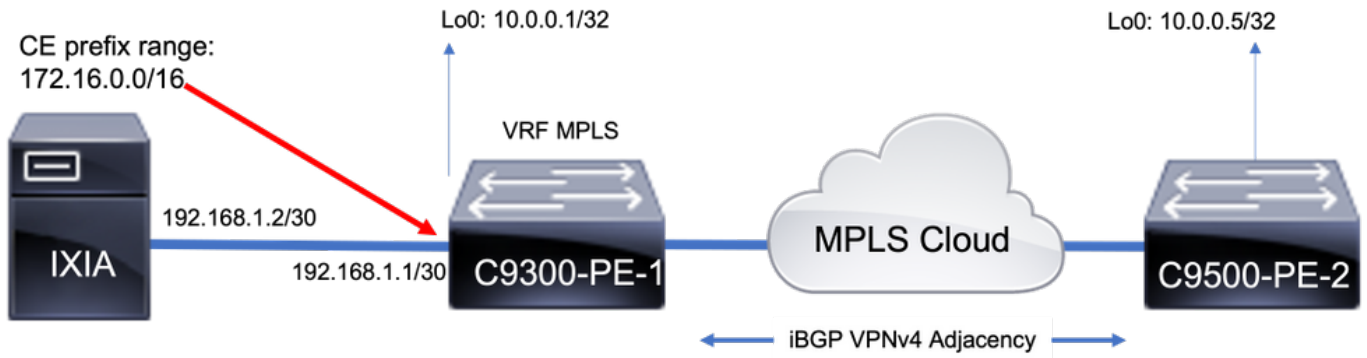
硬件验证命令

show platform hardware fed active fwd-asic resource tcam utilization命令是您想要评估是否存在硬件扩展问题的第一个位置。它按ASIC显示信息。

本部分显示来自vrf MPLS中BGP的PE学习前缀，其参数如下所述：

- 使用默认的每前缀标签分配
- PE是C9300-48U，带Cisco IOS-XE 17.3.4
- CE是BGP邻居，向vrf MPLS中的接口通告前缀
- 使用的前缀长度为/28。因此，平台使用TCAM作为前缀长度/31或更短
- 此平台首先为MPLS/BGP标签使用EM内存，然后在EM变满时向TCAM溢出

拓扑



基准资源使用情况

在添加任何前缀之前，有一些基本用途：

- 此基线是在MPLS LDP邻居在全局表中形成后采用的
- 在此基线中，VPNv4前缀添加到VRF MPLS中
- 您的基准数字可能不同。它取决于交换机上已编程的设备

注意：在本示例中，前缀从一个CE-PE端添加，这会导致资源（如LSPA）仅在需要使用标签堆栈实现可达性的远程PE上分配。在现实场景中，资源将分配到两个PE设备。

```
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
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    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
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

```

注意：SI/RI/DI是数据包重写、目标端口等所需的资源。要对SI/DI/RI问题进行故障排除，请参
[阅了解Catalyst 9000交换机上的硬件资源](#)

添加1000 BGP VPNv4前缀

邻居(Ixia)启用从CE向VRF MPLS添加1000个前缀

9300本地PE (连接到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	IP Route Table	TCAM	I	8192	1025	12.51%	1012	10	2

<-- 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
 lspas: 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

LENTY 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远程PE (通过MPLS获取)

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  1012  0.48%  1003  0      9
0
  IP Route Table        TCAM      I      1536     28     1.82%      23     3      2
0
CTS Cell Matrix/VPN
Label              EM        O      32768     992    3.03%      0      0      992
0  <-- MPLS VPN used 992 entries
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
lspa: 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

<-- LABEL does not increase (no

prefixes learnt from a local CE)

Num of LSPA entries allocated: 1000/32768

<-- LSPA usage increased by 1000

(these prefixes require label stack to reach)

```

Num of local adjs in mpls adjs: 4
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

```

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
```

<-- Different resources are allocated to reach a local prefix (LABEL) versus a remote prefix (LSPA)

注意：有关Catalyst 9000 TCAM的一般信息，或有关如何检查TCAM以了解其他功能的详细信息，请参阅[了解Catalyst 9000交换机上的硬件资源。](#)

注意：ADJ (邻接) 是共享资源。要对ADJ的问题进行故障排除，请参阅[了解Catalyst 9000交换机上的硬件资源。](#)

MPLS标签和IPv4扩展限制和补救

在大多数情况下，当使用MPLS功能且消耗了太多硬件资源时，将标签分配从 (默认) 每前缀更改为每vrf会有所帮助。在本例中，请考虑资源分配前后(在本例中，9500是CE-PE设备)。

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...>
```



```
Label                EM                0                8192                1                0.01%                0                0                1
0  <-- one remote LSPA used to reach the PE learnt prefixes
```

注意：show platform software fed switch active mpls summary中的资源使用情况也显示 LABEL或LSPA (以适用者为准) 中的这种减少。

为TAC收集的命令

本指南介绍了与MPLS相关的最常见硬件资源问题，并采取了相应的补救步骤。但是，如果本指南未解决您的问题，请收集显示的命令列表并将其附加到服务请求。

```
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
```

相关信息

[技术支持和文档 - Cisco Systems](#)

[多协议标签交换\(MPLS\)配置指南, Cisco IOS XE库17.7.x \(Catalyst 9300交换机 \)](#)

[多协议标签交换\(MPLS\)配置指南, Cisco IOS XE库17.7.x \(Catalyst 9500交换机 \)](#)

[了解Catalyst 9000交换机上的硬件资源](#)