

# Controleer MPLS op Catalyst 9000 Switches

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## Inleiding

Dit document beschrijft de manier waarop u Multiprotocol Label Switching (MPLS) Layer 3 Virtual Private Network (VPN) kunt configureren en valideren op Catalyst 9000 Series switches.

## Voorwaarden

### Vereisten

Cisco raadt kennis van de volgende onderwerpen aan:

- IP-doorsturen
- Border Gateway Protocol (BGP)

- MPLS

## Gebruikte componenten

De informatie in dit document is gebaseerd op de volgende software- en hardware-versies:

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

De informatie in dit document is gebaseerd op de apparaten in een specifieke laboratoriumomgeving. Alle apparaten die in dit document worden beschreven, hadden een opgeschoonde (standaard)configuratie. Als uw netwerk levend is, zorg er dan voor dat u de mogelijke impact van om het even welke opdracht begrijpt.

## Achtergrondinformatie

MPLS Layer 3 VPN's (L3VPN) gebruiken een peer-to-peer model dat BGP gebruikt om VPN-gerelateerde informatie te distribueren. Een MPLS VPN bestaat uit een reeks sites die onderling verbonden zijn door middel van een MPLS-kernnetwerk. Op elke klantensite worden één of meer apparaten van de klantrand (CE) aan één of meer randapparatuur (PE) bevestigd.

In conventioneel Layer 3 routing, aangezien een pakkettransport door het netwerk plaatsvindt, extraheert elke switch alle informatie die relevant is om het pakket vanuit Layer 3-header door te sturen. Deze informatie wordt dan gebruikt als een index voor een routingtabelraadpleging om de volgende hop voor het pakket te bepalen.

In het meest voorkomende geval is het enige relevante veld in de header het veld Adres van het doeladres, maar in sommige gevallen zijn andere veldnamen velden ook relevant. Als resultaat hiervan moet de headeranalyse onafhankelijk uitgevoerd worden bij elke switch waardoor het pakje passeert. Bovendien moet bij elke switch een gecompliceerde raadpleging plaatsvinden.

In label switching, wordt Layer 3 header slechts eenmaal geanalyseerd. Layer 3 header wordt dan omgezet in een vaste lengte, niet-gestructureerde waarde die **alabel** wordt genoemd.

Vele verschillende kopregels kunnen in kaart worden gebracht aan het zelfde etiket, zolang die kopregels altijd in de zelfde keuze van volgende hop resulteren. Een etiket staat in feite een **equivalentieklasse** (FEC) voor dat wil zeggen een reeks pakketten die, hoe verschillend ze ook kunnen zijn, ononderscheidbaar kunnen zijn door de verzendingsfunctie.

De eerste keuze van een etiket hoeft niet uitsluitend gebaseerd te zijn op de inhoud van Layer 3-pakkeheader; zo kunnen beslissingen om pakketten in latere hop door te sturen ook op andere factoren worden gebaseerd .

Zodra een label is toegewezen, wordt er een korte label header toegevoegd aan de voorkant van Layer 3-pakket. Deze header wordt als deel van het pakket over het netwerk vervoerd. In de daaropvolgende stappen door elke MPLS-switch in het netwerk worden de etiketten vervangen en worden de beslissingen genomen door middel van MPLS-verzendtafel voor het etiket dat in de pakkeheader wordt gedragen. Daarom hoeft de pakkeheader niet opnieuw te worden beoordeeld tijdens pakketdoorvoer door het netwerk. Omdat het etiket van vaste lengte en niet-gestructureerd

is, is het MPLS het uitzenden van een tabel proces zowel eenvoudig als snel.

Elke Label Switching Router (LSR) in het netwerk neemt een onafhankelijk, lokaal besluit over de waarde van het etiket om een door te sturen equivalentieklasse te vertegenwoordigen. Deze associatie is bekend als een labelbinding. Elke LSR informeert zijn burens over de labelbindingen die het heeft gemaakt. Dit bewustzijn van etiketbindingen door naburige switches wordt vergemakkelijkt door deze protocollen:

- Label Distribution Protocol (LDP) - Hiermee kunnen peer LSR's in een MPLS-netwerk labelinformatie uitwisselen ter ondersteuning van hop-by-hopverzending in een MPLS-netwerk
- Border Gateway Protocol (BGP) - gebruikt ter ondersteuning van MPLS Virtual Private Networks (VPN's)

Wanneer een geëtiketteerd pakket van LSR A naar LSR B wordt verzonden, is de waarde van het etiket die door het IP-pakje wordt gedragen de etiketwaarde die LSR B heeft toegewezen om de verzendende equivalentieklasse van het pakje te vertegenwoordigen. Hierdoor verandert de labelwaarde wanneer het IP-pakket het netwerk overbrengt.

## Hoe gebruikt u deze gids

De handleiding is in twee scenario's onderverdeeld, en aan het eind van het document wordt een valideringssectie voor de hardwareschaal gepresenteerd:

- single-hop nabijheid binnen de kern van MPLS
- Echte kosten Multi-Path (ECMP) nabijheid binnen de MPLS-kern
- hoe u het TCAM-gebruik op schaalproblemen kunt controleren

Elk scenario omvat de verificatie van voorvoegsels en etiketten voor elk MPLS-apparaat.

## Terminologie

<b>MPLS</b>	Multi-Protocol Label Switching	Een hoogwaardige pakketverzendingstechnologie die de prestaties en de mogelijkheden van het verkeersbeheer van datalink Layer 2-switching (Layer 2) integreert met de schaalbaarheid, flexibiliteit en prestaties van de netwerklaag (Layer 3) routing.
<b>PE</b>	Edge (switch/router) voor providers	Het randapparaat van het providernetwerk dat IP prefixes van een klant CE ontvangt, en hen in de MPLS-cloud doorgeeft.
<b>CE</b>	Customer Edge (switch/router)	Een apparaat in het bedrijfsgebouw van de klant dat op de randrouter van de leverancier van een IP/MPLS-netwerk van een dienstverlener is aangesloten.
<b>LDP</b>	Label Discovery Protocol	LDP is een protocol dat automatisch labels tussen routers genereert en uitwisselt. Elke router genereert lokaal labels voor zijn voorvoegsels en adverteert vervolgens de labelwaarden aan zijn burens.
<b>LSPA</b>	Label Switch Path Array	De reeks labels om een specifieke MPLS-bestemming te bereiken. In een typisch L3VPN - kunt u een IGP + VPN label hebben. Als er een TE-tunnel hebt u TE-label + IGP + VPN. Catalyst 9000 kan tot 6 labels ondersteunen deze reeks labels wordt LSPA genoemd.
<b>Label Stack-ID</b>	Label Stack-ID	A unieke index om een labelstack te identificeren (aLSPA-delen).
<b>Etiket</b>	Etiket	Het MPLS-label gebruikt voor raadpleging. Meervoudige labels maken labelstack op.
<b>ID</b>	Prefixidentificati	Catalyst 9000 creëert een globale bron voor elk voorvoegsel (er zijn evenveel

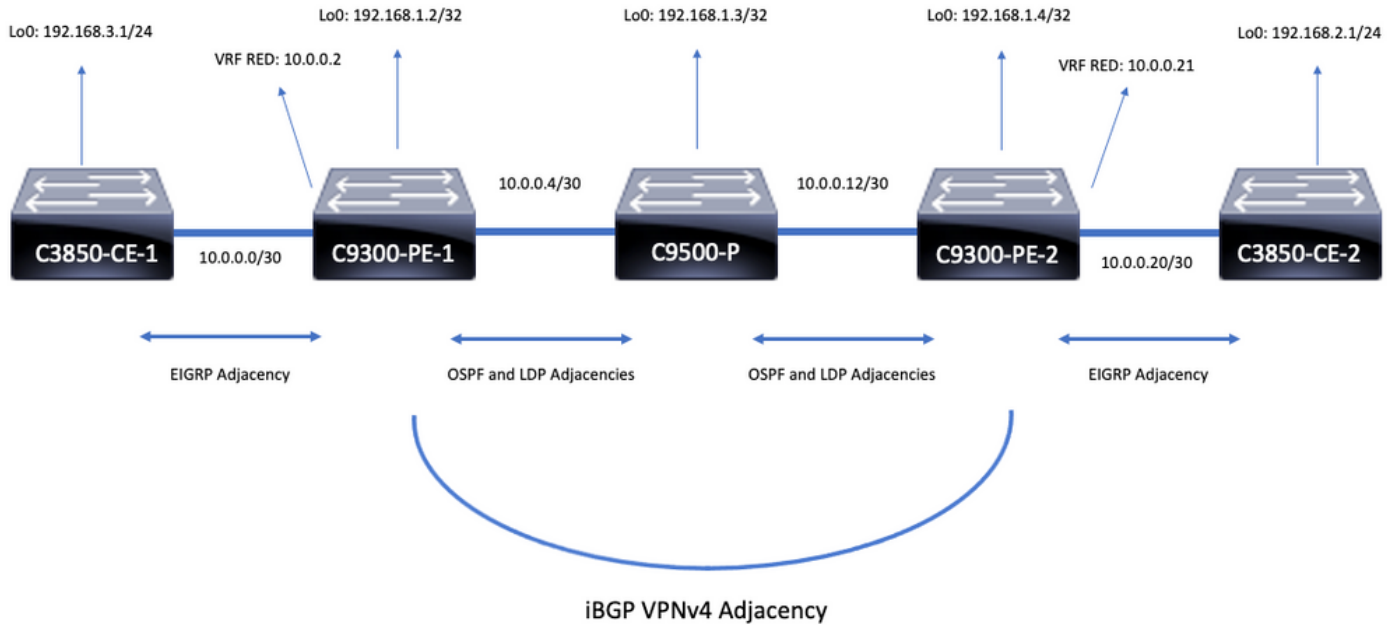
prefixeren	e	voorvoegsel ID's als er routes zijn in het geval van label toewijzing per voorvoegsel).
EM	Exacte overeenkomst	Een ingang in het geheugen van de Was dat een 1:1 overeenkomende (ho route, Direct Connected host) is.
LPM	Langste prefixwedstrijd	Elke route die /31 of korter is (32 routes zijn EM-type).
TCAM	Ternaal contentadreseerbare geheugen	Een type geheugen dat inzendingen opslaat en vraagt met drie verschillende ingangen: 0, 1 en X. Dit type geheugen moet worden gebruikt in gevallen w meerdere overeenkomsten met dezelfde ingang kunnen bestaan, en de resulterende Hash voor elk niet uniek. <b>Deze tabel bevat een masker of "X" waarde die het in staat stelt te weten of het overeenkomt met deze ingang niet.</b>
CAM	Content-adresseerbare geheugen	Algemene term voor hardwaregeheugen (Hash/TCAM).
RIB	Routing Information Base	de routingtabel wordt gezien in ' tonen ip - route '
FILM	Informatiebasis voor doorsturen	vereenvoudigde tabel met prefixes toegevoegd door de tabellen RIB en AR met een muisaanwijzer in de ADJ-tabel
Direct Connected	Direct Connected Route	Een lokaal aangesloten host-prefix (ARP bij)
Indirect verbonden	Indirect Connected Route	Een route die via een afgelegen volgende hop is om te bereiken
ADJ	Adjacentie (tabel)	slaat volgende hopinformatie op die gebruikt wordt voor pakketherschrijven
EM	Exacte overeenkomst	Verbonden hosts, indirecte /32 host prefixes
TCAM	Ternaal contentadreseerbare geheugen	Indirecte prefixes /31 of korter
FED	Stuurprogramma voor voorwaartse motor	De ASIC (hardware)-laag
FMAN-FP	Forward Manager - Forwarding Vliegtuig	FMAN-FP beheert softwareobjecten die FED-informatie toevoegen, verwijderen of wijzigen
SI	Station-index	Station-index = informatie over pakketherschrijven (RI = herschrijfindex) en informatie over uitgaande interface (DI = bestemmingsindex)
RI	Index herschrijven	MAC-adres herschrijven informatie voor Layer 3 verzenden naar de volgende hop nabijheid
DI	Bestemmingsindex	Index die naar de uitgaande interface wijst

## Configureren en controleren

# Scenario 1. L3VPN met Single Hop Adjacement in MPLS Core

## Referentietechnologie

Voor dit voorbeeld werken Catalyst 9300 switches als de PE apparaten, Catalyst 9500 in StackWise Virtuele functie als het P apparaat, en Catalyst 3850 switches als de CE apparaten.



## Configuratiegegevens

### Configuratie C3850-CE-1

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

### Configuratie C9300-PE-1

```
hostname C9300-PE-1
!
ip vrf RED
rd 69:69
route-target export 69:69
route-target import 69:69
!
mpls ldp explicit-null
```

```

!
interface Loopback0
ip address 192.168.1.2 255.255.255.255
!
interface GigabitEthernet1/0/1
no switchport
ip vrf forwarding RED
ip address 10.0.0.2 255.255.255.252
!
interface GigabitEthernet1/0/2
no switchport
ip address 10.0.0.5 255.255.255.252
!
router eigrp 420
!
address-family ipv4 vrf RED
network 10.0.0.0 0.0.0.3
autonomous-system 420
exit-address-family
!
router ospf 420
network 0.0.0.0 255.255.255.255 area 0
mpls ldp autoconfig
!
router bgp 69420
bgp log-neighbor-changes
neighbor 192.168.1.4 remote-as 69420
neighbor 192.168.1.4 update-source Loopback0
!
address-family vpnv4
neighbor 192.168.1.4 activate
neighbor 192.168.1.4 send-community extended
exit-address-family
!
address-family ipv4 vrf RED
redistribute eigrp 420
exit-address-family

```

## Configuratie C9500-P

```

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

```

## Configuratie C9300-CE-2

```

hostname C9300-PE-2
!
ip vrf RED

```

```

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

```

## Configuratie C3850-CE-2

```

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

```

## Basisverificatie

Voordat MPLS-programmering wordt gevalideerd, zijn er basisvereisten die moeten worden gevalideerd:

- Geldig PE tot PE connectiviteit is aanwezig
- bevestig het label switched pad (LSP) tussen de PE's
- BGPv4-nabijheid tussen PE's valideren
- VPNv4- en LDP-labels valideren
- MPLS-doorsturen tabel valideren

### PE-bevestiging aan PE-connectiviteit

U kunt de externe PE loopback en bron van de lokale loopback ping pingelen, maar dit bevestigt niet de MPLS etiket switched pad (LSP) goed is, aangezien de IP Loopback IP-adressen in de onderlay worden geadvertiseerd.

**Opmerking:** De PE to PE MP-BGP VPNv4 nabijheid wordt bereikt door hun respectieve Loopback0 interfaces.

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

### De LSP valideren

U kunt een MPLS-traceroute van PE naar PE-loopback gebruiken om de LSP- en alle MPLS LDP-labels langs het pad te valideren.

**Opmerking:** Deze MPLS-traceroute legt slechts één label op, het LDP-label, dit toont niet aan dat verkeer vanaf de CE succesvol is, omdat dat verkeer is opgelegd met 2 labels, het VPNv4-label (binnenste) en het LDP-label (buitenste).

```
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
```

Als u geen toegang tot CE of een apparaat achter de CE hebt en u wilt aantonen dat er een succesvol VPNv4- en LDP-labelinstelling/-dispositie is, kunt u proberen te pingelen van de CE-georiënteerde interface in VRF op een PE naar de andere CE-georiënteerde interface in VRF op de afgelegen PE.

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

## Bevestig BGP VPNv4-nabijheid tussen PE's

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

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

```
C9300-PE-2#show bgp vpnv4 unicast all neighbors 192.168.1.2
BGP neighbor is 192.168.1.2, remote AS 69420, internal link
BGP version 4, remote router ID 192.168.1.2
BGP state = Established, up for 01:01:00
Last read 00:00:13, last write 00:00:37, hold time is 180, keepalive interval is 60 seconds
Neighbor sessions:
1 active, is not multisession capable (disabled)
Neighbor capabilities:
Route refresh: advertised and received(new)
Four-octets ASN Capability: advertised and received
Address family IPv4 Unicast: advertised and received
Address family VPNv4 Unicast: advertised and received
```

Enhanced Refresh Capability: advertised and received  
Multisession Capability:  
Stateful switchover support enabled: NO for session 1  
Message statistics:  
InQ depth is 0  
OutQ depth is 0

Sent Rcvd  
Opens: 1 1  
Notifications: 0 0  
Updates: 6 6  
Keepalives: 67 66  
Route Refresh: 0 0  
Total: 74 73

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

## Remote PE VPN4-nabijheid is zichtbaar en er is een voorvoegsel ontvangen

### 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

## Controleer welke prefixes in de specifieke VRF worden uitgewisseld

### 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	?

VPN- en LDP-labels valideren:

Controleer het VPNv4-label dat wordt gebruikt om de prefixes in VRF te bereiken

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

## Controleer de LDP-labels die gebruikt worden

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

## bevestig de MPLS-doorvoertabel

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

## Bevestig de binnen- (VPNv4) en buitenste (LDP) labels die gebruikt worden om elk voorvoegsel in VRF te bereiken

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
```

## Controleer de object-Manager statistieken

In ideale scenario's zijn er geen hangende objecten

```
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
```

## Voorvoegingsprogramma's

In de volgende sectie worden voorvoegselprogramma's op de MPLS-routers beschreven, C9300-PE-1, C9500-P en C9300-PE-2.

## C9300-PE-1 prefixprogrammeur

### \*\*\*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-
-----	------	-----	-------	-----	------	------	-------

---	----	---	-----	---	----	-----	-----
2	192.168.2.0/24		0x7feeca12bb8	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:0x7feeca9acf8, ri\_id:0x46 phdl:0, ref\_cnt:2 <-- ri\_id and

ri\_idx values must match

si:0x7feeca6ab98, 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:0x7feecd6d238, ri\_id:0x3e phdl:0x9f00004b, ref\_cnt:1

si:0x7feecd706d8, si\_id:0x4013, di\_id:0x535f <-- di\_id utilized in subsequent

commands

ADJ:objid:70 {link\_type:MPLS ifnum:0x36, si:0x94000021, }





```

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 prefixprogramma

\*\*\*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 prefix programming

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

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

Routing Table: RED

Routing entry for 192.168.2.0/24

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

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

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

Routing Descriptor Blocks:

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

Route metric is 130816, traffic share count is 1

Total delay is 5010 microseconds, minimum bandwidth is 1000000 Kbit

Reliability 255/255, minimum MTU 1500 bytes

Loading 1/255, Hops 1

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

Routing Table: RED

Routing entry for 10.0.0.20/30

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

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

Routing Descriptor Blocks:

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

Route metric is 0, traffic share count is 1

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

192.168.2.0/24, epoch 0

QOS: Precedence routine (0)

dfllt 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	<b>0x19</b>

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 UseRpfmatchTable:0
rpfIncomplete:0 is_src_ce:0 sgtValid:0 sgt:0 src_rloc_trusted:0,sgtCacheControl1 = 0,
sgtCacheControl0 = 0
port_label:0x0 port_mask:0x0 vlan_label:0x0 vlan_mask:0x0 l3if_label:0x0 l3if_mask:0x0
group_label:0x0 group_mask:0x0

```

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

```

IPV4 Adj entries
dest          if_name          dst_mac          si_hdl          ri_hdl          pd_flags
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-labelprogramma

De volgende sectie bestrijkt VPNv4-labelprogramming op de MPLS PE-routers, C9300-PE-1 en C9300-PE-2. De C9500 wordt niet voorwaarts uitgevoerd op het VPNv4-label zodat er geen uitvoer is van de C9500.

C9300-PE-1 VPNv4-labelprogrammeerbaarheid:

**Controleer** het lokale voorvoegsel op het PE, niet het voorvoegsel op afstand.

```
***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)
```

```
dfmt 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 }
```

Controleer C9300-PE-2 VPNv4-label:

Controleer het lokale voorvoegsel op PE, niet het afstandsvoorvoegsel

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

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

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

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

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

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

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

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

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

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

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

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

Object identifier: 3540  
Description: label 0x3b  
Status: Done

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

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

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

## LDP-labelprogramma

De volgende sectie bestrijkt LDP-labelprogrammering op de MPLS-routers, C9300-PE-1, C9500-P en C9300-PE-2.

Het LDP-label (router) is wat het MPLS-netwerklabel switch op de pakketten. Bevestig het lokale LDP-label dat geadverteerd is op de afstandsbediening, en valideer het LDP-label niet.

C9300-PE-1 LDP-labelprogrammering:

**bevestig** het lokale LDP-label dat is geadverteerd met de externe PE, het LDP-label niet. Controleer het etiket vanuit een FED-perspectief en dan terug naar FMAN RP en 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
<b>19</b>	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-labelprogramming:

**bevestig** het lokale LDP-label dat is geadverteerd met de externe PE, het LDP-label niet.  
Controleer het etiket vanuit een FED-perspectief en dan terug naar FMAN RP en 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  
lspa\_handle:0  
AAL: id:2365587461 lbl:17  
eos0:[adj\_hdl:0xcc000037, hw\_hdl:0x7f2894480438]  
eos1:[adj\_hdl:0xcc000037, hw\_hdl:0x7f2894480228]  
deagg\_vrf\_id = 0 lspa\_handle:0  
LABEL:**objid:64** link\_type:MPLS local\_label:17 outlabel:(0, 0) <-- Utilized in previous commands  
flags:0x1:(REAL,) pdflags:0:(INSTALL\_HW\_OK,) adj\_handle:0xcc000037  
unsupported recursion:0 olbl\_changed 0 local\_adj:0 modify\_cnt:0  
bwalk\_cnt:0 subwalk\_cnt:0 collapsed\_oce:0  
AAL: id:3422552119 lbl:0 smac:d4ad.71b5.ddd6 dmac:70d3.79be.ae71  
sub\_type:0 link\_type:2 adj\_flags:0 label\_type:2 rewrite\_type:PSH1(119)  
vlan\_id:0 vrf\_id:0 ri:0x7f2894498008, ri\_id:0x38 phdl:0x76000058, ref\_cnt:1  
si:0x7f2894498478, si\_id:0x400b, di\_id:0x2  
ADJ:objid:73 {link\_type:MPLS ifnum:0x42, si:0x3d000027, }

C9300-PE-2 LDP-labelprogramming:

**bevestig** het lokale LDP-label dat is geadverteerd met de externe PE, het LDP-label niet. Controleer het etiket vanuit een FED-perspectief en dan terug naar FMAN RP en FMAN FP.

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

C9300-PE-2#show mpls forwarding-table

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

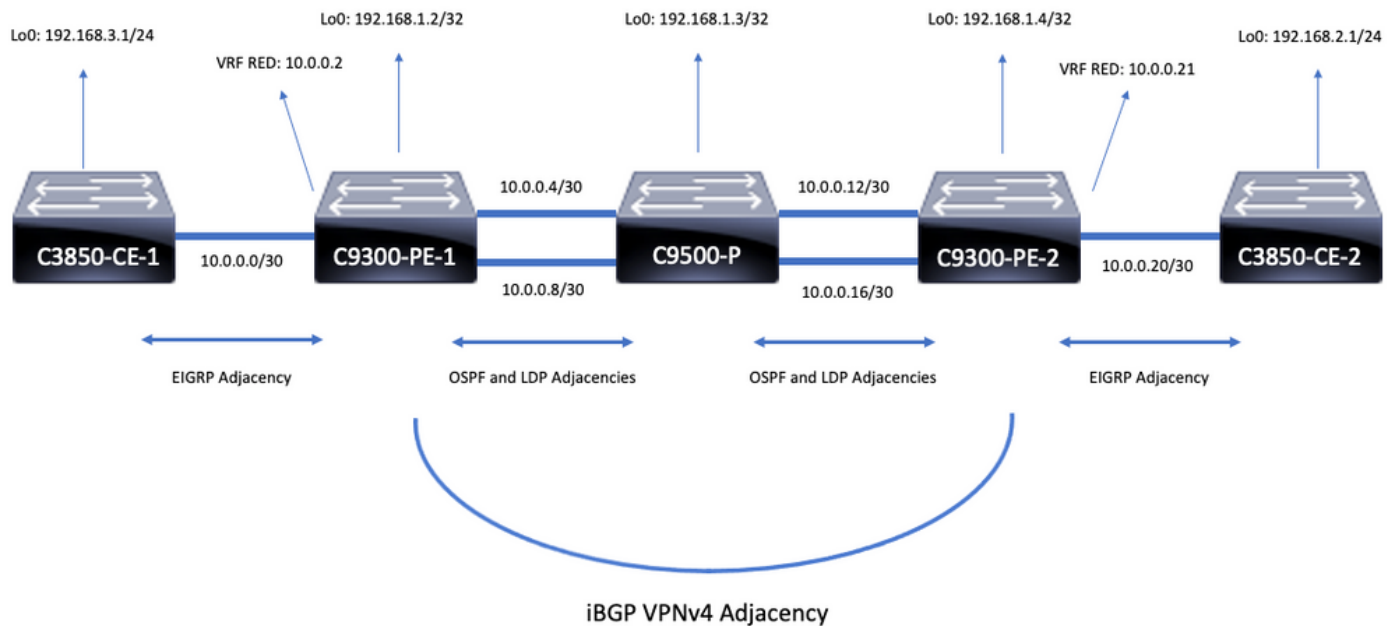
C9300-PE-2#show platform software fed switch active mpls forwarding label 17 detail

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

## Scenario 2. L3VPN met ECMP tussen PE's en P-routers

### Referentietechnologie

Voor dit voorbeeld, functioneert Catalyst 3850 switches als CE apparaten, Catalyst 9300 switches als PE apparaten, Catalyst 9500 in StackWise Virtuele functie als apparaat P. DHCP loopt tussen de CE en PE apparaten, OSPF en LDP nabijheid in de kern van MPLS, met een iBGP VPNv4 nabijheid tussen de PE apparaten. Binnen de MPLS-kern is er ECMP tussen de PE- en P-apparaten.



### Configuratiegegevens

#### Configuratie C3850-CE-1

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

#### Configuratie C9300-PE-1

```
hostname C9300-PE-1
```



```

!
ip vrf RED
rd 69:69
route-target export 69:69
route-target import 69:69
!
mpls ldp explicit-null
!
interface Loopback0
ip address 192.168.1.2 255.255.255.255
!
interface GigabitEthernet1/0/1
no switchport
ip vrf forwarding RED
ip address 10.0.0.2 255.255.255.252
!
interface GigabitEthernet1/0/2
no switchport
ip address 10.0.0.5 255.255.255.252
!
interface GigabitEthernet1/0/3
no switchport
ip address 10.0.0.9 255.255.255.252
!
router eigrp 420
!
address-family ipv4 vrf RED
network 10.0.0.0 0.0.0.3
autonomous-system 420
exit-address-family
!
router ospf 420
network 0.0.0.0 255.255.255.255 area 0
mpls ldp autoconfig
!
router bgp 69420
bgp log-neighbor-changes
neighbor 192.168.1.4 remote-as 69420
neighbor 192.168.1.4 update-source Loopback0
!
address-family vpnv4
neighbor 192.168.1.4 activate
neighbor 192.168.1.4 send-community extended
exit-address-family
!
address-family ipv4 vrf RED
redistribute eigrp 420
exit-address-family

```

## Configuratie C9500-P

```

hostname C9500-P
!
interface Loopback0
ip address 192.168.1.3 255.255.255.255
!
interface TenGigabitEthernet1/0/1
no switchport
ip address 10.0.0.6 255.255.255.252
!
interface TenGigabitEthernet1/0/2
no switchport
ip address 10.0.0.13 255.255.255.252

```

```
!  
interface TenGigabitEthernet2/0/1  
no switchport  
ip address 10.0.0.10 255.255.255.252  
!  
interface TenGigabitEthernet2/0/2  
no switchport  
ip address 10.0.0.17 255.255.255.252  
!  
router ospf 420  
network 0.0.0.0 255.255.255.255 area 0  
mpls ldp autoconfig
```

## Configuratie C9300-PE-2

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

```
redistribute eigrp 400
exit-address-family
```

## Configuratie C3850-CE-2

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

## Basisvalidatie

Voordat MPLS-programmering wordt gevalideerd, zijn er basisvereisten die moeten worden gevalideerd:

- Geldig PE tot PE connectiviteit is aanwezig
- bevestig het label switched pad (LSP) tussen de PE's
- BGPv4-nabijheid tussen PE's valideren
- VPNv4- en LDP-labels valideren
- MPLS-doorsturen tabel valideren

## Bevestig PE-verbinding met PE-connectiviteit

U kunt de externe PE loopback en bron van de lokale loopback ping pingelen, maar dit bevestigt niet de MPLS etiket switched pad (LSP) goed is, aangezien de IP Loopback IP-adressen in de onderlay worden geadverteerd.

**Opmerking:** De PE to PE MP-BGP VPNv4 nabijheid wordt bereikt door hun respectieve Loopback0 interfaces.

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

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

## De LSP valideren

U kunt een MPLS-traceroute van PE naar PE-loopback gebruiken om de LSP- en alle MPLS LDP-labels langs het pad te valideren.

**Opmerking:** Deze MPLS-traceroute legt slechts één label op, het LDP-label, dit toont niet aan dat verkeer vanaf de CE succesvol is, omdat dat verkeer is opgelegd met 2 labels, het VPNv4-label (binnenste) en het LDP-label (buitenste).

```
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] 7 ms
! 2 10.0.0.18 1 ms
```

Als u geen toegang tot CE of een apparaat achter de CE hebt en u wilt aantonen dat er een succesvol VPNv4- en LDP-labelinstelling/-dispositie is, kunt u proberen te pingelen van de CE-georiënteerde interface in VRF op een PE naar de andere CE-georiënteerde interface in VRF op de afgelegen PE.

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

## Bevestig BGP VPNv4-nabijheid tussen PE's

```
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 multisession capable (disabled)

Neighbor capabilities:

Route refresh: advertised and received(new)  
Four-octets ASN Capability: advertised and received  
Address family IPv4 Unicast: advertised and received  
Address family VPNv4 Unicast: advertised and received  
Enhanced Refresh Capability: advertised and received  
Multisession Capability:  
Stateful switchover support enabled: NO for session 1

Message statistics:

InQ depth is 0  
OutQ depth is 0

	Sent	Rcvd
Opens:	1	1
Notifications:	0	0
Updates:	4	4
Keepalives:	1234	1238
Route Refresh:	0	0
Total:	1239	1243

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

## Remote PE VPN4-nabijheid is zichtbaar en er is een voorvoegsel ontvangen

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

## Controleer welke prefixes in de specifieke VRF worden uitgewisseld

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	?

## VPNv4- en LDP-labels valideren

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

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

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

Routing Table: RED

Routing entry for 192.168.2.0/24

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

Last update from 192.168.1.4 18:41:56 ago

Routing Descriptor Blocks:

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

Route metric is 130816, traffic share count is 1

AS Hops 0

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

MPLS Flags: MPLS Required

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

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

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

Routing Table: RED

Routing entry for 192.168.2.0/24

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

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

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

Routing Descriptor Blocks:

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

Route metric is 130816, traffic share count is 1

Total delay is 5010 microseconds, minimum bandwidth is 1000000 Kbit

Reliability 255/255, minimum MTU 1500 bytes

Loading 1/255, Hops 1

## Controleer de LDP-labels die gebruikt worden

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

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

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

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

## bevestig de MPLS-doorvoertabel

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
	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 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	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

**Bevestig de binnen- (VPNv4) en buitenste (LDP) labels die gebruikt worden om elk voorvoegsel in VRF te bereiken**

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
```

**Controleer object-Manager statistieken:**

**In ideale scenario's zijn er geen hangende objecten**

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
```

## Voorvoegingsprogramma's

In de volgende sectie worden voorvoegselprogramma's op de MPLS-routers beschreven, C9300-PE-1, C9500-P en C9300-PE-2.

### C9300-PE-1 prefixprogrammeur

#### \*\*\*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 ETPYE**  
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-
---	----	---	-----	---	---	-----	-----

2 192.168.2.0/24 0x7fbae8d86228 0x0 0 0 lspax2

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



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

=====

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

ASIC#0:

index = 0x535f  
pmap = 0x00000000 0x00000000  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0  
ASIC#1:

index = 0x535f  
pmap = 0x00000000 **0x00000002** <-- Looking at 0x00000002, in binary that is 0000 0000 0000 0000  
**000 0000 0000 0010 = Port 1 (Zero based, count right to left)**  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0

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

ASIC#0:

index = 0x5360  
pmap = 0x00000000 0x00000000  
cmi = 0x0  
rcp\_pmap = 0x0  
al\_rsc\_cmi  
CPU Map Index (CMI) [0]  
ctiLo0 = 0  
ctiLo1 = 0  
ctiLo2 = 0  
cpuQNum0 = 0  
cpuQNum1 = 0  
cpuQNum2 = 0  
npuIndex = 0  
stripSeg = 0  
copySeg = 0  
ASIC#1:

```

index = 0x5360
pmap = 0x00000000 0x00000004 <-- Looking at 0x00000004, in binary that is 0000 0000 0000 0000
0000 0000 0000 0100 = Port 2 (Zero based, count right to left)
cmi = 0x0
rcp_pmap = 0x0
al_rsc_cmi
CPU Map Index (CMI) [0]
ctiLo0 = 0
ctiLo1 = 0
ctiLo2 = 0
cpuQNum0 = 0
cpuQNum1 = 0
cpuQNum2 = 0
npuIndex = 0
stripSeg = 0
copySeg = 0

```

```

C9300-PE-1#show platform software fed switch active ifm map
Interface          IF_ID      Inst Asic Core Port SubPort Mac  Cntx LPN  GPN  Type Active
GigabitEthernet1/0/2  0x36      1  0  1  1  0  6  7  2  2  NIF  Y <--
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 prefixprogramming

### \*\*\*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-
modified							
---	----	---	-----	---	----	-----	-----

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

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

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

## Controleer C9300-PE-2 prefixes

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

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

Routing Table: RED

Routing entry for 192.168.2.0/24

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

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

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

Routing Descriptor Blocks:

\* **10.0.0.22**, from 10.0.0.22, 21:35:22 ago, via GigabitEthernet2/0/1 **<-- Next-hop to reach 192.168.2.0/24**

Route metric is 130816, traffic share count is 1

Total delay is 5010 microseconds, minimum bandwidth is 1000000 Kbit

Reliability 255/255, minimum MTU 1500 bytes

Loading 1/255, Hops 1

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

Routing Table: RED

Routing entry for 10.0.0.20/30

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

Redistributing via eigrp 400, bgp 69420

Advertised by bgp 69420

Routing Descriptor Blocks:

\* directly connected, via GigabitEthernet2/0/1

Route metric is 0, traffic share count is 1

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

192.168.2.0/24, epoch 0

QOS: Precedence routine (0)

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

nexthop 10.0.0.22 GigabitEthernet2/0/1

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

C9300-PE-2#**show ip vrf detail**

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

Old CLI format, supports IPv4 only

Flags: 0xC

Interfaces:

Gi2/0/1

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

Flags: 0x0

Export VPN route-target communities

RT:69:69

Import VPN route-target communities

RT:69:69

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

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

**- Use the VRF ID from previous command**

Forwarding Table

Prefix/Len	Next Object	Index
------------	-------------	-------

192.168.2.0/24	OBJ_ADJACENCY	0x3a
----------------	---------------	------

C9300-PE-2#**show platform software adjacency switch active r0 index 0x3a <-- Use the OBJ\_ADJACENCY value from previous command**

Number of adjacency objects: 10

Adjacency id: 0x3a (58)



```

Interface: GigabitEthernet2/0/1, IF index: 53, Link Type: MCP_LINK_IP
Encap: 0:72:78:c8:c9:c2:70:d3:79:be:ae:42:8:0 <-- MAC ending in C9C2 is the DMAC, MAC ending
in AE42 is SMAC, 0800 is IP ETYPE
Encap Length: 14, Encap Type: MCP_ET_ARPA, MTU: 1500
Flags: no-l3-inject
Incomplete behavior type: None
Fixup: unknown
Fixup_Flags_2: unknown
Nexthop addr: 10.0.0.22 <-- Next-hop IP address
IP FRR MCP_ADJ_IPFRR_NONE 0
OM handle: 0x348062b578

```

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

```

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

```

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

```

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

```

```

Adjacency id: 0x3a (58)
Interface: GigabitEthernet2/0/1, IF index: 53, Link Type: MCP_LINK_IP
Encap: 0:72:78:c8:c9:c2:70:d3:79:be:ae:42:8:0 <-- MAC ending in C9C2 is the DMAC, MAC ending
in AE42 is SMAC, 0800 is IP ETYPE
Encap Length: 14, Encap Type: MCP_ET_ARPA, MTU: 1500
Flags: no-l3-inject
Incomplete behavior type: None
Fixup: unknown
Fixup_Flags_2: unknown
Nexthop addr: 10.0.0.22 <-- Next-hop IP address
IP FRR MCP_ADJ_IPFRR_NONE 0
aom id: 477, HW handle: (nil) (created)

```

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

```

C9300-PE-2#show platform hardware fed switch active ip route vrf-name RED 192.168.2.0/24
vrf  dest                htm                flags  SGT  DGID MPLS Last-
modified
---  ----                ---                -----  ---  ----  -----
-----
2    192.168.2.0/24                0x7f0650a7e3e8  0x0    0    0
2021/06/23 18:46:56.801 <-- HTM value used in subsequent command
FIB: prefix_hdl:0x38000016, mpls_ecr_prefix_hdl:0
===== OCE chain =====
ADJ:objid:58 {link_type:IP ifnum:0x35, si:0x9700001b, IPv4:        10.0.0.22 } <-- objid
relevant in subsequent command, 10.0.0.22 is the next-hop IP
=====
MPLS info: mpls_ecr_scale_prefix_adj:0, mpls_lspa_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 UseRpfmatchTable:0

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

sgtCacheControl0 = 0

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

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

=====

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

IPV4 Adj entries

dest	if_name	dst_mac	si_hdl	ri_hdl	pd_flags
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	<b>0</b>	0	26	6	1	97	NIF	Y

```

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

```

## VPNv4-labelprogramma

De volgende sectie bestrijkt VPNv4-labelprogrammering op de MPLS PE-routers, C9300-PE-1 en C9300-PE-2. De C9500=P wordt niet voorwaarts gericht op het VPNv4-label zodat er geen uitvoer is van C9500-P.

C9300-PE-1 VPNv4-labelprogrammeerbaarheid:

**Controleer het lokale voorvoegsel op PE, niet het voorvoegsel op afstand. Controleer het label vanuit een FED-perspectief en backtrack naar FMAN RP en 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 }
```

## Controleer C9300-PE-2 VPNv4-labels

Controleer het lokale voorvoegsel op de PE, niet het voorvoegsel op afstand. Controleer het label vanuit een FED-perspectief en backtrack naar FMAN RP en 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-labelprogramma

De volgende sectie bestrijkt LDP-labelprogrammering op de MPLS-routers, C9300-PE-1, C9500-P en C9300-PE-2.

Het LDP-label (router) is wat het MPLS-netwerklabel switch op de pakketten. Bevestig het lokale LDP-label dat geadverteerd is op de afstandsbediening, en valideer het LDP-label niet.

C9300-PE-1 LDP-labelprogrammering:

**bevestig** het lokale LDP-label dat is geadverteerd met de externe PE, het LDP-label niet. Controleer het etiket vanuit een FED-perspectief en dan terug naar FMAN RP en FMAN FP.

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

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

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

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

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

```

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

```

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

```

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

```

OM handle: 0x3480642268

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

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

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

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

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

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

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

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

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

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

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

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

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

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

LENTRY:label:19 nobj:(LB, 112) lentry\_hdl:0x9000007  
modify\_cnt:1 backwalk\_cnt:0  
lspa\_handle:0  
AAL: id:150994951 lbl:19  
eos0:[adj\_hdl:0x7d000002, hw\_hdl:0x7fbae8d778b8]  
eos1:[adj\_hdl:0x7d000002, hw\_hdl:0x7fbae8d776a8]  
deagg\_vrf\_id = 0 lspa\_handle:0  
LB:obj\_id:112 link\_type:IP num\_choices:2 Flags:0  
mpls\_ecr:1 local\_label:19 path\_inhw:2 ecrh:0x7d000002 old\_ecrh:0  
modify\_cnt:0 bwalk\_cnt:0 subwalk\_cnt:0 finish\_cnt:0  
bwalk:[req:0 in\_prog:0 nested:0]  
AAL: ecr:id:2097152002 af:0 ecr\_type:0 ref:7 ecrh:0x7fbae8a99268(28:2)  
hwhdl:3903427176 ::0x7fbae8a98b98,0x7fbae8a9ad48,0x7fbae8a98b98,0x7fbae8a9ad48  
Sw Enh ECR scale: objid:112 llabel:19 eos:1 #adjs:2 mixed\_adj:0  
reprogram\_hw:0 ecrhdl:0x7d000002 ecr\_hwhdl:0x7fbae8a99268

```

mod_cnt:0 prev_npath:0 pmismatch:0 pordermatch:0
ecr_adj: id:4278190135 is_mpls_adj:1 l3adj_flags:0x100000
  recirc_adj_id:1744830509
    sih:0x7fbae8a98b98(179) di_id:20499 rih:0x7fbae8a985d8(33)
    adj_lentry [eos0:0x7fbae8d7bf48 eos1:0x7fbae8d76e88]
ecr_adj: id:1392508984 is_mpls_adj:1 l3adj_flags:0x100000
  recirc_adj_id:2013265966
    sih:0x7fbae8a9ad48(180) di_id:20499 rih:0x7fbae8a9a788(46)
    adj_lentry [eos0:0x7fbae8d7c1b8 eos1:0x7fbae8d77158]
ecr_prefix_adj: id:2164260921 (ref:1)
  sih:0x7fbae8d7df08(181) di_id:20499 rih:0x7fbae8d7db98(68)
LABEL:objid:110 link_type:MPLS local_label:19 outlabel:(17, 0) <-- Used in previous
commands
  flags:0x1:(REAL,) pdfflags:0:(INSTALL_HW_OK,) adj_handle:0xff000037
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:4278190135 lbl:0 smac:a0f8.4911.d1d6 dmac:d4ad.71b5.dde4
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7fbae8d78c48, ri_id:0x40 phdl:0x9f00004b, ref_cnt:1
    si:0x7fbae8d78fd8, si_id:0x4013, di_id:0x535f
  ADJ:objid:75 {link_type:MPLS ifnum:0x36, si:0x22000023, }
LABEL:objid:111 link_type:MPLS local_label:19 outlabel:(17, 0) <-- Used in previous
commands
  flags:0x1:(REAL,) pdfflags:0:(INSTALL_HW_OK,) adj_handle:0x53000038
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:1392508984 lbl:0 smac:a0f8.4911.d1d8 dmac:d4ad.71b5.ddc2
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7fbae8d7d0a8, ri_id:0x42 phdl:0x8400004c, ref_cnt:1
    si:0x7fbae8d7a908, si_id:0x4014, di_id:0x5360
  ADJ:objid:78 {link_type:MPLS ifnum:0x37, si:0x74000026, }

```

## C9500-P LDP-labelprogramming:

**bevestig** het lokale LDP-label dat is geadverteerd met de externe PE, het LDP-label niet.  
**Controleer** het etiket vanuit een FED-perspectief en dan terug naar FMAN RP en FMAN FP.

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

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

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

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

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

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

```

  Flags: Real, Number of labels in the OCE: 1
  Label values: 0
  Backup flags: Pop, UHP, backup label 0x100001
  OM handle: 0x348064c530

```

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



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

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

Label OCE 0x68 -> OBJ\_ADJACENCY (0x49)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x348064df70

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

Label OCE 0x69 -> OBJ\_ADJACENCY (0x4e)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
OM handle: 0x348064e108

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

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

Label OCE 0x5e -> OBJ\_ADJACENCY (0x3f)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 564, CPP handle: 0xdeadbeef (created)

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

Label OCE 0x5f -> OBJ\_ADJACENCY (0x44)  
Flags: Real, Number of labels in the OCE: 1  
Label values: 0  
Backup flags: Pop, UHP, backup label 0x100001  
aom id: 565, CPP handle: 0xdeadbeef (created)

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

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

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

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

**C9500-P#show platform software object-manager switch active f0 object 564**  
Object identifier: 564

Description: label 0x5e  
Status: Done, Epoch: 0, Client data: 0x4f737108

**C9500-P#show platform software object-manager switch active f0 object 564 parents**

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

**C9500-P#show platform software object-manager switch active f0 object 565**

Object identifier: 565  
Description: label 0x5f  
Status: Done, Epoch: 0, Client data: 0x4f737448

**C9500-P#show platform software object-manager switch active f0 object 565 parents**

Object identifier: 525  
Description: adj 0x44, Flags None  
Status: Done

**C9500-P#show platform software object-manager switch active f0 object 576**

Object identifier: 576  
Description: label 0x68  
Status: Done, Epoch: 0, Client data: 0x4f6d4bf8

**C9500-P#show platform software object-manager switch active f0 object 576 parents**

Object identifier: 536  
Description: adj 0x49, Flags None  
Status: Done

**C9500-P#show platform software object-manager switch active f0 object 577**

Object identifier: 577  
Description: label 0x69  
Status: Done, Epoch: 0, Client data: 0x4f737f78

**C9500-P#show platform software object-manager switch active f0 object 577 parents**

Object identifier: 545  
Description: adj 0x4e, Flags None  
Status: Done

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

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

LENTRY:label:16 nobj:(LB, 96) lentry\_hdl:0xeb000004  
modify\_cnt:2 backwalk\_cnt:0  
lspa\_handle:0  
AAL: id:3942645764 lbl:16  
eos0:[adj\_hdl:0x44000002, hw\_hdl:0x7f0b284b4d98]  
eos1:[adj\_hdl:0x44000002, hw\_hdl:0x7f0b284b4be8]  
deagg\_vrf\_id = 0 lspa\_handle:0  
LB:obj\_id:96 link\_type:IP num\_choices:2 Flags:0  
mpls\_ecr:1 local\_label:16 path\_inhw:2 ecrh:0x44000002 old\_ecrh:0  
modify\_cnt:0 bwalk\_cnt:0 subwalk\_cnt:0 finish\_cnt:0  
bwalk:[req:0 in\_prog:0 nested:0]  
AAL: ecr:id:1140850690 af:0 ecr\_type:0 ref:2 ecrh:0x7f0b284a3998(28:2)  
hwhdl:675953048 ::0x7f0b284b4268,0x7f0b284a1d78,0x7f0b284b4268,0x7f0b284a1d78  
Sw Enh ECR scale: objid:96 llabel:16 eos:1 #adjs:2 mixed\_adj:0  
reprogram\_hw:0 ecrhdl:0x44000002 ecr\_hwhdl:0x7f0b284a3998  
mod\_cnt:0 prev\_npath:0 pmismatch:0 pordermatch:0  
ecr\_adj: id:1610612787 is\_mpls\_adj:1 l3adj\_flags:0x100000  
recirc\_adj\_id:1207959601  
sih:0x7f0b284b4268(181) di\_id:23709 rih:0x7f0b284b3ca8(31)  
adj\_lentry [eos0:0x7f0b284a32d8 eos1:0x7f0b284a3cc8]  
ecr\_adj: id:805306420 is\_mpls\_adj:1 l3adj\_flags:0x100000

```

recirc_adj_id:67108914
  sih:0x7f0b284a1d78(182) di_id:23709 rih:0x7f0b284b47d8(44)
adj_lentry [eos0:0x7f0b284c1608 eos1:0x7f0b284a2138]
ecr_prefix_adj: id:3976200245 (ref:1)
  sih:0x7f0b284c2bf8(183) di_id:23709 rih:0x7f0b284c2888(50)
LABEL:objid:94 link_type:MPLS local_label:16 outlabel:(0, 0)
  flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0x60000033
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:1610612787 lbl:0 smac:d4ad.71b5.dde4 dmac:a0f8.4911.d1d6
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7f0b284a2cd8, ri_id:0x2e phdl:0xe9000057, ref_cnt:1
    si:0x7f0b284a3048, si_id:0x4009, di_id:0x1
ADJ:objid:63 {link_type:MPLS ifnum:0x41, si:0x2d000023, }
LABEL:objid:95 link_type:MPLS local_label:16 outlabel:(0, 0)
  flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0x30000034
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:805306420 lbl:0 smac:d4ad.71b5.ddc2 dmac:a0f8.4911.d1d8
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7f0b284a57c8, ri_id:0x30 phdl:0x67000059, ref_cnt:1
    si:0x7f0b284a6008, si_id:0x400a, di_id:0x61
ADJ:objid:68 {link_type:MPLS ifnum:0x43, si:0xef000026, }

```

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

```

LENTRY:label:17 nobj:(LB, 106) lentry_hdl:0xf6000005
  modify_cnt:1 backwalk_cnt:0
  lsp_handle:0
  AAL: id:4127195141 lbl:17
    eos0:[adj_hdl:0x44000002, hw_hdl:0x7f0b284ce2f8]
    eos1:[adj_hdl:0x44000002, hw_hdl:0x7f0b284ce0e8]
    deagg_vrf_id = 0 lsp_handle:0
LB:obj_id:106 link_type:IP num_choices:2 Flags:0
  mpls_ecr:1 local_label:17 path_inhw:2 ecrh:0x44000002 old_ecrh:0
  modify_cnt:0 bwalk_cnt:0 subwalk_cnt:0 finish_cnt:0
  bwalk:[req:0 in_prog:0 nested:0]
  AAL: ecr:id:1140850690 af:0 ecr_type:0 ref:2 ecrh:0x7f0b284a3998(28:2)
  hwhdl:675953048 ::0x7f0b284b4268,0x7f0b284a1d78,0x7f0b284b4268,0x7f0b284a1d78
Sw Enh ECR scale: objid:106 llabel:17 eos:1 #adjs:2 mixed_adj:0
reprogram_hw:0 ecrhdl:0x44000002 ecr_hwhdl:0x7f0b284a3998
mod_cnt:0 prev_npath:0 pmismatch:0 pordermatch:0
ecr_adj: id:4127195192 is_mpls_adj:1 l3adj_flags:0x100000
  recirc_adj_id:1207959601
    sih:0x7f0b284b4268(181) di_id:23709 rih:0x7f0b284b3ca8(31)
    adj_lentry [eos0:0x7f0b284c38e8 eos1:0x7f0b284cd858]
ecr_adj: id:1157627961 is_mpls_adj:1 l3adj_flags:0x100000
  recirc_adj_id:67108914
    sih:0x7f0b284a1d78(182) di_id:23709 rih:0x7f0b284b47d8(44)
    adj_lentry [eos0:0x7f0b284c3af8 eos1:0x7f0b284cdb28]
ecr_prefix_adj: id:3707764794 (ref:1)
  sih:0x7f0b284c5028(184) di_id:23709 rih:0x7f0b284c4c48(60)
LABEL:objid:104 link_type:MPLS local_label:17 outlabel:(0, 0)
  flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0xf6000038
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0
  AAL: id:4127195192 lbl:0 smac:d4ad.71b5.ddd6 dmac:70d3.79be.ae71
    sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
    vlan_id:0 vrf_id:0 ri:0x7f0b284ceaa8, ri_id:0x38 phdl:0x76000058, ref_cnt:1
    si:0x7f0b284ceeb8, si_id:0x400b, di_id:0x2
ADJ:objid:73 {link_type:MPLS ifnum:0x42, si:0x1f000028, }
LABEL:objid:105 link_type:MPLS local_label:17 outlabel:(0, 0)
  flags:0x1:(REAL,) pdflags:0:(INSTALL_HW_OK,) adj_handle:0x45000039
  unsupported recursion:0 olbl_changed 0 local_adj:0 modify_cnt:0
  bwalk_cnt:0 subwalk_cnt:0 collapsed_oce:0

```

```
AAL: id:1157627961 lbl:0 smac:d4ad.71b5.ddf1 dmac:70d3.79be.ae61
sub_type:0 link_type:2 adj_flags:0 label_type:2 rewrite_type:PSH1(119)
vlan_id:0 vrf_id:0 ri:0x7f0b284c4588, ri_id:0x3a phdl:0x5500005a, ref_cnt:1
si:0x7f0b284d0548, si_id:0x400c, di_id:0x62
ADJ:objid:78 {link_type:MPLS ifnum:0x44, si:0x4900002a, }
```

## C9300-PE-2 LDP-labelprogramming:

**bevestig** het lokale LDP-label dat is geadverteerd met de externe PE, het LDP-label niet. Begin door het etiket vanuit een FED-perspectief te controleren en dan terug te krabbelen naar FMAN RP en FMAN FP.

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

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

Local Label	Outgoing Label	Prefix or Tunnel Id	Bytes Switched	Outgoing interface	Next Hop
16	Pop Label	192.168.1.3/32	0	Gi2/0/2	10.0.0.13
	Pop Label	192.168.1.3/32	0	Gi2/0/3	10.0.0.17
<b>17</b>	16	192.168.1.2/32	0	Gi2/0/2	10.0.0.13 <b>&lt;-- LDP Label 17 is advertised to Remote PE 192.168.1.2</b>
	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, }

```

## Hardware voor probleemoplossing

Deze sectie verschaft informatie die u kunt gebruiken om problemen met uw configuratie op te lossen.

### MPLS-hardwareplatforms

Als u een bepaalde resource, zoals MPLS-labels, niet hebt, wordt het SYSLOG-bericht gegenereerd door het systeem.

#### Belangrijkste punten om te onthouden

- De MPLS-ETIKET wordt gebruikt voor de **afwerking van de label**. (Deze hulpbron wordt gebruikt wanneer prefixes worden geleerd van een lokale CE)
- LSPA wordt gebruikt voor **labelinstelling**. (Deze hulpbron wordt gebruikt wanneer prefixes worden geleerd van een externe PE)

#### MPLS-logbericht

#### Definitie

#### Herstelactie

%FED\_L3\_ERRMSG-3-RSRC\_ERR:  
Switch 1 R0/0: Dient: geen toegewezen hardwarebron voor **fib-invoer door uitputting van hardwarebronnen**

Voor IP-prefixes gereserveerde hardware is verlopen zonder ruimte (EM of TCAM)

Voer een van deze acties uit om aantal voorvoegsels dat door **lokale of afgelegen PE** wordt geleerd, te verminderen:

1. Voorvoegsels samenvatten
2. Wijzig de toewijzingsmodus het label per prefix in per-vrf

%FED\_L3\_ERRMSG-3-  
**mpls\_out\_of\_resource**: Switch 1 R0/0: voer: **Geen middelen voor MPLS LABEL-INVVOER**. Programma's voor lokaal label:8205 (8192/8192) in hardware mislukt

**Toewijzing van lokaal label**: voor MPLS bestemde lokale labels hebben geen ruimte meer (EM of TCAM)

Een van deze maatregelen om aantal op **lokale PE** gebruikte etiketten te verminderen:

1. Voorvoegsels samenvatten plaatselijke CE of plaatselijke PE
2. Wijzig de verdelingsmodus het label per prefix in per-vrf op lokale PE

%FED\_L3\_ERRMSG-3-  
MPLS\_LENTRY\_PAUSE: Switch 1 R0/0: voer: **Cruciale limiet bereikt voor MPLS**

**Toewijzing lokaal label**: Voor MPLS bestemde hardware-as- lokale labels hebben geen

Een van deze maatregelen om aantal op **lokale PE** gebruikte etiketten te verminderen:

**LABEL resource. Lentry moet worden onderbroken.**

ruimte meer (EM of TCAM)

%FED\_L3\_ERRMSG-3-  
mpls\_out\_of\_resource: Switch 1 R0/0:  
voer: **Geen resource voor MPLS LSPA.**  
**Programma in hardware mislukt**

**Toewijzing van het etiket op afstand:** Hardware gereserveerd voor LSPA-labels met afstandsbediening heeft geen ruimte meer

1. Voorvoegsels samenvatten plaatselijke CE of plaatselijke PE
  2. Wijzig de verdelingsmodus van het label per prefix in per-vrf op lokale PE
- Voer een van deze acties uit om aantal labels op **afgelegen PE** te verminderen:
1. Voorvoegsels samenvatten op afstand CE of PE op afstand
  2. Wijzig de verdelingsmodus van het label per prefix naar per-vrf op de afgelegen PE

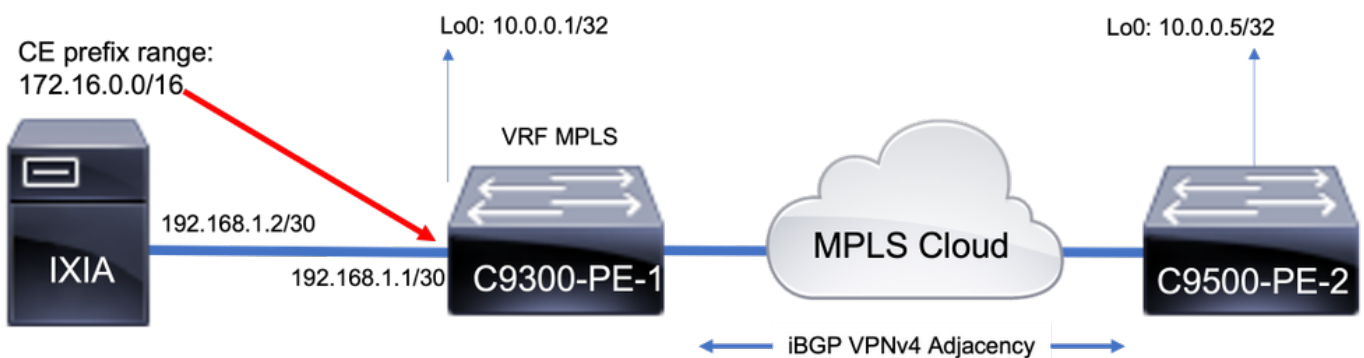
## Opdrachten voor hardwarevalidatie

tonen platform hardware gevoed actieve fwd-basis resource tcam use opdracht is de eerste plaats die je wilt evalueren of je een probleem hebt met hardware-schaal. Het geeft informatie per ASIC-basis weer.

In dit deel is een PE-leerprefix van BGP in vrf MPLS te zien met de hier beschreven parameters:

- De standaardinstelling per prefix wordt gebruikt
- PE is C9300-48U met Cisco IOS-XE 17.3.4
- CE is Ixia als een BGP-buurman die prefixatie bij een interface in vrf MPLS adverteert
- Prefixlengte gebruikt is /28. Zo gebruikt het platform TCAM voor prefix lengtes /31 of korter
- Dit platform gebruikt EM geheugen voor MPLS/BGP-labels eerst en dan overstroomt naar TCAM als EM vol wordt

## Topologie



## Gebruik van primaire hulpbronnen

Voorafgaand aan de toevoeging van prefixes is er enig basisgebruik:

- Deze basislijn werd genomen nadat MPLS LDP-buren waren gevormd in een globale tabel
- Vanaf deze basislijn worden VPNv4 prefixes toegevoegd aan VRF MPLS
- Uw basisgetallen kunnen variëren. Het hangt af van wat al op de switch is geprogrammeerd

**Opmerking:** In dit voorbeeld worden prefixes toegevoegd aan één CE-PE kant, wat in middelen zoals LSPA resulteert die slechts op verre PE worden toegewezen die een etiket stapel voor bereikbaarheid moeten gebruiken. In scenario's in de echte wereld zouden de

middelen worden toegewezen aan beide PE-apparaten.

```
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								
<b>IP Route Table</b>	<b>EM</b>	<b>I</b>	<b>24576</b>	<b>23</b>	<b>0.09%</b>	<b>14</b>	<b>0</b>	<b>9</b>
<b>0 &lt;-- 23 EM (hash) base usage</b>								
<b>IP Route Table</b>	<b>TCAM</b>	<b>I</b>	<b>8192</b>	<b>25</b>	<b>0.31%</b>	<b>12</b>	<b>10</b>	<b>2</b>
<b>1 &lt;-- 25 TCAM base usage</b>								

```
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

**Opmerking:** SI/RI/DI zijn bronnen vereist voor pakketherschrijven, bestemmingsprts enzovoort. Zie artikel [Hardware resources begrijpen](#) van [Catalyst 9000 Switches voor problemen met probleemoplossing](#)

## Voeg 1000 BGP VPNv4-prefixes toe

De buurman (Ixia) heeft 1000 voorfixes toegevoegd aan VRF MPLS van CE

## 9300 Lokale PE (verbonden met 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
1
```

```
<-- 25 base + 1000 /28 prefixes = 1025 TCAM entries
<-- MPLS labels are added to EM, and each MPLS label uses 2 entries (one IPv4 prefix, and one
MPLS label results in 3 entries used in hardware)
```

```
C9300-48U#show platform software fed switch active mpls summary | b Resource shar
Resource sharing info:
SI: 4/65536
RI: 1010/65536
Well Known Index: 49/2048
Tcam: 1021/57344
lv1_ecr: 0/64
```

lv2\_ecr: 0/256  
lspa: 0/16385  
label\_stack\_id: 1002/65537  
vpn\_spoke\_id: 0/255  
indirect\_si: 0/255

RSM resource database stats:

Num of (L3+mpls) ADJ entries allocated: 1036/131072

**Num of LABEL entries allocated: 1004/8192**

<-- Increased by 1000 on local PE

**Num of LSPA entries allocated: 0/8192**

<-- No prefixes learnt from remote

**PE, no LSPA allocated**

Num of local adjs in mpls adjs: 3

Num of SI stats allocated: 1006/49152

Adjs stats allocated by MPLS:

Num of mpls adjs: 1011

Num of L3 adjs: 0

**Num of VPN prefix\_id: 0**

<...snip...>

**Other MPLS resource alloc error stats: <-- no resource allocation issues**

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

<-- Resources shown in baseline outputs are now increased by 1000

9500H afstandsbediening (via MPLS geleerd)

C9500-24Y4C#show platform hardware fed active fwd-asic resource tcam utilization

Codes: EM - Exact\_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable

CAM Utilization for ASIC [0]

Table	Subtype	Dir	Max	Used	%Used	V4	V6	MPLS
Other								
-----								
Mac Address Table	EM	I	32768	19	0.06%	0	0	0
19								
Mac Address Table	TCAM	I	768	21	2.73%	0	0	0
21								
L3 Multicast	EM	I	32768	0	0.00%	0	0	0
0								
L3 Multicast	TCAM	I	768	6	0.78%	3	3	0
0								
L2 Multicast	TCAM	I	2304	7	0.30%	3	4	0
0								
<b>IP Route Table</b>	<b>EM/LPM</b>	<b>I</b>	<b>212992</b>	<b>1012</b>	<b>0.48%</b>	<b>1003</b>	<b>0</b>	<b>9</b>
0								
IP Route Table	TCAM	I	1536	28	1.82%	23	3	2
0								
<b>CTS Cell Matrix/VPN</b>								
<b>Label</b>	<b>EM</b>	<b>O</b>	<b>32768</b>	<b>992</b>	<b>3.03%</b>	<b>0</b>	<b>0</b>	<b>992</b>
0								
<-- 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)

**Opmerking:** Voor algemene Catalyst 9000 TCAM informatie, of details over hoe u TCAM voor andere functies kunt controleren zie artikel [Hardware Resources op Catalyst 9000 Switches begrijpen](#).

**Opmerking:** ADJ (nabijheid) is een gedeeld resource. Zie artikel [Hardware resources op Catalyst 9000 Switches voor problemen met probleemoplossing bij ADJ](#).

## MPLS-label en IPv4-schaallimiet en -verbetering

In de meeste gevallen wanneer de MPLS-functie wordt gebruikt en er te veel hardwarebronnen worden verbruikt, kan een verandering in de labeltoewijzing van (standaard) per prefix naar per-vrf

helpen. In dit voorbeeld wordt de toewijzing van middelen vóór en na (in dit geval is de 9500 het CE-PE-apparaat) overwogen.

**### 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								
<b>IP Route Table</b>	<b>EM/LPM</b>	<b>I</b>	<b>212992</b>	<b>3023</b>	<b>1.42%</b>	<b>1014</b>	<b>0</b>	<b>2009</b>
<b>0</b>	<b>&lt;-- 1 IPv4 prefix entry + 2 entries for labels (2 labels created per every 1 IPv4 prefix)</b>							
IP Route Table	TCAM	I	1536	17	1.11%	12	3	2
0								

**### New usage after change to per-vrf lable allocation ###**

C9500-24Y4C(config)#mpls label mode vrf MPLS protocol all-afs per-vrf

C9500-24Y4C#show bgp vpnv4 unicast all BGP table version is 164901, local router ID is 10.0.0.5

```
Network      Next Hop      Metric LocPrf Weight Path
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
               x best-external, a additional-path, c RIB-compressed,
               t secondary path, L long-lived-stale,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found
Network Next Hop Metric LocPrf Weight Path
Route Distinguisher: 1:1 (default for vrf MPLS) *> 172.30.0.0/24 192.168.3.2 2219
0 65100 65101 65102 65103 {65104} e
<...snip...>
```

C9500-24Y4C#show bgp vpnv4 unicast all 172.30.0.0

BGP routing table entry for 1:1:172.30.0.0/24, version 163902

Paths: (1 available, best #1, table MPLS)

```
Advertised to update-groups:
 8
Refresh Epoch 1
65100 65101 65102 65103 {65104}
 192.168.3.2 (via vrf MPLS) from 192.168.3.2 (192.168.3.2)
   Origin EGP, metric 2219, localpref 100, valid, external, best
   Extended Community: RT:1:1
   mpls labels in/out IPv4 VRF Aggr:18116/nolabel <-- Verify you see a 'VRF Aggr' label
type
  rx pathid: 0, tx pathid: 0x0
  Updated on Dec 9 2021 19:50:22 UTC
```

**### Usage with per-vrf label allocation ###**

Allocation on both local and remote PE is dramatically reduced via change to label allocation

mode

**local switch (PE-CE)**

C9500-24Y4C#show platform hardware fed active fwd-asic resource tcam utilization

Codes: EM - Exact\_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable

CAM Utilization for ASIC [0]

Table	Subtype	Dir	Max	Used	%Used	V4	V6	MPLS
Other								
-----								
-----								
Mac Address Table	EM	I	32768	19	0.06%	0	0	0
19								
Mac Address Table	TCAM	I	768	21	2.73%	0	0	0
21								
L3 Multicast	EM	I	32768	0	0.00%	0	0	0
0								
L3 Multicast	TCAM	I	768	6	0.78%	3	3	0
0								
L2 Multicast	TCAM	I	2304	7	0.30%	3	4	0
0								
<b>IP Route Table</b>	<b>EM/LPM</b>	<b>I</b>	<b>212992</b>	<b>1025</b>	<b>0.48%</b>	<b>1014</b>	<b>0</b>	<b>11</b>
<b>0</b>	<b>&lt;-- one local LABEL used to reach the CE learnt prefixes</b>							
IP Route Table	TCAM	I	1536	17	1.11%	12	3	2
0								
QOS ACL	TCAM	I	1024	45	4.39%	15	20	0
10								

**remote switch (PE-PE)**

C9300-48U#show platform hardware fed switch active fwd-asic resource tcam utilization

Codes: EM - Exact\_Match, I - Input, O - Output, IO - Input & Output, NA - Not Applicable

CAM Utilization for ASIC [0]

Table	Subtype	Dir	Max	Used	%Used	V4	V6	MPLS
Other								
-----								
-----								
<...snip...>								
IP Route Table	EM	I	24576	23	0.09%	14	0	9
0								
<b>IP Route Table</b>	<b>TCAM</b>	<b>I</b>	<b>8192</b>	<b>1025</b>	<b>12.51%</b>	<b>1012</b>	<b>10</b>	<b>2</b>
<b>1</b>	<b>&lt;-- Still 1:1 usage for IPv4 prefixes</b>							
<...snip...>								
<b>CTS Cell Matrix/VPN</b>								
<b>Label</b>	<b>EM</b>	<b>O</b>	<b>8192</b>	<b>1</b>	<b>0.01%</b>	<b>0</b>	<b>0</b>	<b>1</b>
<b>0</b>	<b>&lt;-- one remote LSPA used to reach the PE learnt prefixes</b>							

**Opmerking:** Het gebruik van middelen in toonplatformsoftware die de actieve-multiplexmpls-samenvatting van de switch heeft gekregen toont ook deze vermindering in LABEL of LSPA (indien van toepassing).

## Opdrachten voor TAC

De meest voorkomende problemen met betrekking tot de hardware-middelen in verband met MPLS worden in deze handleiding behandeld, met passende corrigerende maatregelen. Als deze handleiding uw probleem echter niet oplost, verzamelt u de weergegeven opdrachtlijst en voegt u deze bij het servicetoestel.

```
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_ace 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
```

## Gerelateerde informatie

[Technische ondersteuning en documentatie – Cisco Systems](#)

[MPLS-configuratiegids \(Multiprotocol Label Switching\), Cisco IOS XE-versie 17.7.x \(Catalyst 9300 Switches\)](#)

[MPLS-configuratiegids \(Multiprotocol Label Switching\), Cisco IOS XE-versie 17.7.x \(Catalyst 9500 Switches\)](#)

[Ga naar hardwarebronnen op Catalyst 9000 Switches](#)