在Nexus 9300中部署使用SR MPLS的第3層 EVPN [Ospf / iBGP] [PE-CE是OSPF]

目錄

簡介

本檔案介紹如何使用PE-CE協定作為開放最短路徑優先(OSPF)，在Nexus 9300產品上部署/設定透過分段路由(SR)的多通訊協定標籤交換(MPLS)的第3層EVPN。

必要條件

需求

思科建議您瞭解以下主題：

- 邊界閘道通訊協定(BGP)
- 開放最短路徑優先(OSPF)
- L3VPN
- EVPN
- 分段路由(SR)

採用元件

本文中的資訊係根據以下軟體和硬體版本：

- 主乾硬體 — 93360YC-FX2使用9.3.(3)運行
- 枝葉硬體 — 93240YC-FX2使用9.3.(3)運行
- 客戶端 — 93216TC-FX2(Host-1),Catalyst-3750(Host-2)

本文中的資訊是根據特定實驗室環境內的裝置所建立。文中使用到的所有裝置皆從已清除（預設）的組態來啟動。如果您的網路正在作用，請確保您已瞭解任何指令可能造成的影響。

背景資訊

MPLS L3VPN重述

VPN是：

- 基於IP的網路，通過公共基礎設施提供專用網路服務。
- 允許通過Internet或其它公共或專用網路相互私下通訊的一組站點。

傳統VPN是通過配置到VPN中所有站點的全網狀隧道或永久虛擬電路(PVC)建立的。這種型別的VPN不易維護或擴展，因為新增新站點需要更改VPN中的每個邊緣裝置。

基於MPLS的VPN在第3層建立，並基於對等體模型。對等體模型使服務提供商和客戶能夠交換第3層路由資訊。服務提供商在客戶站點之間轉發資料，而無需客戶參與。

MPLS VPN比傳統VPN更易於管理和擴展。向MPLS VPN新增新站點時，僅需要更新向客戶站點提供服務的服務提供商的邊緣路由器。

以下是MPLS VPN的元件：

- 提供商(P)路由器 — 提供商網路核心的路由器。PE路由器運行MPLS交換，並且不會將VPN標籤附加到路由資料包。VPN標籤用於將資料包定向到正確的專用網路或客戶邊緣路由器。

- PE路由器 — 根據接收傳入資料包的介面或子介面將VPN標籤附加到這些資料包的路由器，同時附加MPLS核心標籤。PE路由器直接連線到CE路由器。

- 客戶(C)路由器 — 網際網路服務提供商(ISP)或企業網路中的路由器。

- 客戶邊緣(CE)路由器 — ISP網路中的邊緣路由器，連線到網路上的PE路由器。CE路由器必須與PE路由器介面。

含L3VPN(MPLS SR)的EVPN概觀

資料中心(DC)部署已採用VXLAN EVPN（或）MPLS EVPN，其優勢包括EVPN控制平面學習、多租戶、無縫移動性、冗餘和更輕鬆的POD新增。同樣，CORE是基於標籤分發協定(LDP)的MPLS L3VPN網路，或從傳統的基於MPLS L3VPN LDP的底層過渡到更複雜的解決方案，如分段路由(SR)。

分部路由以其優勢獲採納，例如：

- 整合IGP和MPLS控制平面
- 更簡單的流量工程方法
- 更輕鬆的配置
- SDN採用
- EVPN(RFC 7432)是基於BGP MPLS的解決方案，已用於虛擬化資料中心網路中的下一代乙太網服務。
- EVPN使用來自現有MPLS技術的多個構建塊，例如RD、RT和VRF。
- NXOS 7.0(3)I6(1)版本中引入的L3 EVPN over SR使用帶MPLS封裝的EVPN第5類路由。
- 基於SR的第3層EVPN為演化的資料中心服務提供了多租戶、可擴充性和高效能。

附註：在DC中，資料平面可以是VXLAN或MPLS。

傳統MPLS第3層VPN
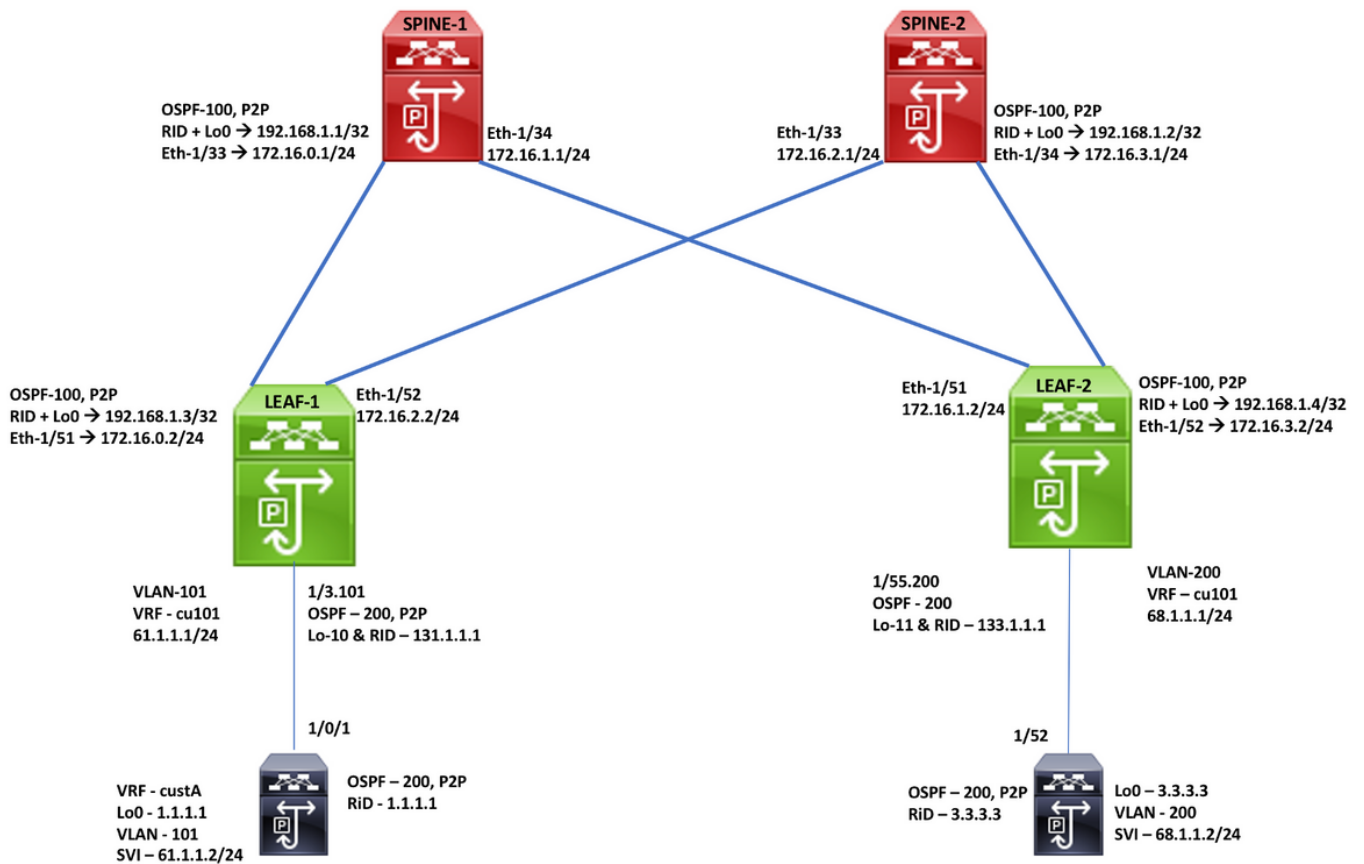主構建塊：RD、RT和VRF
用於傳輸的底層層：IGP、LDP和RSVP-TE
服務的覆蓋層：VPNv4和VPNv6

使用SR的MPLS第3層VPN
主構建塊：RD、RT和VRF
用於傳輸的底層層：IGP/BGP-LU和SR-TE
服務的覆蓋層：EVPN

網路圖表

SPINE-1
OSPF-100, P2P
RID + Lo0 → 192.168.1.1/32
Eth-1/33 → 172.16.0.1/24
Eth-1/34
172.16.1.1/24

SPINE-2
Eth-1/33
172.16.2.1/24
OSPF-100, P2P
RID + Lo0 → 192.168.1.2/32
Eth-1/34 → 172.16.3.1/24

LEAF-1
OSPF-100, P2P
RID + Lo0 → 192.168.1.3/32
Eth-1/51 → 172.16.0.2/24
Eth-1/52
172.16.2.2/24

LEAF-2
Eth-1/51
172.16.1.2/24
OSPF-100, P2P
RID + Lo0 → 192.168.1.4/32
Eth-1/52 → 172.16.3.2/24

VLAN-101
VRF - cu101
61.1.1.1/24

1/3.101
OSPF – 200, P2P
Lo-10 & RID – 131.1.1.1

1/55.200
OSPF - 200
Lo-11 & RID – 133.1.1.1

VLAN-200
VRF – cu101
68.1.1.1/24

1/0/1

1/52

VRF - custA
Lo0 - 1.1.1.1
VLAN - 101
SVI – 61.1.1.2/24

OSPF – 200, P2P
RiD - 1.1.1.1

OSPF – 200, P2P
RiD – 3.3.3.3

Lo0 – 3.3.3.3
VLAN - 200
SVI – 68.1.1.2/24

組態

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

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

LEAF-1 Configuration

Enabling Features, Label-Range, Route-map, Label-Index	OSPF Configuration	BGP/EVPN Configuration
install feature-set mpls	interface Ethernet1/51	router bgp 65001
feature-set mpls	ip address 172.16.0.2/24	router-id 192.168.1.3
nv overlay evpn	ip ospf network point-to-point	address-family ipv4 unicast
feature ospf	ip router ospf 100 area 0.0.0.0	network 192.168.1.3/32 route-map label-index-leaf-1
feature bgp	mpls ip forwarding	allocate-label all
feature mpls segment-routing	no shutdown	address-family ipv4 labeled-unicast
feature mpls evpn		address-family l2vpn evpn
feature interface-vlan	interface Ethernet1/52	
feature mpls oam	ip address 172.16.2.2/24	template peer EVPN
feature nv overlay	ip ospf network point-to-point	remote-as 65001
	ip router ospf 100 area 0.0.0.0	update-source loopback0
mpls label range 5000 450000	mpls ip forwarding	address-family l2vpn evpn
segment-routing	no shutdown	send-community extended
mpls		encapsulation mpls
global-block 16000 25000	interface loopback0	
connected-prefix-sid-map	ip address 192.168.1.3/32	template peer Labeled-unicast
address-family ipv4	ip router ospf 100 area 0.0.0.0	remote-as 65001
192.168.1.3/32 index 311		address-family ipv4 labeled-unicast
	router ospf 100	send-community extended
ip prefix-list test1 seq 5 permit 61.1.1.0/24	segment-routing mpls	soft-reconfiguration inbound always
ip prefix-list test1 seq 10 permit 131.1.1.1/32	router-id 192.168.1.3	
ip prefix-list test3 seq 5 permit 1.1.1.1/32	**PE-CE**	neighbor 172.16.0.1
	vrf cu101	inherit peer Labeled-unicast
	address-family ipv4 unicast	neighbor 172.16.2.1
route-map bgp65001 permit 10		inherit peer Labeled-unicast
match route-type internal		neighbor 192.168.1.1
route-map direct1 permit 10	interface Ethernet1/3	inherit peer EVPN
match ip address prefix-list test1	no shutdown	neighbor 192.168.1.2
set community 65001:10	interface Ethernet1/3.101	inherit peer EVPN
route-map label-index-leaf-1 permit 10	encapsulation dot1q 101	
set label-index 311	vrf member cu101	
route-map ospf200 permit 10	ip address 61.1.1.1/24	vrf cu101
match ip address prefix-list test3	ip ospf network point-to-point	router-id 131.1.1.1
	ip router ospf 200 area 0.0.0.0	address-family ipv4 unicast
	no shutdown	advertise l2vpn evpn
vrf context cu101		redistribute direct route-map direct1
rd auto	interface loopback10	redistribute ospf 200 route-map ospf200
address-family ipv4 unicast	vrf member cu101	
route-target import 1:101	ip address 131.1.1.1/32	
route-target import 1:101 evpn	ip router ospf 200 area 0.0.0.0	
route-target export 1:101		
route-target export 1:101 evpn	router ospf 200	
	vrf cu101	
	router-id 131.1.1.1	
	redistribute bgp 65001 route-map bgp65001	

LEAF-2 Configuration

Enabling Features, Label-Range, Route-map, Label-Index	OSPF Configuration	BGP/EVPN Configuration

Enabling Features, Label-Range, Route-map, Label-Index

```
install feature-set mpls
feature-set mpls
nv overlay evpn
feature ospf
feature bgp
feature mpls segment-routing
feature mpls evpn
feature interface-vlan
feature mpls oam
feature nv overlay

mpls label range 5000 450000
segment-routing
  mpls
    global-block 16000 25000
    connected-prefix-sid-map
      address-family ipv4
        192.168.1.4/32 index 321

ip prefix-list new seq 5 permit 68.1.1.0/24
ip prefix-list new seq 10 permit 133.1.1.1/32

ip prefix-list new1 seq 5 permit 3.3.3.3/32

ip prefix-list redtoospf seq 5 permit 61.1.1.0/24
ip prefix-list redtoospf seq 10 permit 1.1.1.1/32

route-map bgp65001 permit 10
  match route-type internal
route-map direct1 permit 10
  match ip address prefix-list new
route-map label-index-Leaf2 permit 10
  set label-index 321
route-map ospf200 permit 10
  match ip address prefix-list new1

vrf context cu101
  rd auto
  address-family ipv4 unicast
    route-target import 1:101
    route-target import 1:101 evpn
    route-target export 1:101
    route-target export 1:101 evpn
```

OSPF Configuration

```
interface Ethernet1/51
  ip address 172.16.1.2/24
  ip ospf network point-to-point
  ip router ospf 100 area 0.0.0.0
  mpls ip forwarding
  no shutdown

interface Ethernet1/52
  ip address 172.16.3.2/24
  ip ospf network point-to-point
  ip router ospf 100 area 0.0.0.0
  mpls ip forwarding
  no shutdown

interface loopback0
  ip address 192.168.1.4/32
  ip router ospf 100 area 0.0.0.0

router ospf 100
  segment-routing mpls
  router-id 192.168.1.4

PE-CE
  vrf cu101
    address-family ipv4 unicast
interface Ethernet1/55
  no shutdown
interface Ethernet1/55.200
  encapsulation dot1q 200
  vrf member cu101
  ip address 68.1.1.1/24
  ip ospf network point-to-point
  ip router ospf 200 area 0.0.0.0
  no shutdown

interface loopback11
  vrf member cu101
  ip address 133.1.1.1/32
  ip router ospf 200 area 0.0.0.0

router ospf 200
  vrf cu101
    router-id 133.1.1.1
    redistribute bgp 65001 route-map bgp65001
```

BGP/EVPN Configuration

```
router bgp 65001
  router-id 192.168.1.4
  address-family ipv4 unicast
    network 192.168.1.4/32 route-map label-index-Leaf2
    allocate-label all
  address-family ipv4 labeled-unicast
  address-family l2vpn evpn

  template peer EVPN
    remote-as 65001
    update-source loopback0
    address-family l2vpn evpn
      send-community extended
      encapsulation mpls


  template peer Labeled-unicast
    remote-as 65001
    address-family ipv4 labeled-unicast
      send-community extended
      soft-reconfiguration inbound always

  neighbor 172.16.1.1
    inherit peer Labeled-unicast
  neighbor 172.16.3.1
    inherit peer Labeled-unicast
  neighbor 192.168.1.1
    inherit peer EVPN
  neighbor 192.168.1.2
    inherit peer EVPN


  vrf cu101
    router-id 133.1.1.1
    address-family ipv4 unicast
      advertise l2vpn evpn
      redistribute direct route-map direct1
      redistribute ospf 200 route-map ospf200
```

Host-1 / Cat-3750

```
vrf definition custA
 rd 101:1
 !
 address-family ipv4
 exit-address-family
 !


interface Loopback0
 vrf forwarding custA
 ip address 1.1.1.1 255.255.255.255


interface GigabitEthernet1/0/1
 switchport trunk allowed vlan 101
 switchport trunk encapsulation dot1q
 switchport mode trunk
 !


interface Vlan101
 vrf forwarding custA
 ip address 61.1.1.2 255.255.255.0
 ip ospf network point-to-point
 ip ospf 200 area 0.0.0.0



router ospf 200 vrf custA
 router-id 1.1.1.1
 network 1.1.1.1 0.0.0.0 area 0.0.0.0
 network 61.1.1.0 0.0.0.255 area 0.0.0.0
```

Host-2 / N9K

```
feature ospf
feature interface-vlan


interface Ethernet1/52
 switchport
 switchport mode trunk
 switchport trunk allowed vlan 200
 no shutdown


interface Vlan200
 no shutdown
 ip address 68.1.1.2/24
 ip ospf network point-to-point
 ip router ospf 200 area 0.0.0.0


interface loopback0
 ip address 3.3.3.3/32
 ip router ospf 200 area 0.0.0.0



router ospf 200
 router-id 3.3.3.3
```

驗證

```
Host2# show ip int brief
IP Interface Status for VRF "default"(1)
Interface         IP Address      Interface Status
Vlan200           68.1.1.2        protocol-up/link-up/admin-up
Vlan1001          100.0.0.100     protocol-down/link-down/admin-up
Lo0               3.3.3.3         protocol-up/link-up/admin-up

Host2# show ip route
IP Route Table for VRF "default"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

1.1.1.1/32, ubest/mbest: 1/0
    *via 68.1.1.1, Vlan200, [110/1], 00:29:24, ospf-200, type-2, tag 65001
3.3.3.3/32, ubest/mbest: 2/0, attached
    *via 3.3.3.3, Lo0, [0/0], 20:16:34, local
    *via 3.3.3.3, Lo0, [0/0], 20:16:34, direct
61.1.1.0/24, ubest/mbest: 1/0
    *via 68.1.1.1, Vlan200, [110/1], 00:29:24, ospf-200, type-2, tag 65001
68.1.1.0/24, ubest/mbest: 1/0, attached
    *via 68.1.1.2, Vlan200, [0/0], 20:20:55, direct
68.1.1.2/32, ubest/mbest: 1/0, attached
    *via 68.1.1.2, Vlan200, [0/0], 20:20:55, local
131.1.1.1/32, ubest/mbest: 1/0
    *via 68.1.1.1, Vlan200, [110/1], 00:29:24, ospf-200, type-2, tag 65001
133.1.1.1/32, ubest/mbest: 1/0
    *via 68.1.1.1, Vlan200, [110/41], 20:15:32, ospf-200, intra
```

```
Host2# traceroute 1.1.1.1
traceroute to 1.1.1.1 (1.1.1.1), 30 hops max, 40 byte packets
 1  68.1.1.1 (68.1.1.1)  0.989 ms  0.585 ms  0.407 ms
 2  172.16.3.1 (172.16.3.1)  0.886 ms 172.16.1.1 (172.16.1.1)  0.765 ms  0.731 ms
    [Label=16311 E=0 TTL=1 S=0, Label=492289 E=0 TTL=1 S=1]
    [Label=16311 E=0 TTL=1 S=0, Label=492289 E=0 TTL=1 S=1]
    [Label=16311 E=0 TTL=1 S=0, Label=492289 E=0 TTL=1 S=1]
 3  172.16.0.2 (172.16.0.2)  0.717 ms 172.16.2.2 (172.16.2.2)  0.509 ms 172.16.0.2 (172.16.0.2)  0.678 ms
    [Label=492289 E=0 TTL=1 S=1]
    [Label=492289 E=0 TTL=1 S=1]
    [Label=492289 E=0 TTL=1 S=1]
 4  61.1.1.2 (61.1.1.2)  2.061 ms * 1.315 ms

Host2# ping 1.1.1.1 source 3.3.3.3
PING 1.1.1.1 (1.1.1.1) from 3.3.3.3: 56 data bytes
64 bytes from 1.1.1.1: icmp_seq=0 ttl=251 time=5.538 ms
64 bytes from 1.1.1.1: icmp_seq=1 ttl=251 time=1.338 ms
64 bytes from 1.1.1.1: icmp_seq=2 ttl=251 time=2.201 ms
64 bytes from 1.1.1.1: icmp_seq=3 ttl=251 time=2.217 ms
64 bytes from 1.1.1.1: icmp_seq=4 ttl=251 time=4.021 ms

--- 1.1.1.1 ping statistics ---
5 packets transmitted, 5 packets received, 0.00% packet loss
round-trip min/avg/max = 1.338/3.063/5.538 ms
```

```
Leaf1# show ip route 3.3.3.3/32 vrf cu101
IP Route Table for VRF "cu101"
'*' denotes best ucast next-hop
'**' denotes best mcast next-hop
'[x/y]' denotes [preference/metric]
'%<string>' in via output denotes VRF <string>

3.3.3.3/32, ubest/mbest: 1/0
    *via 192.168.1.4%default, [200/2], 00:44:27, bgp-65001, internal, tag 65001 (mpls-vpn)
```

```
Leaf1# show forwarding mpls 192.168.1.4/32
slot  1
=======

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

```
Leaf1# show forwarding 3.3.3.3/32 vrf cu101
slot  1
=======

IPv4 routes for table cu101/base

------------------+----------------------------+------------------+------------------+------------------
Prefix            | Next-hop                   | Interface        | Labels           | Partial Install
------------------+----------------------------+------------------+------------------+------------------
*3.3.3.3/32         172.16.0.1                   Ethernet1/51       PUSH 16321 492288
                    172.16.2.1                   Ethernet1/52       PUSH 16321 492288
```

相關資訊

- [多重通訊協定BGP MPLS VPN](#)
- [Cisco Nexus 9500、9300、9200、3200和3100平台交換機上的分段路由白皮書](#)
- [在分段路由MPLS上配置第3層EVPN和第3層VPN](#)