

驗證SD-Access Fabric中的前端複製

目錄

[簡介](#)

[必要條件](#)

[需求](#)

[採用元件](#)

[背景資訊](#)

[拓撲](#)

[組態](#)

[控制平面驗證](#)

[組播接收方傳送IGMP成員報告](#)

[PIM稀疏模式共用樹建立](#)

[重疊中的PIM鄰居](#)

[任播RP建立\(*, G\)](#)

[多點傳送來源註冊](#)

[MSDP源通告](#)

[最短路徑樹\(SPT\)切換](#)

[資料層面驗證 \(與平台無關\)](#)

[源端驗證](#)

[來源註冊](#)

[接收方驗證](#)

[LHR PIM\(*, G\)驗證](#)

[LHR PIM共用樹狀結構驗證](#)

[MFIB轉發-源端驗證](#)

[MFIB轉發-接收方端驗證](#)

[資料層面驗證 \(取決於平台\)](#)

[\(S, G\)建立- CPU傳送路徑](#)

[Mroute硬體程式設計- IOS Mroute](#)

[Mroute硬體程式設計- IOS MFIB](#)

[Mroute硬體程式設計- RP MFIB](#)

[Mroute硬體程式設計- FP MFIB](#)

[Mroute硬體程式設計- Mroute對象](#)

[Mroute硬體程式設計- Mlist對象](#)

[Mroute硬體程式設計- FED Mroute](#)

簡介

本文檔介紹如何對SD-Access (SDA)交換矩陣中的頭端複製進行故障排除。

必要條件

需求

思科建議您瞭解以下主題：

- 網際網路通訊協定(IP)轉送
- Locator/ID Separation Protocol (LISP)
- 通訊協定無關多點傳送(PIM)稀疏模式

採用元件

- Cisco IOS® XE 17.10.1上的C9000v
- Cisco Catalyst中心版本2.3.5.3

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。如果您的網路運作中，請確保您瞭解任何指令可能造成的影響。

本文件也適用於以下硬體和軟體版本：

- C9200
- C9300
- C9400
- C9500
- C9600
- Cisco IOS® XE 16.12及更高版本

背景資訊

SDA頭端複製是一種重疊組播形式，用於在交換矩陣裝置之間傳送組播流量，將組播流量封裝到單播IP報頭中。頭端複製可以在相同VLAN或不同VLAN中的來源與接收者之間路由多點傳播流量 (可以路由相同VLAN多點傳送)。

同一交換矩陣邊緣上的源和接收器之間的組播流量不使用重疊組播 (VXLAN封裝) 進行轉發，而是由交換矩陣邊緣進行本地路由。

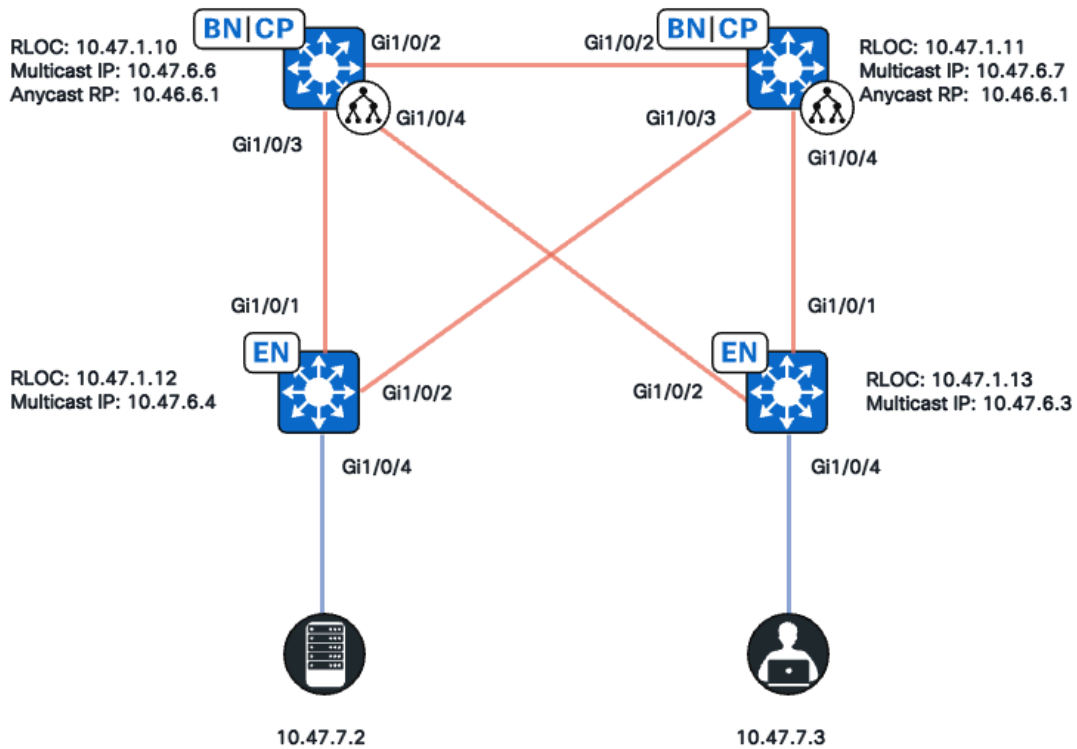
任何形式的重疊組播 (頭端或本地) 都無法為224.0.0.0/24範圍內的組路由組播流量，或者在TTL=1的情況下，這透過第2層泛洪處理

注意：表示讀者需要注意。註記包含有用的建議或檔案未涵蓋的材料的參照。



註：平台(Fed)命令可能有所不同。命令可以是「show platform fed <active|standby>」或「show platform fed switch <active|standby>」。「」。如果示例中註明的語法未解析出，請嘗試該變體。

拓撲



網路拓撲

在此拓撲中：

- 10.47.10和10.47.1.11是共置邊界，在虛擬網路(VN)/VRF中的兩個節點之間還用作具有組播源發現協定(MSDP)的任播集合點(RP)。
- 10.47.1.12和10.47.1.13是交換矩陣邊緣節點
- 10.47.7.2是組播源
- 10.47.7.3是組播接收器
- 239.1.1.1是組播組目標地址(GDA)

組態

假設Cisco Catalyst Center用於使用預設設定調配SDA交換矩陣：

- 複製實施是頭端複製
- 任意播RP在配置邊界上為任意源組播(ASM)組播提供MSDP

從Catalyst Center成功配置後，每台裝置的相關配置包含幾個部分：

交換矩陣邊緣(10.47.1.12)配置

```
ip multicast-routing vrf blue_vn
ip multicast vrf blue_vn multipath
!
```

```
interface LISP0.4100
vrf forwarding blue_vn
ip pim sparse-mode
end
!
interface Loopback4100
vrf forwarding blue_vn
ip address 10.47.6.4 255.255.255.255
ip pim sparse-mode
end
!
ip pim vrf blue_vn register-source Loopback4100
ip pim vrf blue_vn rp-address 10.47.6.1 ASM_ACL_IPV4_blue_vn_10.47.6.1
!
interface Vlan1025
description Configured from Cisco DNA-Center
mac-address 0000.0c9f.fb87
vrf forwarding blue_vn
ip address 10.47.7.1 255.255.255.0
ip helper-address 10.47.9.9
no ip redirects
ip pim passive
ip route-cache same-interface
ip igmp version 3
ip igmp explicit-tracking
no lisp mobility liveness test
lisp mobility blue-IPV4
end
!
ip access-list standard ASM_ACL_IPV4_blue_vn_10.47.6.1
10 permit 239.0.0.0 0.255.255.255
```

交換矩陣邊緣(10.47.1.13)配置

```
ip multicast-routing vrf blue_vn
ip multicast vrf blue_vn multipath
!
interface LISP0.4100
vrf forwarding blue_vn
ip pim sparse-mode
end
!
interface Loopback4100
vrf forwarding blue_vn
ip address 10.47.6.4 255.255.255.255
ip pim sparse-mode
end
!
ip pim vrf blue_vn register-source Loopback4100
ip pim vrf blue_vn rp-address 10.47.6.1 ASM_ACL_IPV4_blue_vn_10.47.6.1
!
interface Vlan1025
description Configured from Cisco DNA-Center
mac-address 0000.0c9f.fb87
vrf forwarding blue_vn
ip address 10.47.7.1 255.255.255.0
ip helper-address 10.47.9.9
```

```
no ip redirects
ip pim passive
ip route-cache same-interface
ip igmp version 3
ip igmp explicit-tracking
no lisp mobility liveness test
lisp mobility blue-IPV4
end
!
ip access-list standard ASM_ACL_IPV4_blue_vn_10.47.6.1
10 permit 239.0.0.0 0.255.255.255
```

並置邊界/任播RP (10.47.1.10)配置

```
router bgp 69420
address-family ipv4 vrf blue_vn
aggregate-address 10.47.6.0 255.255.255.0 summary-only
!
router lisp
site site_uci
eid-record instance-id 4100 10.47.6.0/24 accept-more-specifics
!
ip multicast-routing vrf blue_vn
ip multicast vrf blue_vn multipath
!
interface LISP0.4100
vrf forwarding blue_vn
ip pim sparse-mode
end
!
interface Loopback4100
vrf forwarding blue_vn
ip address 10.47.6.1 255.255.255.255
ip pim sparse-mode
end
!
interface Loopback4600
vrf forwarding blue_vn
ip address 10.47.6.6 255.255.255.255
ip pim sparse-mode
end
!
ip pim vrf blue_vn rp-address 10.47.6.1 ASM_ACL_IPV4_blue_vn_10.47.6.1
ip pim vrf blue_vn register-source Loopback4100
!
ip access-list standard ASM_ACL_IPV4_blue_vn_10.47.6.1
10 permit 239.0.0.0 0.255.255.255
!
ip msdp vrf blue_vn peer 10.47.6.7 connect-source Loopback4600
ip msdp vrf blue_vn cache-sa-state
ip msdp vrf blue_vn originator-id Loopback4600
```

並置邊界/任播RP (10.47.1.11)配置

```
router bgp 69420
address-family ipv4 vrf blue_vn
aggregate-address 10.47.6.0 255.255.255.0 summary-only
!
router lisp
site site_uci
eid-record instance-id 4100 10.47.6.0/24 accept-more-specifics
!
ip multicast-routing vrf blue_vn
ip multicast vrf blue_vn multipath
!
interface LISP0.4100
vrf forwarding blue_vn
ip pim sparse-mode
end
!
interface Loopback4100
vrf forwarding blue_vn
ip address 10.47.6.1 255.255.255.255
ip pim sparse-mode
end
!
interface Loopback4600
vrf forwarding blue_vn
ip address 10.47.6.7 255.255.255.255
ip pim sparse-mode
end
!
ip pim vrf blue_vn rp-address 10.47.6.1 ASM_ACL_IPV4__blue_vn_10.47.6.1
ip pim vrf blue_vn register-source Loopback4100
!
ip access-list standard ASM_ACL_IPV4_blue_vn_10.47.6.1
10 permit 239.0.0.0 0.255.255.255
!
ip msdp vrf blue_vn peer 10.47.6.6 connect-source Loopback4600
ip msdp vrf blue_vn cache-sa-state
ip msdp vrf blue_vn originator-id Loopback4600
```

控制平面驗證

接下來，驗證網際網路組成員協定(IGMP)和PIM。

組播接收方傳送IGMP成員報告

組播接收方(10.47.7.3)傳送IGMP成員報告(MR)或IGMP加入以表示接收組播流量的興趣。您可以配置嵌入式資料包捕獲(EPC)以確認收到的IGMP MR為：

```
<#root>
```

```
Edge-2#
```

```
monitor capture 1 interface GigabitEthernet1/0/5 IN
```

```
Edge-2#
```

```
monitor capture 1 match any
```

```
Edge-2#
```

```
monitor capture 1 buffer size 10
```

```
Edge-2#
```

```
monitor capture 1 start
```

```
Edge-2#
```

```
monitor capture 1 stop
```

```
Edge-1#
```

```
show monitor capture 1 buff display-filter igmp brief
```

```
Starting the packet display ..... Press Ctrl + Shift + 6 to exit  
145 63.730527 10.47.7.4 -> 239.1.1.1 IGMPv2 60 Membership Report group 239.1.1.1
```

接下來，請確保交換矩陣邊緣是組播接收器所在的VLAN的PIM指定路由器(DR)。這也稱為最後一跳路由器(LHR)。您可以使用命令「show ip pim vrf <VN Name> interface vlan <vlan> detail | 包括PIM DR」

```
<#root>
```

```
Edge-2#
```

```
show ip pim vrf blue_vn interface vlan 1025 detail | i PIM DR
```

```
PIM DR: 10.47.7.1 (this system)
```

驗證IGMP偵聽已使用命令「show ip igmp vrf <VN Name>偵聽組」獲取IGMP MR

```
<#root>
```

```
Edge-1#
```

```
show ip igmp vrf blue_vn snooping groups
```

```
Vlan Group          Type Version Port List
```

```
-----  
1025 239.255.255.254 igmp v2      Gi1/0/5
```

PIM稀疏模式共用樹建立

Edge-2，即該網段上的DR，向任播RP傳送(*, G) PIM加入。如果LISP對映快取中未解析任播RP地址，則LISP EID監視進程負責觸發LISP對映請求。您可以使用命令「show lisp instance-id <LISP L3 IID> ipv4/ipv6 eid-watch | 開始RLOC」

```
<#root>
```

```
Edge-2#
```

```
show lisp instance-id 4100 ipv4 eid-watch | begin RLOC
```

```
LISP IPv4 EID Watches for Table (RLOC mapping in vrf blue_vn IPv4) IID (4100), 1 watch entries  
Watch entries for prefix 10.47.6.1/32
```

```
10.47.6.1
```

```
,
```

```
multicast
```

```
Edge-2#
```

```
show lisp instance-id 4100 ipv4 map-cache 10.47.6.1
```

```
LISP IPv4 Mapping Cache for LISP 0 EID-table vrf blue_vn (IID 4100), 1 entries  
10.47.6.1/32, uptime: 9w1d, expires: 20:19:57, via map-reply, complete  
Sources: map-reply  
State: complete, last modified: 9w1d, map-source: 10.47.1.10  
Active, Packets out: 577721(21849998 bytes), counters are not accurate (~ 00:00:12 ago)  
Locator Uptime State Pri/Wgt Encap-IID
```

```
10.47.1.10
```

```
9w1d up 10/10 -  
Last up-down state change: 1w1d, state change count: 3  
Last route reachability change: 9w1d, state change count: 1  
Last priority / weight change: never/never  
RLOC-probing loc-status algorithm:  
Last RLOC-probe sent: 1w1d (rtt 272ms)
```

```
10.47.1.11
```

```
9w1d up 10/10 -  
Last up-down state change: 9w1d, state change count: 1  
Last route reachability change: 9w1d, state change count: 1  
Last priority / weight change: never/never  
RLOC-probing loc-status algorithm:  
Last RLOC-probe sent: 1w1d (rtt 602ms)
```

```
Edge-2#
```

```
show ip rpf vrf blue_vn 10.47.6.1
```

```
RPF information for (10.47.6.1)  
RPF interface: LISPO.4100
```

```
RPF neighbor: ? (10.47.1.10)
RPF route/mask: 10.47.6.1/32
RPF type: unicast ()
Doing distance-preferred lookups across tables
Multicast Multipath enabled.
RPF topology: ipv4 multicast base
```

在Edge-2上使用命令「show ip mroute vrf <VN Name> <multicast group>」驗證(*, G)條目

```
<#root>
```

```
Edge-2#
```

```
show ip mroute vrf blue_vn 239.1.1.1
```

```
IP Multicast Routing Table
```

```
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
U - URD, I - Received Source Specific Host Report,
Z - Multicast Tunnel, z - MDT-data group sender,
Y - Joined MDT-data group, y - Sending to MDT-data group,
G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
Q - Received BGP S-A Route, q - Sent BGP S-A Route,
V - RD & Vector, v - Vector, p - PIM Joins on route,
x - VxLAN group, c - PFP-SA cache created entry,
* - determined by Assert, # - iif-starg configured on rpf intf,
e - encap-helper tunnel flag, l - LISP decap ref count contributor
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
t - LISP transit group
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(*, 239.1.1.1), 4d05h/00:02:12, RP
```

```
10.47.6.1
```

```
, flags: SC
```

```
<-- Anycast RP IP address 10.47.6.1
```

```
Incoming interface: LISP0.4100, RPF nbr
```

```
10.47.1.10 <-- Reverse Path Forwarding (RPF) neighbor to get to the Anycast RP IP
```

```
Outgoing interface list:
```

```
Vlan1025
```

```
, Forward/Sparse-Dense, 4d05h/00:02:12, flags:
```

```
<-- Outgoing interface list (OIL) is populated via PIM Join or IGMP Membership Report
```

重疊中的PIM鄰居

RPF鄰居由其路由定位器(RLOC)表示並可透過LISP介面訪問後，就會作為PIM鄰居增加到VRF/VN中。

需要注意以下幾點：

- 用於傳送PIM (*, G)加入的RPF檢查會觸發使用兩分鐘過期計時器建立PIM鄰居。如果2分鐘內未傳送PIM加入消息，則鄰居超時。
- 由於PIM Hello消息未在SDA覆蓋中傳送，因此PIM必須為相應的RLOC顯式建立鄰居結構

<#root>

Edge-2#

```
show ip pim vrf blue_vn neighbor
```

PIM Neighbor Table

Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,

P - Proxy Capable, S - State Refresh Capable, G - GenID Capable,

L - DR Load-balancing Capable

Neighbor Interface Uptime/Expires Ver DR

Address Prio/Mode

10.47.1.10 LISP0.4100 4d23h/00:01:37 v2 0 /

任播RP建立(*, G)

根據從Edge-2接收的PIM (*, G)連線，Border-1使用OIL向Edge-2的RLOC建立(*, G)

<#root>

Border-1#

```
show ip mroute vrf blue_vn 239.1.1.1
```

IP Multicast Routing Table

Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,

L - Local, P - Pruned, R - RP-bit set, F - Register flag,

T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,

X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,

U - URD, I - Received Source Specific Host Report,

Z - Multicast Tunnel, z - MDT-data group sender,

Y - Joined MDT-data group, y - Sending to MDT-data group,

G - Received BGP C-Mroute, g - Sent BGP C-Mroute,

N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,

Q - Received BGP S-A Route, q - Sent BGP S-A Route,

V - RD & Vector, v - Vector, p - PIM Joins on route,

x - VxLAN group, c - PFP-SA cache created entry,

```
* - determined by Assert, # - iif-starg configured on rpf intf,
e - encap-helper tunnel flag, l - LISP decap ref count contributor
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
t - LISP transit group
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(*, 239.1.1.1), 4d23h/00:02:48, RP 10.47.6.1, flags: S
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:

LISP0.4100
,
10.47.1.13
, Forward/Sparse, 4d23h/00:02:33, flags:
<-- RLOC of Edge-2
```

多點傳送來源註冊

組播源10.47.7.2傳送組播流量，該流量進入Edge-1。Edge-1將資料包傳送到CPU以建立(S, G)狀態，Edge-1將源註冊到任播RP。

```
<#root>
```

```
Edge-1#
```

```
monitor capture 1 interface GigabitEthernet1/0/4 IN
```

```
Edge-1#
```

```
monitor capture 1 match any
```

```
Edge-1#
```

```
monitor capture 1 buffer size 10
```

```
Edge-1#
```

```
monitor capture 1 start
```

```
Edge-1#
```

```
monitor capture 1 stop
```

```
Edge-1#
```

```
show monitor capture 1 buffer brief
```

```
Starting the packet display ..... Press Ctrl + Shift + 6 to exit
```

```
1 0.000000 10.47.7.2 -> 239.1.1.1 ICMP 98 Echo (ping) request id=0x0007, seq=107/27392, ttl=5
```

```
2 0.355071 10.47.7.3 -> 239.1.1.1 ICMP 98 Echo (ping) request id=0x0007, seq=107/27392, ttl=5
3 1.096757 10.47.7.3 -> 239.1.1.1 ICMP 98 Echo (ping) request id=0x0007, seq=108/27648, ttl=5
4 1.102425 10.47.7.3 -> 239.1.1.1 ICMP 98 Echo (ping) request id=0x0007, seq=108/27648, ttl=5
```

一旦Border-1透過PIM註冊接收組播資料包，Border-1將具有(S, G)並透過MSDP將此通告給Border-2

```
<#root>
```

```
Border-1#
```

```
show ip mroute vrf blue_vn 239.1.1.1 10.47.7.2
```

```
IP Multicast Routing Table
```

```
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
U - URD, I - Received Source Specific Host Report,
Z - Multicast Tunnel, z - MDT-data group sender,
Y - Joined MDT-data group, y - Sending to MDT-data group,
G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
Q - Received BGP S-A Route, q - Sent BGP S-A Route,
V - RD & Vector, v - Vector, p - PIM Joins on route,
x - VxLAN group, c - PFP-SA cache created entry,
* - determined by Assert, # - iif-starg configured on rpf intf,
e - encap-helper tunnel flag, l - LISP decap ref count contributor
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
t - LISP transit group
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(10.47.7.2, 239.1.1.1), 00:02:26/00:00:34, flags: T
```

```
A <-- A flag indicates that this is a candidate for MSDP advertisement
```

```
Incoming interface: LISP0.4100, RPF nbr 10.47.1.12
```

```
Outgoing interface list:
```

```
LISP0.4100, 10.47.1.13, Forward/Sparse, 00:02:26/00:02:36, flags:
```

MSDP源通告

使用命令「show ip msdp vrf <VN name> sa-cache」檢視源活動快取。您可以使用命令「show ip msdp vrf <VN name> summary」檢視MSDP對等體

```
<#root>
```

```
Border-1#
```

```
show ip msdp vrf blue_vn sa-cache
```

```
MSDP Source-Active Cache - 1 entries
(10.47.7.2, 239.1.1.1), RP 10.47.6.7, BGP/AS 23456, 00:00:34/00:05:25, Peer 10.47.6.7
```

```
Border-1#
```

```
show ip msdp vrf blue_vn summary
```

```
MSDP Peer Status Summary
```

```
Peer Address AS      State Uptime/  Reset SA  Peer Name
                               Downtime Count Count
```

```
10.47.6.7
```

```
23456
```

```
Up
```

```
1w1d      0      1
```

Border-2透過MSDP通告從Border-1接收(S, G)資訊。如果Border-2已收到來自Edge-2的PIM (*, G)連線, Border-2將建立一個(S, G)條目, 並從指向Edge-2的RLOC的(*, G)繼承LISP OIL。經驗法則是, 如果存在(*, G), MSDP SA條目僅安裝在組播路由資訊庫(MRIB)中。

```
<#root>
```

```
Border-2#
```

```
show ip msdp vrf blue_vn sa-cache
```

```
MSDP Source-Active Cache - 1 entries
```

```
(10.47.7.2, 239.1.1.1), RP 10.47.6.6, BGP/AS 23456, 00:13:59/00:03:28, Peer 10.47.6.6
```

```
Border-2#
```

```
show ip mroute vrf blue_vn 239.1.1.1
```

```
IP Multicast Routing Table
```

```
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
```

```
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
```

```
T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
```

```
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
```

```
U - URD, I - Received Source Specific Host Report,
```

```
Z - Multicast Tunnel, z - MDT-data group sender,
```

```
Y - Joined MDT-data group, y - Sending to MDT-data group,
```

```
G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
```

```
N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
```

```
Q - Received BGP S-A Route, q - Sent BGP S-A Route,
```

```
V - RD & Vector, v - Vector, p - PIM Joins on route,
```

```
x - VxLAN group, c - PFP-SA cache created entry,
```

```
* - determined by Assert, # - iif-starg configured on rpf intf,
```

```
e - encap-helper tunnel flag, l - LISP decap ref count contributor
```

```
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
```

```
t - LISP transit group
```

```
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(*, 239.1.1.1), 00:21:04/00:00:06, RP 10.47.6.1, flags: SP
Incoming interface: Null, RPF nbr 0.0.0.0
```

```
Outgoing interface list: Null <-- Indicates no PIM (*,G) Join received, if there was an OIL, then
```

Border-1向源10.47.7.2傳送PIM (S , G)加入以吸引本地多播流量 , 這允許Edge-1更新 (S , G) OIL

```
<#root>
```

```
Edge-1#
```

```
show ip mroute vrf blue_vn 239.1.1.1 10.47.7.3
```

```
IP Multicast Routing Table
```

```
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
U - URD, I - Received Source Specific Host Report,
Z - Multicast Tunnel, z - MDT-data group sender,
Y - Joined MDT-data group, y - Sending to MDT-data group,
G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
Q - Received BGP S-A Route, q - Sent BGP S-A Route,
V - RD & Vector, v - Vector, p - PIM Joins on route,
x - VxLAN group, c - PFP-SA cache created entry,
* - determined by Assert, # - iif-starg configured on rpf intf,
e - encap-helper tunnel flag, l - LISP decap ref count contributor
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
t - LISP transit group
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(10.47.7.2, 239.1.1.1), 01:19:57/00:02:29, flags: FT
Incoming interface:
```

```
vlan1025
```

```
, RPF nbr 0.0.0.0
```

```
<-- Multicast source 10.47.7.2 is in VLAN 1025
```

```
Outgoing interface list:
```

```
LISPO.4100,
```

```
10.47.1.10
```

```
, Forward/Sparse, 01:19:55/00:02:30, flags:
```

```
<-- RLOC of Border-1
```

從10.47.7.2到239.1.1.1的組播流量透過單播VXLAN封裝從10.47.6.6 (Border-1)轉發出去。
Border-1解封VXLAN流量，並將其重新封裝到Edge-2 (10.47.1.13)

<#root>

Border-1#

show ip mroute vrf blue_vn 239.1.1.1

IP Multicast Routing Table

Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,

L - Local, P - Pruned, R - RP-bit set, F - Register flag,

T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,

X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,

U - URD, I - Received Source Specific Host Report,

Z - Multicast Tunnel, z - MDT-data group sender,

Y - Joined MDT-data group, y - Sending to MDT-data group,

G - Received BGP C-Mroute, g - Sent BGP C-Mroute,

N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,

Q - Received BGP S-A Route, q - Sent BGP S-A Route,

V - RD & Vector, v - Vector, p - PIM Joins on route,

x - VxLAN group, c - PFP-SA cache created entry,

* - determined by Assert, # - iif-starg configured on rpf intf,

e - encap-helper tunnel flag, l - LISP decap ref count contributor

Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join

t - LISP transit group

Timers: Uptime/Expires

Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 239.1.1.1), 5d01h/00:03:14, RP 10.47.6.1, flags: S

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

LISP0.4100, 10.47.1.13, Forward/Sparse, 5d01h/00:02:54, flags:

(

10.47.7.2

, 239.1.1.1), 00:02:28/00:00:30, flags: MT

<-- Unicast Source

Incoming interface: LISP0.4100, RPF nbr

10.47.1.12

<-- RPF neighbor to get to the source (Edge-1)

Outgoing interface list:

LISP0.4100,

10.47.1.13

, Forward/Sparse, 00:02:28/00:03:14, flags:

<-- RLOC of Edge-2

最短路徑樹(SPT)切換

一旦最後一跳路由器(LHR) Edge-2沿著(*, G)樹接收組播資料包，它將嘗試執行SPT切換並向Edge-1傳送PIM (S, G)加入。

<#root>

Edge-2#

```
show ip mroute vrf blue_vn 239.1.1.1
```

IP Multicast Routing Table

Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
U - URD, I - Received Source Specific Host Report,
Z - Multicast Tunnel, z - MDT-data group sender,
Y - Joined MDT-data group, y - Sending to MDT-data group,
G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
Q - Received BGP S-A Route, q - Sent BGP S-A Route,
V - RD & Vector, v - Vector, p - PIM Joins on route,
x - VxLAN group, c - PFP-SA cache created entry,
* - determined by Assert, # - iif-starg configured on rpf intf,
e - encaps-helper tunnel flag, l - LISP decap ref count contributor
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
t - LISP transit group
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(* , 239.1.1.1), 4d23h/stopped, RP 10.47.6.1, flags: SJC
Incoming interface: LISPO.4100, RPF nbr 10.47.1.10
Outgoing interface list:

vlan1025

, Forward/Sparse-Dense, 4d23h/00:02:40, flags:

<-- LHR creates the OIL because of receipt of an IGMP MR

(

10.47.7.2

, 239.1.1.1), 00:00:02/00:02:57, flags: JT

<-- Unicast Source

Incoming interface: LISPO.4100, RPF nbr

10.47.1.12

<-- RPF neighbor to get to 10.47.7.2, which is Edge-1 RLOC

Outgoing interface list:

vlan1025

, Forward/Sparse-Dense, 00:00:02/00:02:57, flags:

<-- Multicast traffic is forwarded into VLAN 1025, where 10.47.7.3 is

FHR (Edge-1)具有(S , G)直接指向Edge-2的RLOC

<#root>

Edge-1#

show ip mroute vrf blue_vn 239.1.1.1

IP Multicast Routing Table

Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,

L - Local, P - Pruned, R - RP-bit set, F - Register flag,

T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,

X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,

U - URD, I - Received Source Specific Host Report,

Z - Multicast Tunnel, z - MDT-data group sender,

Y - Joined MDT-data group, y - Sending to MDT-data group,

G - Received BGP C-Mroute, g - Sent BGP C-Mroute,

N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,

Q - Received BGP S-A Route, q - Sent BGP S-A Route,

V - RD & Vector, v - Vector, p - PIM Joins on route,

x - VxLAN group, c - PFP-SA cache created entry,

* - determined by Assert, # - iif-starg configured on rpf intf,

e - encap-helper tunnel flag, l - LISP decap ref count contributor

Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join

t - LISP transit group

Timers: Uptime/Expires

Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 239.1.1.1), 5d01h/stopped, RP 10.47.6.1, flags: SCF

Incoming interface: LISPO.4100, RPF nbr 10.47.1.10

Outgoing interface list:

Vlan1025, Forward/Sparse-Dense, 5d01h/00:01:40, flags:

(

10.47.7.2

, 239.1.1.1), 01:53:06/00:02:42, flags: FT

<-- Unicast Source

Incoming interface: Vlan1025, RPF nbr 0.0.0.0

Outgoing interface list:

LISPO.4100,

10.47.1.13

, Forward/Sparse, 00:14:22/00:03:07, flags:

<-- Edge-2's RLOC

資料層面驗證 (與平台無關)

可能有多種問題會阻止組播源或組播接收器傳送/接收流量。本節重點介紹如何驗證會影響組播源和組播接收方的問題，重點是與硬體程式設計無關的問題。

源端驗證

要驗證組播源和FHR建立(S, G)的能力，請驗證交換機整合安全功能(SISF)、LISP、思科快速轉發(CEF)，然後驗證RPF。

組播源必須位於SISF/IP裝置跟蹤(IPDT)中，IPDT將驅動LISP的其餘部分、CEF以及最終的RPF。

您可以使用命令「show device-tracking database address <IP address>」確保組播源具有有效的IPDT條目。

```
<#root>
```

```
Edge-1#
```

```
show device-tracking database address 10.47.7.2
```

```
Codes: L - Local, S - Static, ND - Neighbor Discovery, ARP - Address Resolution Protocol, DH4 - I
Preflevel flags (prlvl):
0001:MAC and LLA match 0002:Orig trunk 0004:Orig access
0008:Orig trusted trunk 0010:Orig trusted access 0020:DHCP assigned
0040:Cga authenticated 0080:Cert authenticated 0100:Statically assigned
      Network Layer Address Link Layer Address Interface vlan prlvl age state      Time left
DH4  10.47.7.2                5254.0012.521d    Gi1/0/4   1025 0024  163s REACHABLE 81 s try 0(8428
```

接下來，確保FHR上的LISP資料庫包含組播源的條目。使用命令「show lisp instance-id <LISP L3 IID> ipv4 資料庫ip地址/32」

```
<#root>
```

```
Edge-1#
```

```
show lisp instance-id 4100 ipv4 database 10.47.7.2/32
```

```
LISP ETR IPv4 Mapping Database for LISP 0 EID-table vrf blue_vn (IID 4100), LSBs: 0x1
Entries total 1, no-route 0, inactive 0, do-not-register 1
10.47.7.3/32, dynamic-eid blue-IPv4, inherited from default locator-set rloc_691b1fe4-5264-44c2-b
Uptime: 1w2d, Last-change: 1w2d
Domain-ID: local
Service-Insertion: N/A
Locator Pri/Wgt Source State
10.47.1.13 10/10 cfg-intf site-self, reachable
Map-server Uptime ACK Domain-ID
```

```
10.47.1.10 1w2d Yes 0
10.47.1.11 1w2d Yes 0
```

```
Edge-1#
```

```
show ip lisp instance-id 4100 forwarding eid local 10.47.7.2
```

```
Prefix
```

```
10.47.7.2/32
```

CEF基於LISP建立一個條目，CEF指向/32主機條目而不是LISP。

```
<#root>
```

```
Edge-1#
```

```
show ip cef vrf blue_vn 10.47.7.2
```

```
10.47.7.2/32
```

```
nexthop 10.47.7.2 Vlan1025
```

接下來，RPF從CEF派生

```
<#root>
```

```
Edge-1#
```

```
show ip rpf vrf blue_vn 10.47.7.2
```

```
RPF information for (10.47.7.2)
```

```
RPF interface: Vlan1025
```

```
RPF neighbor: ? (
```

```
10.47.7.2
```

```
) - directly connected
```

```
RPF route/mask: 10.47.7.2/32
```

```
RPF type:
```

```
unicast (lisp)
```

```
Doing distance-preferred lookups across tables
```

```
Multicast Multipath enabled.
```

```
RPF topology: ipv4 multicast base, originated from ipv4 unicast base
```

如果SISF/IPDT中沒有有效條目，則會導致FHR上沒有LISP資料庫對映，從而導致CEF和

RPF指向邊框。如果組播源傳送流量RPF指向不正確的介面，導致RPF故障，則不會形成(S, G)。

<#root>

Edge-1#

show device-tracking database address 10.47.7.2

Codes: L - Local, S - Static, ND - Neighbor Discovery, ARP - Address Resolution Protocol, DHCP -
Preflevel flags (prlvl):
0001:MAC and LLA match 0002:Orig trunk 0004:Orig access
0008:Orig trusted trunk 0010:Orig trusted access 0020:DHCP assigned
0040:Cga authenticated 0080:Cert authenticated 0100:Statically assigned
Network Layer Address Link Layer Address Interface vlan prlvl age state Time left

Edge-1#

show lisp instance-id 4100 ipv4 database 10.47.7.2/32

% No database-mapping entry for 10.47.7.2/32.

Edge-1#

show ip cef vrf blue_vn 10.47.7.2

10.47.7.0/24
nexthop 10.47.1.10

LISP0.4100 <-- Result of a LISP Negative Map-Reply, so the LISP interface is now the RPF interface

nexthop 10.47.1.11

LISP0.4100 <-- Result of a LISP Negative Map-Reply, so the LISP interface is now the RPF interface

Edge-1#

show ip rpf vrf blue_vn 10.47.7.2

RPF information for (10.47.7.2)
RPF interface:

LISP0.4100

RPF neighbor: ? (

10.47.1.11

)

RPF route/mask: 10.47.7.2/32

RPF type: unicast (

Doing distance-preferred lookups across tables

Multicast Multipath enabled.

RPF topology: ipv4 multicast base

要避免這種情況，請將組播源視為靜默主機，在這裡，IP定向廣播、泛洪、靜態SISF/IPDT繫結可以解決此問題。

來源註冊

PIM註冊是一種單播資料包流，它像使用任何其他單播資料包一樣使用LISP/VXLAN。需要執行若干必要檢查，以驗證FHR是否可以將組播源正確註冊到任播RP。

首先，確保已為GDA正確配置任播RP。

```
<#root>
```

```
Edge-1#
```

```
show ip pim vrf blue_vn rp 239.1.1.1
```

```
Group: 239.1.1.1, RP: 10.47.6.1, uptime 5d22h, expires never
```

確保PIM暫存器隧道已形成。

```
<#root>
```

```
Edge-1#
```

```
show ip pim vrf blue_vn tunnel
```

```
Tunnel1
```

```
Type : PIM Encap
```

```
RP :
```

```
10.47.6.1 <-- This is from "ip pim vrf blue_vn rp-address 10.47.6.1 ASM_ACL_IPV4_blue_vn_10.47.6.1"
```

```
Source :
```

```
10.47.6.4 <-- This is from "ip pim vrf blue_vn register-source Loopback4100"
```

```
State : UP
```

```
Last event : Created (1w2d)
```

確保任播RP的IP可達性

```
<#root>
```

```
Edge-1#  
show ip cef vrf blue_vn 10.47.6.1
```

```
10.47.6.1/32  
nexthop  
10.47.1.10  
LISP0.4100  
<-- RLOC of Border-1
```

```
nexthop  
10.47.1.11  
LISP0.4100  
<-- RLOC of Border-2
```

```
Edge-1#  
ping vrf blue_vn 10.47.6.1 source lo4100
```

```
Type escape sequence to abort.  
Sending 5, 100-byte ICMP Echos to 10.47.6.1, timeout is 2 seconds:  
Packet sent with a source address of 10.47.6.4  
!!!!  
Success rate is 100 percent (5/5), round-trip min/avg/max = 257/275/294 ms
```

接收方驗證

- 確保組播接收方正在傳送IGMP MR。
- 確保啟用IGMP監聽。僅L2 VN是唯一未啟用IGMP監聽的VN型別
- 確保未配置可丟棄IGMP MR的埠ACL、VLAN ACL、路由埠ACL。
- 驗證IGMP MR的版本，預設情況下，如果組播接收器是IGMPv3，則需要「ip igmp version 3」
- 確保未配置「ip option drop」

LHR PIM (*, G)驗證

- 確保LHR是接收方子網/網段的PIM DR
- 確保未配置「ip multicast group-range」
- 確保未配置可丟棄IGMP MR的埠ACL、VLAN ACL、路由埠ACL。
- 確保沒有高CPU或控制平面管制(CoPP)丟棄IGMP MR。

LHR PIM共用樹狀結構驗證

確保為組播組配置了RP

<#root>

Edge-2#

show ip mroute vrf blue_vn 239.1.1.1

IP Multicast Routing Table

Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
U - URD, I - Received Source Specific Host Report,
Z - Multicast Tunnel, z - MDT-data group sender,
Y - Joined MDT-data group, y - Sending to MDT-data group,
G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
Q - Received BGP S-A Route, q - Sent BGP S-A Route,
V - RD & Vector, v - Vector, p - PIM Joins on route,
x - VxLAN group, c - PFP-SA cache created entry,
* - determined by Assert, # - iif-starg configured on rpf intf,
e - encap-helper tunnel flag, l - LISP decap ref count contributor

Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
t - LISP transit group

Timers: Uptime/Expires

Interface state: Interface, Next-Hop or VCD, State/Mode
(* , 239.1.1.1), 6d01h/stopped,

RP 10.47.6.1

, flags: SCF

Incoming interface: LISPO.4100, RPF nbr 10.47.1.10

Outgoing interface list:

Vlan1025, Forward/Sparse-Dense, 6d01h/00:01:34, flags:

確保任播RP的RPF是正確的

<#root>

Edge-2#

show ip cef vrf blue_vn 10.47.6.1

10.47.6.1/32

nexthop 10.47.1.10 LISPO.4100

nexthop 10.47.1.11 LISPO.4100

Edge-2#

show ip rpf vrf blue_vn 10.47.6.1

RPF information for (10.47.6.1)

RPF interface: LISPO.4100

RPF neighbor: ? (10.47.1.10)

RPF route/mask: 10.47.6.1/32

RPF type: unicast ()
Doing distance-preferred lookups across tables
Multicast Multipath enabled.
RPF topology: ipv4 multicast base

MFIB轉發-源端驗證

您可以使用命令「show ip mfib vrf <VN Name> <multicast group> <unicast source> verbose」獲取有關資料包轉發的其他資訊

<#root>

Edge-1#

```
show ip mfib vrf blue_vn 239.1.1.1 10.47.7.2 verbose
```

Entry Flags: C - Directly Connected, S - Signal, IA - Inherit A flag,
ET - Data Rate Exceeds Threshold, K - Keepalive
DDE - Data Driven Event, HW - Hardware Installed
ME - MoFRR ECMP entry, MNE - MoFRR Non-ECMP entry, MP - MFIB
MoFRR Primary, RP - MRIB MoFRR Primary, P - MoFRR Primary
MS - MoFRR Entry in Sync, MC - MoFRR entry in MoFRR Client,
e - Encap helper tunnel flag.
I/O Item Flags: IC - Internal Copy, NP - Not platform switched,
NS - Negate Signalling, SP - Signal Present,
A - Accept, F - Forward, RA - MRIB Accept, RF - MRIB Forward,
MA - MFIB Accept, A2 - Accept backup,
RA2 - MRIB Accept backup, MA2 - MFIB Accept backup
Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kbits per second
Other counts: Total/RPF failed/Other drops
I/O Item Counts: HW Pkt Count/FS Pkt Count/PS Pkt Count Egress Rate in pps
VRF blue_vn
(10.47.7.2,239.1.1.1) Flags: K HW DDE
0x42 OIF-IC count: 0, OIF-A count: 1
SW Forwarding: 0/0/0/0, Other: 272/272/0
HW Forwarding: 7431223059161284608/0/0/0, Other: 0/0/0
Vlan1025 Flags: RA A MA NS
LISP0.4100,

10.47.1.13

Flags: RF F NS

<-- RLOC of Edge-2

CEF: Adjacency with MAC: 450000000004000001164770A2F010D0A2F010C000012B50000000084000000100400

Pkts: 0/0/0 Rate: 0 pps

Edge-1#

```
show adjacency lisp0.4100
```

```
Protocol Interface Address
IP LISP0.4100 10.47.1.10(23)
IP LISP0.4100 10.47.1.11(27)
IP LISP0.4100
```

```
10.47.1.13
```

```
(8)
```

```
Edge-2#
```

```
show adjacency lisp0.4100 10.47.1.13 detail
```

```
Protocol Interface Address
IP LISP0.4100
```

```
10.47.1.13
```

```
(8)
```

```
0 packets, 0 bytes
```

```
epoch 0
```

```
sourced in sev-epoch 14
```

```
Encap length 50
```

```
4500000000004000001164770A2F010D
```

```
0A2F010C000012B50000000008400000
```

```
00100400BA25CDF4AD3852540017FE73
```

```
0000
```

```
L2 destination address byte offset 0
```

```
L2 destination address byte length 0
```

```
Link-type after encap: ip
```

```
LISP
```

```
Next chain element:
```

```
IP adj out of GigabitEthernet1/0/1
```

```
, addr 10.47.1.6
```

EPC可用於驗證組播資料包的VXLAN封裝

```
<#root>
```

```
Edge-1#monitor capture 1 interface GigabitEthernet1/0/4 IN
```

```
Edge-1#monitor capture 1 interface GigabitEthernet1/0/1 OUT
```

```
Edge-1#monitor capture 1 match any
```

```
Edge-1#monitor capture 1 buffer size 10
```

```
Edge-1#monitor capture 1 limit pps 1000
```

```
Edge-1#monitor capture 1 start
```

```
Edge-1#monitor capture 1 stop
```

```
Edge-1#
```

```
show monitor capture 1 buffer brief
```

```
Starting the packet display ..... Press Ctrl + Shift + 6 to exit
```

```
1 0.000000 10.47.7.2 -> 239.1.1.1 ICMP 98 Echo (ping) request id=0x0008, seq=28213/13678,
```

t1=5 <-- Packet as it ingresses the FHR, TTL is 5

2 0.014254 10.47.7.2 -> 239.1.1.1 ICMP 148 Echo (ping) request id=0x0008, seq=28213/13678,

t1=4 <-- Packet as it leaves the FHR, TTL is 4 as is it decremented

MFIB轉發-接收方端驗證

底層網路使用單播路由將此資料包從Edge-1路由到Edge-2。

<#root>

Edge-2#

show ip mroute vrf blue_vn 239.1.1.1 10.47.7.2

IP Multicast Routing Table

Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,

L - Local, P - Pruned, R - RP-bit set, F - Register flag,

T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,

X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,

U - URD, I - Received Source Specific Host Report,

Z - Multicast Tunnel, z - MDT-data group sender,

Y - Joined MDT-data group, y - Sending to MDT-data group,

G - Received BGP C-Mroute, g - Sent BGP C-Mroute,

N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,

Q - Received BGP S-A Route, q - Sent BGP S-A Route,

V - RD & Vector, v - Vector, p - PIM Joins on route,

x - VxLAN group, c - PFP-SA cache created entry,

* - determined by Assert, # - iif-starg configured on rpf intf,

e - encap-helper tunnel flag, l - LISP decap ref count contributor

Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join

t - LISP transit group

Timers: Uptime/Expires

Interface state: Interface, Next-Hop or VCD, State/Mode

(

10.47.7.2

,

239.1.1.1

), 00:01:39/00:01:20, flags: JT

Incoming interface: LISPO.4100, RPF nbr

10.47.1.12

Outgoing interface list:

vlan1025

, Forward/Sparse-Dense, 00:01:39/00:02:45, flags:

使用show ip mfib vrf <VN Name> <group address> <unicast source> counters命令，您可以確保硬體轉發計數器增加

<#root>

Edge-2#

```
show ip mfib vrf blue_vn 239.1.1.1 counters
```

```
Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second
Other counts: Total/RPF failed/Other drops(OIF-null, rate-limit etc)
```

```
VRF blue_vn
```

```
12 routes, 7 (*,G)s, 4 (*,G/m)s
```

```
Group: 239.1.1.1
```

```
RP-tree,
```

```
SW Forwarding: 0/0/0/0, Other: 0/0/0
```

```
HW Forwarding: 0/0/2/0, Other: 0/0/0
```

```
Source: 10.47.7.2,
```

```
SW Forwarding: 0/0/0/0, Other: 2/1/1
```

```
HW Forwarding:
```

```
6118996613340856320
```

```
/0/0/0, Other: 0/0/0
```

```
Totals - Source count: 1, Packet count:
```

```
6118996613340856320
```

Edge-2#

```
show ip igmp snooping groups vlan 1025 239.1.1.1
```

```
Vlan Group      Type Version Port List
```

```
-----  
1025 239.1.1.1 igmp v2      Gi1/0/4
```

您可以使用出口組播計數器來驗證組播流量是否已離開LHR流向組播接收器。使用命令「show controllers ethernet-controller <interface> | include Multicast|Transmit」

<#root>

Edge-2#

```
show controllers ethernet-controller g1/0/4 | include Multicast|Transmit
Transmit
```

```
GigabitEthernet1/0/5
```

```
Receive
```

```
426729240 Total bytes
```

```
100803109 Total bytes
```

```

5732 Unicast frames                                949355 Unicast frames

5732 Unicast bytes                                93563018 Unicast bytes

4388433

Multicast frames                                32346 Multicast frames

4388433

Multicast bytes                                7236178 Multicast bytes
<snip>
Edge-2#

show controllers ethernet-controller g1/0/5 | include |Multicast|Transmit

```

```

Transmit

                GigabitEthernet1/0/5                Receive
426742895 Total bytes                                100813570 Total bytes
5733 Unicast frames                                949456 Unicast frames
5733 Unicast bytes                                93573016 Unicast bytes

4388569

Multicast frames                                32348 Multicast frames

4388569

Multicast bytes                                7236641 Multicast bytes

```

驗證離開LHR的組播流量的另一種方式是向組播接收方執行EPC。

```

<#root>

Edge-2#

show monitor capture 1 buffer brief

Starting the packet display ..... Press Ctrl + Shift + 6 to exit
1 0.168401 10.47.7.2 -> 239.1.1.1 ICMP 106 Echo (ping) request id=0x0008, seq=35903/16268, ttl=3
2 0.969138 10.47.7.2 -> 239.1.1.1 ICMP 106 Echo (ping) request id=0x0008, seq=35904/16524, ttl=3

```

資料層面驗證 (取決於平台)

(S , G)建立- CPU傳送路徑

為了使FHR建立(S, G)狀態，從多點傳送來源傳送的若干個多點傳送封包被傳送到CPU以由MFIB處理。組播資料包被傳送到FED隊列「CPU_Q_MCAST_DATA」

```
<#root>
```

```
Edge-1#
```

```
show platform software fed switch active punt cpuq 30
```

```
Punt CPU Q Statistics
```

```
=====
```

```
CPU Q Id : 30
```

```
CPU Q Name : CPU_Q_MCAST_DATA
```

```
Packets received from ASIC : 27124
```

```
Send to IOSd total attempts : 27124
```

```
Send to IOSd failed count : 0
```

```
RX suspend count : 0
```

```
RX unsuspend count : 0
```

```
RX unsuspend send count : 0
```

```
RX unsuspend send failed count : 0
```

```
RX consumed count : 0
```

```
RX dropped count : 0
```

```
RX non-active dropped count : 0
```

```
RX conversion failure dropped : 0
```

```
RX INTACK count : 0
```

```
RX packets dq'd after intack : 0
```

```
Active RxQ event : 0
```

```
RX spurious interrupt : 0
```

```
RX phy_idb fetch failed: 0
```

```
RX table_id fetch failed: 0
```

```
RX invalid punt cause: 0
```

```
Replenish Stats for all rxq:
```

```
-----
```

```
Number of replenish : 0
```

```
Number of replenish suspend : 0
```

```
Number of replenish un-suspend : 0
```

```
-----
```

此外，MCAST資料的CoPP隊列不能有任何丟失。使用命令「show platform hardware fed active qos queue stats internal cpu policer | include MCAST Data | QId」

```
<#root>
```

```
Edge-1#
```

```
show platform hardware fed active qos queue stats internal cpu policer | include MCAST Data | QId
```

QId	PlcIdx	Queue	Name	Enabled	Rate	Rate
-----	--------	-------	------	---------	------	------

如果流量來自直接連線的源，則如果流量來自(S, G)加入，則由「直接連線的源」的Linux共用記憶體傳送介面(LSMPI)隊列處理，即「Mcast PIM信令」

使用命令「show platform software infrastructure lsmipi punt | 包含原因 |Mcast」

```
<#root>
```

```
Edge-1#
```

```
show platform software infrastructure lsmipi punt | include Cause|Mcast
```

Cause	Total	Total	Length	Dot1q encap	Other
Mcast Directly Connected Source					
0					
27038					
0	0	0	0		
Mcast IPv4 Options data packet	0	0	0	0	0
Mcast Internal Copy	0	0	0	0	0
Mcast IGMP Unroutable	0	0	0	0	0
Mcast PIM signaling					
0	0	0	0	0	
Mcast punt to RP	0	0	0	0	0
Mcast UDLR	0	0	0	0	0

接下來，可以執行FED Punject資料包捕獲，以檢視源傳送的多播資料包和對CPU的組播，從而確認傳入介面和CPU隊列。

```
<#root>
```

```
Edge-1#
```

```
debug platform software fed switch active punt packet-capture set-filter "ip.addr==239.1.1.1"
```

```
Edge-1#
```

```
debug platform software fed switch active punt packet-capture start
```

```
Edge-1#
```

```
debug platform software fed switch active punt packet-capture stop
```

```
Punt packet capturing stopped. Captured 2 packet(s)
```

```
Edge-1#
```

```
show platform software fed switch active punt packet-capture brief
```

```
Punt packet capturing: disabled. Buffer wrapping: disabled
Total captured so far: 2 packets. Capture capacity : 4096 packets
Capture filter : "ip.addr==239.255.255.254"
----- Punt Packet Number: 1, Timestamp: 2024/08/26 15:38:27.341 -----
interface : physical:

GigabitEthernet1/0/4

[if-id: 0x0000000c], pal:

vlan1025

  [if-id: 0x0000001d]
  metadata : cause: 12 [

Mcast Directly Connected Source

], sub-cause: 0, q-no: 30, linktype: MCP_LINK_TYPE_IP [1]
ether hdr : dest mac: 0100.5e7f.ffffe, src mac: 5254.0012.521d
ether hdr : ethertype: 0x0800 (IPv4)
ipv4 hdr : dest ip:

239.1.1.1,

  src ip: 10.47.7.2
ipv4 hdr : packet len: 84, ttl: 5, protocol: 1 (ICMP)
icmp hdr : icmp type: 8, code: 0
```

Mroute硬體程式設計- IOS Mroute

(S, G)的硬體程式設計使用與任何其他程式設計路徑相同的結構：IOS到FMAN RP、FMAN FP、FED。

```
<#root>
```

```
Edge-1#
```

```
show ip mroute vrf blue_vn 239.1.1.1
```

```
IP Multicast Routing Table
```

```
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
L - Local, P - Pruned, R - RP-bit set, F - Register flag,
T - SPT-bit set, J - Join SPT, M - MSDP created entry, E - Extranet,
X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,
U - URD, I - Received Source Specific Host Report,
Z - Multicast Tunnel, z - MDT-data group sender,
Y - Joined MDT-data group, y - Sending to MDT-data group,
G - Received BGP C-Mroute, g - Sent BGP C-Mroute,
N - Received BGP Shared-Tree Prune, n - BGP C-Mroute suppressed,
Q - Received BGP S-A Route, q - Sent BGP S-A Route,
V - RD & Vector, v - Vector, p - PIM Joins on route,
x - VxLAN group, c - PFP-SA cache created entry,
* - determined by Assert, # - iif-starg configured on rpf intf,
```

e - encaps-helper tunnel flag, 1 - LISP decap ref count contributor
Outgoing interface flags: H - Hardware switched, A - Assert winner, p - PIM Join
t - LISP transit group
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(* , 239.255.255.254), 00:08:29/stopped, RP

10.47.6.1

, flags: SCF

<-- Anycast RP address

Incoming interface: LISP0.4100, RPF nbr

10.47.1.10 <-- RLOC of Border-1

Outgoing interface list:

Vlan1025, Forward/Sparse-Dense, 00:08:29/00:00:30, flags:

(

10.47.7.2

,

239.1.1.1

), 00:08:28/00:02:54, flags: FT

<-- Unicast source

Incoming interface:

Vlan1025

, RPF nbr 0.0.0.0

<-- Multicast source is in VLAN 1025

Outgoing interface list:

LISP0.4100

,

10.47.1.13

, Forward/Sparse, 00:08:23/00:03:07, flags:

<-- Forwarding to Edge-2

Mroute硬體程式設計- IOS MFIB

然後將組播路由增加到組播轉發資訊庫(MFIB), 這類似於將路由資訊庫(RIB)增加到思科快速轉發(CEF)的方式, 組播等效值是MFIB。

<#root>

Edge-1#

```
show ip mfib vrf blue_vn 239.1.1.1 10.47.7.2 verbose
```

Entry Flags: C - Directly Connected, S - Signal, IA - Inherit A flag,
ET - Data Rate Exceeds Threshold, K - Keepalive

DDE - Data Driven Event, HW - Hardware Installed

ME - MoFRR ECMP entry, MNE - MoFRR Non-ECMP entry, MP - MFIB

MoFRR Primary, RP - MRIB MoFRR Primary, P - MoFRR Primary

MS - MoFRR Entry in Sync, MC - MoFRR entry in MoFRR Client,

e - Encap helper tunnel flag.

I/O Item Flags: IC - Internal Copy, NP - Not platform switched,

NS - Negate Signalling, SP - Signal Present,

A - Accept, F - Forward, RA - MRIB Accept, RF - MRIB Forward,

MA - MFIB Accept, A2 - Accept backup,

RA2 - MRIB Accept backup, MA2 - MFIB Accept backup

Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kbits per second

Other counts: Total/RPF failed/Other drops

I/O Item Counts: HW Pkt Count/FS Pkt Count/PS Pkt Count Egress Rate in pps

VRF blue_vn

(

10.47.7.2,239.1.1.1

) Flags: K HW DDE

<-- Multicast source and GDA

0x21 OIF-IC count: 0, OIF-A count: 1

SW Forwarding: 0/0/0/0, Other: 2/2/0

HW Forwarding: 0/0/0/0, Other: 0/0/0

Vlan1025 Flags: RA A MA NS

LISP0.4100, 10.47.1.13

Flags: RF F NS

<-- RLOC of Edge-2 and the RPF interface to reach 10.47.1.13

CEF: Adjacency with MAC: 4500000000004000001164770A2F010D0A2F010C000012B5000000000840000000100400

Pkts: 0/0/0 Rate: 0 pps

Mroute硬體程式設計- RP MFIB

使用命令「show platform software ip switch active r0 mfib vrf index <VRF index> group <GDA/32>」

<#root>

Edge-1#

```
show vrf detail blue_vn | inc Id
```

VRF blue_vn (

VRF Id = 2

); default RD <not set>; default VPNID <not set>

Edge-1#

```
show platform software ip switch active r0 mfib vrf index 2 group 239.1.1.1/32
```

Route flags:

S - Signal; C - Directly connected;

IA - Inherit A Flag; L - Local;

BR - Bidir route

*,

239.1.1.1/32

--> OBJ_INTF_LIST (0x6b)

Obj id:

0x6b

, Flags: C

OM handle: 0x34803c47f0

Edge-2#

```
show platform software ip switch active r0 mfib vrf index 2 group address 239.1.1.1 10.47.7.2
```

Route flags:

S - Signal; C - Directly connected;

IA - Inherit A Flag; L - Local;

BR - Bidir route

239.1.1.1, 10.47.7.2/64

--> OBJ_INTF_LIST (0x21)

Obj id:

0x21

, Flags: unknown

OM handle: 0x34803c4088

Mroute硬體程式設計- FP MFIB

相同mroutes的FMAN RP條目包括非同步對象管理器(AOM) ID，此AOM ID用於驗證進一步的程式設計。

使用命令「show platform software ip switch active f0 mfib vrf index <VRF Index> group <GDA/32>」

<#root>

Edge-1#

```
show platform software ip switch active f0 mfib vrf index 2 group 239.1.1.1/32
```

```
Route flags:
S - Signal; C - Directly connected;
IA - Inherit A Flag; L - Local;
BR - Bidir route
*,
239.1.1.1/32
--> OBJ_INTF_LIST (0x6b)
Obj id:
0x6b
, Flags: C
aom id:
29154
, HW handle: (nil) (created)
Edge-1#
show platform software ip switch active f0 mfib vrf index 2 group address 239.1.1.1 10.47.7.2
```

```
Route flags:
S - Signal; C - Directly connected;
IA - Inherit A Flag; L - Local;
BR - Bidir route
239.1.1.1., 10.47.7.2/64
--> OBJ_INTF_LIST (0x21)
Obj id:
0x21
, Flags: unknown
aom id:
36933
, HW handle: (nil) (created)
```

Mroute硬體程式設計- Mroute對象

使用AOM ID，使用object-manager指令檢查(*, G)和(S, G)的物件和父物件。您可以使用命令「show platform software object-manager switch active f0 object <AOM ID>」或「show platform software object-manager switch active f0 object <AOM ID> parents」

每個mroute有兩個父物件。其中一個物件參照ipv4_mcast表格，另一個物件是mlist，用於後續的指令。

```
<#root>
```

```
Edge-1#
```

```
show platform software object-manager switch active f0 object 29154
```

Object identifier: 29154

Description:

PREFIX 0.0.0.0 , 239.1.1.1/32

(Table id 2)

Obj type id: 72

Obj type:

mroute-pfx

Status:

Done

, Epoch: 0, Client data: 0xa3e23c48

Edge-1#

show platform software object-manager switch active f0 object 29154 parents

Object identifier: 26509

Description:

ipv4_mcast table 2 (blue_vn

), vrf id 2

Status: Done

Object identifier: 29153

Description:

mlist 107

Status:

Done

Edge-1#

show platform software object-manager switch active f0 object 36933

Object identifier: 36933

Description:

PREFIX 10.47.7.2 , 239.1.1.164

(Table id 2)

Obj type id: 72

Obj type:

mroute-pfx

Status:

Done

, Epoch: 0, Client data: 0xa413c928

Edge-1#

```
show platform software object-manager switch active f0 object 36933 parents
```

```
Object identifier: 26509  
Description: ipv4_mcast table 2 (blue_vn), vrf id 2  
Status:
```

```
Done
```

```
Object identifier: 47695  
Description:
```

```
mlist 33
```

```
Status:
```

```
Done
```

Mroute硬體程式設計- Mlist對象

MLIST對象是傳入介面和傳出介面清單的組合。您可以使用命令「show platform software mlist switch active f0 index <index>」

```
<#root>
```

```
This is for (*,G)
```

```
Edge-1#
```

```
show platform software mlist switch active f0 index 107
```

```
Multicast List entries
```

```
OCE Flags:
```

```
NS - Negate Signalling; IC - Internal copy;
```

```
A - Accept; F - Forward;
```

```
OCE      Type                OCE Flags  Interface
```

```
-----  
0xf8000171  OBJ_ADJACENCY
```

```
  A
```

```
    LISP0.4100
```

```
<-- A Flag indicates an Incoming interface for (*,G)
```

```
0xf80001d1  OBJ_ADJACENCY      NS,
```

```
  F
```

```
    Vlan1025
```

```
<-- F Flag indicates an Outgoing interface for (*,G)
```

This is for (S,G)

Edge-1#

```
show platform software mlist switch active f0 index 33
```

Multicast List entries

OCE Flags:

NS - Negate Signalling; IC - Internal copy;

A - Accept; F - Forward;

OCE	Type	OCE Flags	Interface
-----	------	-----------	-----------

0x5c	OBJ_ADJACENCY	NS,	
------	---------------	-----	--

F

LISP0.4100

<-- F Flag indicates an Outgoing interface(s), for (S,G)

0xf80001d1 OBJ_ADJACENCY

A

Vlan1025

<-- A Flag indicates an Incoming interface, for (S,G)

Mroute硬體程式設計- FED Mroute

要驗證FED程式設計，請使用命令「show platform software fed switch active ip mfib vrf <VN Name> <GDA> <unicast source>」

<#root>

Edge-1#

```
show platform software fed switch active ip mfib vrf blue_vn 239.1.1.1 10.47.7.2
```

Multicast (S,G) Information

VRF : 2

Source Address : 10.47.7.2

HTM Handler : 0x7f45d98c7728

SI Handler : 0x7f45d9a44a28

DI Handler : 0x7f45d9bcb2d8

REP RI handler : 0x7f45d97e7188

Flags :

Packet count : 0

State : 4

RPF :

Vlan1025 A

OIF :

Vlan1025 A

LISPO.4100 F NS
(Adj: 0x5c)

重寫索引提供有關組播流量封裝的資訊，這是頭端複製所利用的。您可以使用命令「show platform hardware fed switch active fwd-asic abstraction print-resource-handle <REP RI Handle> 1」

<#root>

Edge-1#

show platform hardware fed switch active fwd-asic abstraction print-resource-handle 0x7f45d97e718

Handle:0x7f45d97e7188 Res-Type:ASIC_RSC_RI_REP Res-Switch-Num:255 Asic-Num:255 Feature-ID:AL_FID_
priv_ri/priv_si Handle: (nil)Hardware Indices/Handles: index0:0x19 mtu_index/13u_ri_index0:0x0 in
Cookie length: 56
00 00 00 00 00 00 00 00 02 00 00 00 03 07 2f 0a fe ff ff ef 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Detailed Resource Information (ASIC_INSTANCE# 0)

Replication list RI handle = 7f45d97e7188

~~~~~  
ASIC [0] Replication Expansion Handle [0x7f45d9b9c048]

Replication list :

Number of RIs = 6

Start RI = 25

Common rewrite = No

Replication REP\_RI 0x19 [elements = 1]

[0] ri\_list[0]=4 RI\_MCAST\_BRIDGE\_V6 port=88 ri\_ref\_count:1 dirty=0

RIL first:4 last:4 start:4 ril\_total:4 ref\_count:0

RI list this:4 num\_pairs:4 free:3 next:0 prev:0 ---->

uri1:

50

ri\_ref\_count\_1:1 uri0:

26

ri\_ref\_count\_0:1 ptr\_type:0 last:1 dirty:1

uri1:

49151

ri\_ref\_count\_1:0 uri0:49151 ri\_ref\_count\_0:1 ptr\_type:1 last:1 dirty:1

uri1:49151 ri\_ref\_count\_1:0 uri0:49151 ri\_ref\_count\_0:0 ptr\_type:1 last:1 dirty:0

uri1:49151 ri\_ref\_count\_1:0 uri0:49151 ri\_ref\_count\_0:0 ptr\_type:1 last:1 dirty:0

<snip>

然後，使用URI值驗證重寫索引範圍。使用命令「show platform hardware fed switch active fwd-asic resource asic all rewrite-index range <URI> <URI>」

---



---

<#root>

Edge-1#

```
show platform hardware fed switch active fwd-asic resource asic all rewrite-index range 50 50
```

ASIC#:0

RI:50

Rewrite\_type:AL\_RRM\_REWRITE\_IPV4\_VXLAN\_INNER\_IPV4\_ENCAP(110) Mapped\_rii:LVX\_L3\_ENCAP\_L2\_PAYLOAD

Dst Mac: MAC Addr: ba:25:cd:f4:ad:38,

Src IP: 10.47.1.12 <-- RLOC of Edge-1

Dst IP: 10.47.1.13 <--

RLOC of Edge-2

IPv4 TTL: 0

LISP INSTANCEID: 0

L3IF LE Index: 49

ASIC#:1

RI:50

Rewrite\_type:AL\_RRM\_REWRITE\_IPV4\_VXLAN\_INNER\_IPV4\_ENCAP(110) Mapped\_rii:LVX\_L3\_ENCAP\_L2\_PAYLOAD

Dst Mac: MAC Addr: ba:25:cd:f4:ad:38,

Src IP: 10.47.1.12 <-- RLOC of Edge-1

Dst IP: 10.47.1.13 <-- RLOC of Edge-2

IPv4 TTL: 0

LISP INSTANCEID: 0

L3IF LE Index: 49

接著，取得上一個指令的RI以進行進一步驗證。使用命令「show platform software fed switch active ip mfib vrf <VN Name> <GDA> <source>」

<#root>

Edge-1#

```
show platform software fed switch active ip mfib vrf blue_vn 239.1.1.1 10.47.7.2
```

Multicast (S,G) Information

VRF : 2

Source Address : 10.47.7.2

HTM Handler : 0x7f45d98c7728

SI Handler : 0x7f45d9a44a28

DI Handler : 0x7f45d9bcb2d8

---

---

```
REP RI handler : 0x7f45d97e7188
Flags :
Packet count : 0
State : 4
RPF :
Vlan1025 A
OIF :
Vlan1025 A
LISP0.4100 F NS

(Adj: 0x5c )
```

使用命令「show platform software fed switch active ip adj | include <destination RLOC>」

<#root>

Edge-1#

```
show platform software fed switch active ip adj 10.47.1.12
```

```
IPV4 Adj entries
```

| dest       | if_name    | dst_mac        | si_hdl         | ri_hdl         | pd_flags | adj_id | Last-modified |
|------------|------------|----------------|----------------|----------------|----------|--------|---------------|
| 10.47.1.12 | LISP0.4100 | 4500.0000.0000 | 0x7f45d9a4a5e8 | 0x7f45d9a4a798 | 0x60     |        |               |

```
0x5c
```

```
2024/08/21 16:18:58.948
```

```
<-- 0x5c matches the Adj in the previous command
```

在LHR上，您可以驗證目標索引以檢視多播資料包轉發到的位置，即多播接收方。您可以使用命令「show platform software fed switch active ip mfib vrf <VN Name> <GDA> <source>」

<#root>

Edge-2#

```
show platform software fed switch active ip mfib vrf blue_vn 239.1.1.1 10.47.7.2
```

```
Multicast (S,G) Information
```

```
VRF : 2
```

```
Source Address : 10.47.7.2
```

```
HTM Handler : 0x7f0efdad33a8
```

```
SI Handler : 0x7f0efdad2648
```

```
DI Handler : 0x7f0efdad7668
```

```
REP RI handler : 0x7f0efdad4858
```

```
Flags :
```

```
Packet count : 0
```

---

```

State : 4
RPF :
LISPO.4100 A
OIF :
Vlan1025 F NS
LISPO.4100 A
(Adj: 0xf8000171 )

```

使用DI處理程式並在命令「show platform hardware fed switch active fwd-asic abstraction print-resource-handle <DI handle> 1」中使用

```
<#root>
```

```
Edge-2#
```

```
show platform hardware fed switch active fwd-asic abstraction print-resource-handle 0x7f0efd766
```

```

Handle:0x7f0efd7668 Res-Type:ASIC_RSC_DI Res-Switch-Num:255 Asic-Num:255 Feature-ID:AL_FID_L3_M
priv_ri/priv_si Handle: (nil)Hardware Indices/Handles: index0:0x527c mtu_index/13u_ri_index0:0x0
Cookie length: 56
00 00 00 00 00 00 00 00 02 00 00 00 03 07 2f 0a fe ff ff ef 00 00 00 00 00 00 00 00 00 00 00 00 00 00
Detailed Resource Information (ASIC_INSTANCE# 0)
-----

```

```
Destination index = 0x527c
```

```
pmap = 0x00000000 0x00000010
```

```
pmap_intf : [GigabitEthernet1/0/4]
```

```

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
Detailed Resource Information (ASIC_INSTANCE# 1)
-----

```

```

Destination index = 0x527c
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

=====

---

## 關於此翻譯

思科已使用電腦和人工技術翻譯本文件，讓全世界的使用者能夠以自己的語言理解支援內容。請注意，即使是最佳機器翻譯，也不如專業譯者翻譯的內容準確。Cisco Systems, Inc. 對這些翻譯的準確度概不負責，並建議一律查看原始英文文件（提供連結）。