SDA园区交换矩阵环境中的任意源组播(ASM)概述

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简介

本文档介绍在软件定义访问(SD-Access)环境中使用单个交汇点(RP)的任何源组播(ASM)的概述。

先决条件

要求

建议您了解定位器ID分离协议(LISP)和组播。

使用的组件

本文档不限于特定的软件和硬件版本。

本文档中的信息在特定实验室环境设备上创建。如果您的网络处于活动状态，请确保您了解任何命令的潜在影响。GUI

用于本文的设备

数字网络架构控制器(DNAC) — 版本1.2.1

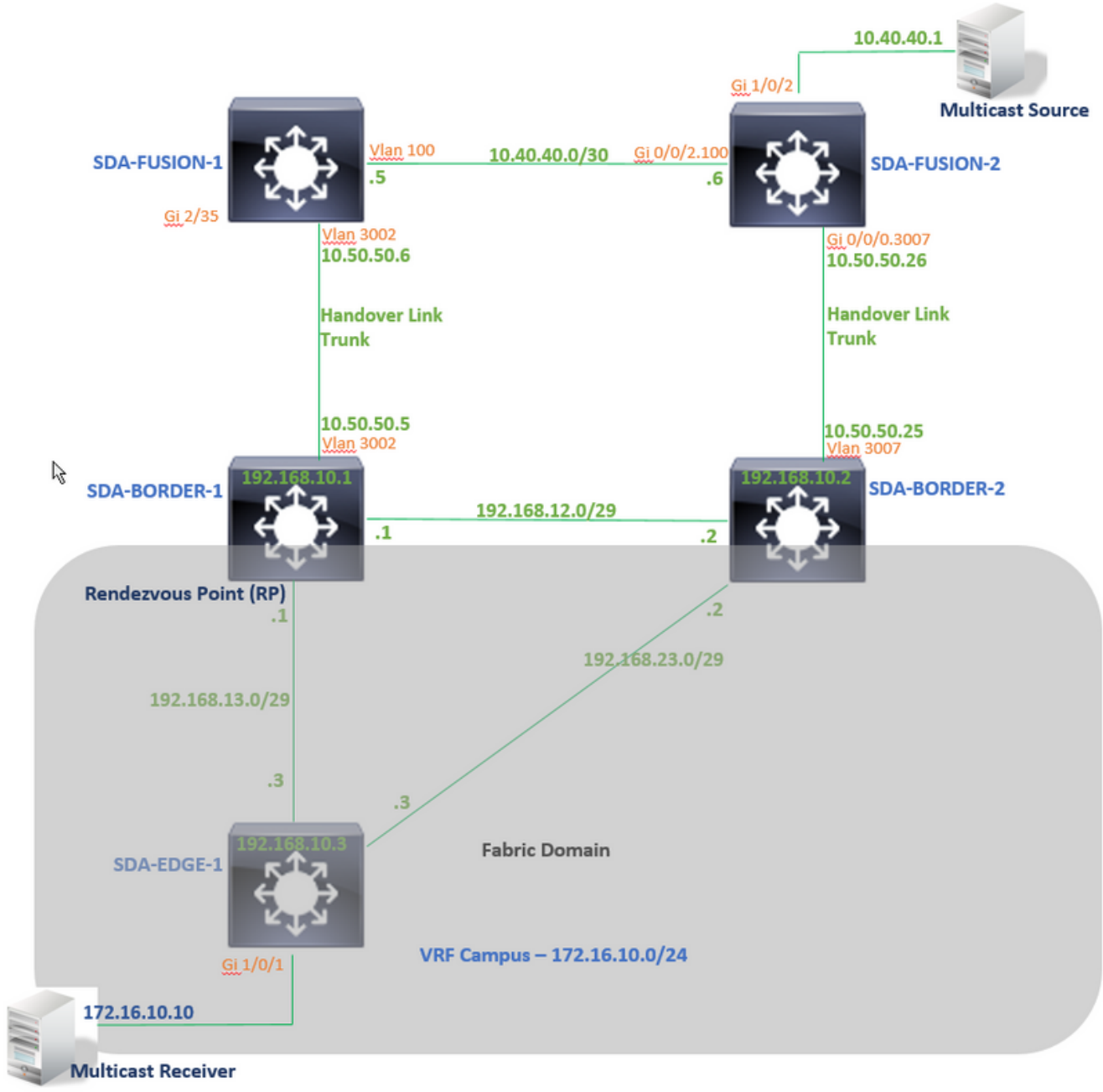
边缘和边界 — Cat3k Cisco交换机

Fusion — 支持VRF（虚拟路由转发）泄漏的思科路由器

配置

网络图

本文使用的拓扑包括两个均被配置为外部边界的边界路由器，以及两个连接到每个边界路由器的融合路由器。Border-1配置为RP，组播源连接到Fusion-2，组播接收器连接到Edge-1。



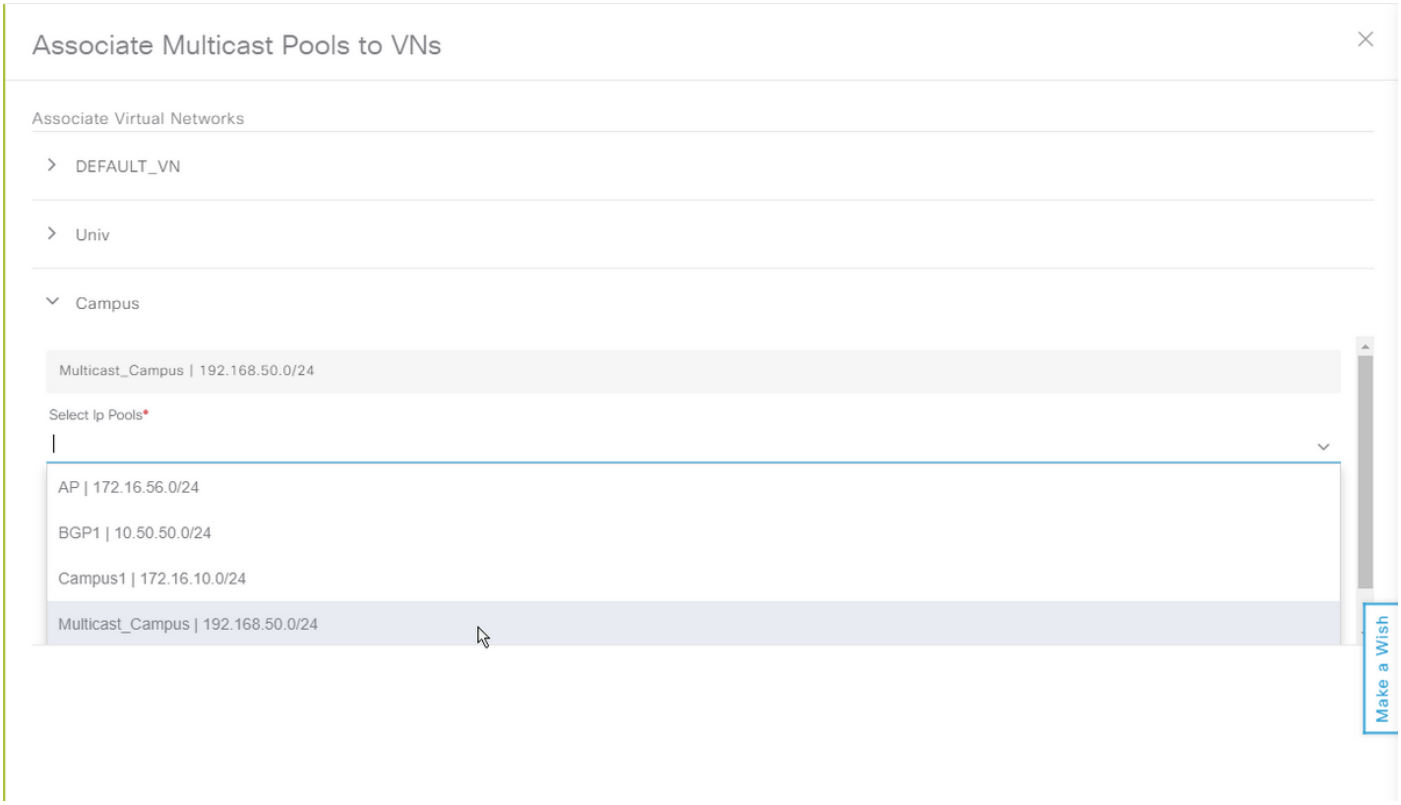
配置

本文不介绍在软件定义访问(SDA)环境中配置交换矩阵的步骤，而是从为特定VN配置交换矩阵域中的组播的步骤说明开始。

步骤1：从DNAC配置交换矩阵设备上的组播

在DNAC图形用户界面(GUI)中的“调配”(Provision)->“交换矩阵工作流”(Fabric Workflow)下。组播通过SDA-BORDER-1设备上的“启用交汇点”选项进行配置。

然后，在指定VN下选择要用于组播配置的Internet协议(IP)池。在本例中为“园区”。



步骤2：验证设备上推送的配置

本部分介绍交换矩阵设备上的组播配置的验证。

SDA-BORDER-1

```
interface Loopback4099                          <<<<<<<<<<<< Loopback Interface is created and assign
 vrf forwarding Campus
 ip address 192.168.50.1 255.255.255.255
 ip pim sparse-mode                             <<<<<<<<<<< PIM is enabled on Interface
end


interface LISP0.4099                            <<<<<<<<<<< PIM is enabled on LISP interface
 ip pim sparse-mode
end

SDA-Border1#sh run | in pim|multicast
```

```
ip multicast-routing                              <<<<<<<<<<< Multicast Routing is enabled for Global
ip multicast-routing vrf Campus                   <<<<<<<<<<< Multicast Routing is enabled for Campus VN

ip pim ssm default                                <<<<<<<<<<< PIM SSM mode is enabled for Global for defa
ip pim vrf Campus rp-address 192.168.50.1         <<<<<<<<<<< BORDER-1 Loopback4099 is configued as RP
ip pim vrf Campus register-source Loopback4099
ip pim vrf Campus ssm default                     <<<<<<<<<<< PIM SSM mode is enabled for vrf Campus for

SDA-Border1#sh run | s address-family ipv4 vrf Campus
 address-family ipv4 vrf Campus
.....
 network 192.168.50.1 mask 255.255.255.255       <<<<<<<<<<< RP Address is injected into BGP Table
 aggregate-address 192.168.50.0 255.255.255.0 summary-only <<<<<<<<<<< Aggregate for Multicast Pool is
.....
```

SDA-BORDER-2

```
interface Loopback4099
 vrf forwarding Campus
 ip address 192.168.50.3 255.255.255.255
 ip pim sparse-mode
end

interface LISP0.4099
 ip pim sparse-mode
end


SDA-Border2#sh run | in pim|multicast

ip multicast-routing
ip multicast-routing vrf Campus

ip pim ssm default
ip pim vrf Campus rp-address 192.168.50.1       <<<<<<<<<<< BORDER-1 Loopback4099 is configued as RP
ip pim vrf Campus register-source Loopback4099
ip pim vrf Campus ssm default


SDA-Border2#sh run | s address-family ipv4 vrf Campus
 address-family ipv4 vrf Campus
.....
 network 192.168.50.1 mask 255.255.255.255
 aggregate-address 192.168.50.0 255.255.255.0 summary-only
.....
```

SDA-EDGE-1

```
interface Vlan1021
```

```
 description Configured from apic-em
 mac-address 0000.0c9f.f45c
 vrf forwarding Campus
 ip address 172.16.10.1 255.255.255.0
 ip helper-address 10.10.10.100
 no ip redirects
 ip local-proxy-arp
 ip pim sparse-mode                              <<<<<<<<<<< PIM is enabled on all SVI-s under Campus VN
 ip route-cache same-interface
 ip igmp version 3
 no lisp mobility liveness test
 lisp mobility 172_16_10_0-Campus
end


interface Loopback4099
 vrf forwarding Campus
 ip address 192.168.50.2 255.255.255.255
 ip pim sparse-mode
end


interface LISP0.4099
 ip pim sparse-mode
end


SDA-Edge1#sh run | in pim|multicast

ip multicast-routing
ip multicast-routing vrf Campus

ip pim ssm default
ip pim vrf Campus rp-address 192.168.50.1       <<<<<<<<<< BORDER-1 Loopback4099 is configued as RP
ip pim vrf Campus register-source Loopback4099
ip pim vrf Campus ssm default
```

步骤3: 在切换链路上手动配置PIM

在本示例中，组播源在交换矩阵外部连接到Fusion-2。 对于要传输的组播流，请确保存在从RP到源和接收器到源的PIM路径（路径可能不同！）。

SDA-BORDER-1和SDA-FUSION-1之间的PIM对等

<#root>

SDA-BORDER-1

```
------------------------------------------------
interface Vlan3002                              <<<<<<<< Enable PIM on Handover link in Campus VN
 description vrf interface to External router
 vrf forwarding Campus
 ip address 10.50.50.5 255.255.255.252
 no ip redirects
 ip pim sparse-mode
```

```
 ip route-cache same-interface
end
```

SDA-FUSION-1

```
-------------------------------------------------
ip multicast-routing
```

ip multicast-routing vrf Campus

```
               <<<<<<<<< Enable Multicast Routing in vrf Campus
```

ip pim vrf Campus rp-address 192.168.50.1

```
     <<<<<<<<< Configure BORDER-1 Loopback4099 as RP

interface Vlan3002                              <<<<<<<<< Enable PIM on Fusion Interface towards Border
vrf forwarding Campus
ip address 10.50.50.6 255.255.255.252
```

ip pim sparse-mode

```
end
```

SDA-BORDER-2和SDA-FUSION-2之间的PIM对等

<#root>

SDA-BORDER-2

```
-------------------------------------------------
interface Vlan3007
 description vrf interface to External router
 vrf forwarding Campus
 ip address 10.50.50.25 255.255.255.252
 no ip redirects
```

ip pim sparse-mode

```
 ip route-cache same-interface
end
```

SDA-FUSION-2

```
-------------------------------------------------
ip multicast-routing distributed
```

ip multicast-routing vrf Campus distributed

ip pim vrf Campus rp-address 192.168.50.1

```
interface GigabitEthernet0/0/0.3007
 encapsulation dot1Q 3007
```

```
 vrf forwarding Campus
 ip address 10.50.50.26 255.255.255.252

 ip pim sparse-mode

 no cdp enable
end
```

SDA-FUSION-1和SDA-FUSION-2之间的PIM对等

<#root>

SDA-FUSION-1

```
------------------------------------------------
interface Vlan100
 description Muticast_Campus
 vrf forwarding Campus
 ip address 10.40.40.5 255.255.255.252


ip pim sparse-mode

end
```

SDA-FUSION-2

```
------------------------------------------------
interface GigabitEthernet0/0/2.100
 encapsulation dot1Q 100
 vrf forwarding Campus
 ip address 10.40.40.6 255.255.255.252

 ip pim sparse-mode

end
```

在连接到源的接口上启用PIM

<#root>

SDA-FUSION-2

```
------------------------------------------------

interface GigabitEthernet1/0/2
 vrf forwarding Campus
 ip address 10.40.40.2 255.255.255.252

 ip pim sparse-mode

 load-interval 30
 negotiation auto
end
```

控制平面进程

组播接收端会发送互联网组管理协议(IGMP)加入到最后一跳路由器(LHR)以接收特定组的流，组播源（服务器）开始将组播流发送到第一跳路由器(FHR)。 在本例中，FHR是SDA-FUSION-2,LHR是SDA-EDGE-1，控制平面过程在接收方首先请求流，源随后开始对该组进行流式处理的场景中进行了说明。

LHR上的IGMP加入

组播接收器将组239.1.1.1的IGMP报告（加入）发送到LHR。接收器连接到SDA-EDGE-1上的Gi1/0/1(SVI 1021)。

<#root>

SDA-Edge1#

debug ip igmp vrf Campus 239.1.1.1

IGMP debugging is on

*Aug 14

23:53:06.445

: IGMP(4):

Received v2 Report on Vlan1021 from 172.16.10.10 for 239.1.1.1

*Aug 14 23:53:06.445: IGMP(4): Received Group record for group 239.1.1.1, mode 2 from 172.16.10.10 for
Aug 14 23:53:06.445: IGMP(4): MRT Add/Update Vlan1021 for (,239.1.1.1) by 0

*Aug 14

23:54:07.445

: IGMP(4):

Received v2 Report on Vlan1021 from 172.16.10.10 for 239.1.1.1

<<<<<<< one minute apart

SDA-Edge1#

show ip igmp vrf Campus group

IGMP Connected Group Membership
Group Address Interface Uptime Expires Last Reporter
239.1.1.1 Vlan1021 00:49:10 00:02:45 172.16.10.10 <<<<<<< Receiver is prese
SDA-Edge1#

新的组播路由监视服务确定指向RP（用于共享树）和指向源(用于最短路径树(SPT))的反向路径转发(RPF)信息。 对于LISP可访问地址，下一跳邻居由上游站点的远程路由定位器(RLOC)地址表示。

<#root>

SDA-Edge1#

show ip pim vrf Campus rp mapping 239.1.1.1

PIM Group-to-RP Mappings

Group(s): 224.0.0.0/4, Static
    RP: 192.168.50.1 (?)   <<<<<<<<<<< RP is 192.168.50.1
SDA-Edge1#
SDA-Edge1#

SDA-Edge1#

show lisp eid-table vrf Campus ipv4 map 192.168.50.1/32

       <<<<<<<<< check Reachability towards the RP address
LISP IPv4 Mapping Cache for EID-table vrf Campus (IID 4099), 4 entries

192.168.50.1/32, uptime: 2w5d, expires: 23:10:58, via map-reply, complete
  Sources: map-reply
  State: complete, last modified: 2w5d, map-source: 192.168.10.1
  Active, Packets out: 171704(3435172 bytes) (~ 00:00:43 ago)
  Locator   Uptime   State   Pri/Wgt   Encap-IID

192.168.10.1

  2w5d   up   10/10   -   <<<<<<<<<<< RLOC is 192.168.10.1
    Last up-down state change: 2w5d, state change count: 1
    Last route reachability change: 2w5d, state change count: 1
    Last priority / weight change: never/never
    RLOC-probing loc-status algorithm:
      Last RLOC-probe sent: 00:49:02 (rtt 3ms)

SDA-Edge1#

show ip cef vrf Campus 192.168.50.1/32

192.168.50.1/32
  nexthop 192.168.10.1

LISP0.4099

                                  <<<<<<<<<<< RP is reachable via LISP interface

SDA-Edge1#

show ip mroute vrf Campus 239.1.1.1

IP Multicast Routing Table

(*, 239.1.1.1), 00:50:06/00:02:57, RP 192.168.50.1, flags: SJC   <<<<<<<<<<< (*,G) entry is created

Incoming interface: LISP0.4099, RPF nbr 192.168.10.1

             <<<<<<<<<<< Incoming interface is set as LISP interface

```
  Outgoing interface list:
    Vlan1021, Forward/Sparse, 00:50:06/00:02:57                    <<<<<<<<<<< Outgoing Interface is se
```

接下来，LHR向RP发送PIM(*,G)加入（间隔一分钟） — 如果LHR是该网段的DR。

<#root>

```
SDA-Edge1#debug ip pim vrf Campus 239.1.1.1
PIM debugging is on

*Aug 15 00:03:44.592: PIM(4): Building Periodic (*,G) Join / (S,G,RP-bit) Prune message for 239.1.1.1
*Aug 15 00:03:44.593: PIM(4):

Insert (*,239.1.1.1) join in nbr 192.168.10.1's queue


*Aug 15 00:03:44.593: PIM(4): Building Join/Prune packet for nbr 192.168.10.1
*Aug 15 00:03:44.594: PIM(4):  Adding v2 (192.168.50.1/32, 239.1.1.1), WC-bit, RPT-bit, S-bit Join
*Aug 15 00:03:44.594: PIM(4): Adding LISP Unicast transport attribute in join/prune to 192.168.10.1 (LI
*Aug 15

00:03:44.594

: PIM(4):

Send v2 join/prune to 192.168.10.1 (LISP0.4099)

         <<<<<<< PIM (*,G) Join is sent towards the RP

*Aug 15 00:04:42.892: PIM(4): Building Periodic (*,G) Join / (S,G,RP-bit) Prune message for 239.1.1.1
*Aug 15 00:04:42.892: PIM(4): Insert (*,239.1.1.1) join in nbr 192.168.10.1's queue
*Aug 15 00:04:42.892: PIM(4): Building Join/Prune packet for nbr 192.168.10.1
*Aug 15 00:04:42.892: PIM(4):  Adding v2 (192.168.50.1/32, 239.1.1.1), WC-bit, RPT-bit, S-bit Join
*Aug 15 00:04:42.892: PIM(4): Adding LISP Unicast transport attribute in join/prune to 192.168.10.1 (LI
*Aug 15

00:04:42.892

: PIM(4):

Send v2 join/prune to 192.168.10.1 (LISP0.4099)

SDA-Edge1#
```

邻居创建

一旦获得指向LISP接口的RPF信息，PIM必须明确创建对应RLOC的邻居结构。这是必要的，因为上游隧道路由器(xTR)不发送hello消息。当加入/修剪之间的标准间隔时间2倍后没有向邻居发送加入/修剪消息时，新的邻居块将过期。

在本例中，SDA-EDGE-1使用上游/RPF RLOC地址创建PIM邻居。

<#root>

SDA-Edge1#

show ip pim vrf Campus neighbor

PIM Neighbor Table

Neighbor Address | Interface | Uptime/Expires | Ver | DR Prio/Mode

192.168.10.1

LISP0.4099

1w5d/00:01:27 v2 0 / <<<<<<< RLOC address used for the neighbor

SDA-Edge1#debug ip pim vrf Campus timers <- chatty!
PIM-TIMERS debugging is on

Aug 15 00:08:37.992: PIM(4): Building Periodic (,G) Join / (S,G,RP-bit) Prune message for 239.1.1.1
*Aug 15 00:08:37.993: PIM(4)

Twheel Start: Neighbor Timer for Nbr: 192.168.10.1. idb LISP0.4099

. delay: 120000 ms. jitter 0.

...

在RP上收到PIM加入

PIM加入在RP(SDA-BORDER-1)上通过LISP接口从LHR(SDA-EDGE-1)接收

<#root>

SDA-Border1#

debug ip pim vrf Campus 239.1.1.1

PIM debugging is on

*Aug 18 01:47:14.812: PIM(4): J/P Transport Attribute, Transport Type: Unicast
Aug 18 01:47:14.813: PIM(4): Join-list: (, 239.1.1.1), RPT-bit set, WC-bit set, S-bit set
Aug 18 01:47:14.813: PIM(4): Check RP 192.168.50.1 into the (, 239.1.1.1) entry
Aug 18 01:47:14.813: PIM(4): Adding register decap tunnel (Tunnel1) as accepting interface of (, 239.
*Aug 18 01:47:14.813: PIM(4):

Add LISP0.4099/192.168.10.3 to (*, 239.1.1.1), Forward state, by PIM *G Join

<<<<<< (*,G) join received from RLOC of LHR over LISP Interface

*Aug 18 01:48:14.267: PIM(4): J/P Transport Attribute, Transport Type: Unicast
Aug 18 01:48:14.267: PIM(4): Join-list: (, 239.1.1.1), RPT-bit set, WC-bit set, S-bit set
*Aug 18 01:48:14.267: PIM(4):

Update LISP0.4099/192.168.10.3 to (*, 239.1.1.1), Forward state, by PIM *G Join

```
SDA-Border1#
show ip mroute vrf Campus 239.1.1.1
IP Multicast Routing Table

(*, 239.1.1.1), 00:01:38/00:02:51, RP 192.168.50.1, flags: S
  Incoming interface:
 Null, RPF nbr 0.0.0.0
                                <<<<<<<<<<<< RP is myself hence RPF Neighbor is Null
  Outgoing interface list:

LISP0.4099, 192.168.10.3
, Forward/Sparse, 00:01:38/00:02:51          <<<<<<<<<<<< Outgoing Interface is set towards LHR RLOC
```

RP(Border1)不会通过LISP接口发送任何连接，因此不会通过LISP接口在RP上创建PIM邻居。

在本例中，唯一的PIM邻居通过非LISP接口指向Fusion-1，并且是接收到的定期PIM Hello数据包的结果。

<#root>

```
SDA-Border1#
debug ip pim vrf Campus hello

PIM-HELLO debugging is on
SDA-Border1#
*Aug 24
00:02:19
.944: PIM(4):
Received v2 hello on Vlan3002 from 10.50.50.6

*Aug 24 00:02:19.944: PIM(4): Neighbor (10.50.50.6) Hello GENID = 1315387214
SDA-Border1#
*Aug 24
00:02:49
.396: PIM(4):
Received v2 hello on Vlan3002 from 10.50.50.6

*Aug 24 00:02:49.397: PIM(4): Neighbor (10.50.50.6) Hello GENID = 1315387214

SDA-Border1#
```

show ip pim vrf Campus neigh

```
PIM Neighbor Table

Neighbor          Interface                Uptime/Expires    Ver   DR
Address                                                            Prio/Mode
10.50.50.6        Vlan3002
                 2w0d/00:01:31     v2    1 / DR S P G
```

Fusion路由器上的PIM邻居

Fusion路由器上的PIM邻居位于非LISP接口上，因此也基于收到的定期PIM Hello-s创建。

<#root>

SDA-FUSION-1

```
SDA-Fusion1#
```

show ip pim vrf Campus neighbor

```
PIM Neighbor Table

Neighbor          Interface                Uptime/Expires    Ver   DR
Address                                                            Prio/Mode
10.40.40.6        Vlan100                  5d00h/00:01:41    v2    1 / S P G
10.50.50.5        Vlan3002                 2w4d/00:01:44     v2    1 / S P G
```

SDA-FUSION-2

```
SDA-Fusion2#
```

show ip pim vrf Campus neighbor

```
PIM Neighbor Table

Neighbor          Interface                Uptime/Expires    Ver   DR
Address                                                            Prio/Mode
10.50.50.25       Gi0/0/0.3007             2w5d/00:01:36     v2    1 / S P G
10.40.40.5        GigabitEthernet0/0/2.100 5d00h/00:01:23    v2    100/ DR S P G
```

从FHR在RP上注册PIM

当源开始为组发送流量时，FHR(SDA-FUSION-2)一旦收到来自源的第一个组播数据包，即向RP注册(S，G)，并且如果FHR是该网段上的DR。

<#root>

```
SDA-Fusion2#

show ip pim vrf Campus rp mapping 239.1.1.1

PIM Group-to-RP Mappings

Group(s): 224.0.0.0/4, Static


 RP: 192.168.50.1

 (?)                              <<<<<<<< RP for the Group

SDA-Fusion2#

show ip cef vrf Campus 192.168.50.1

192.168.50.1/32
  nexthop 10.40.40.5 GigabitEthernet0/0/2.100         <<<<<<<< Next-hop Interface towards RP


SDA-Fusion2#

debug ip mrouting vrf Campus

IP multicast routing debugging is on
SDA-Fusion2#

debug ip pim vrf Campus

PIM debugging is on

*Aug 22 21:59:42.601: PIM(2): Check RP 192.168.50.1 into the (*, 239.1.1.1) entry
*Aug 22 21:59:42.601: MRT(2):

(*,239.1.1.1), RPF change from  /0.0.0.0 to GigabitEthernet0/0/2.100/10.40.40.5

         <<<<<<<< RPF Interface is determined
*Aug 22 21:59:42.601: PIM(2): Building Triggered (*,G) Join / (S,G,RP-bit) Prune message for 239.1.1.1
*Aug 22 21:59:42.601: MRT(2): Create (*,239.1.1.1), RPF (GigabitEthernet0/0/2.100, 10.40.40.5, 1/0)
*Aug 22 21:59:42.602: MRT(2): (10.40.40.1,239.1.1.1), RPF install from  /0.0.0.0 to GigabitEthernet1/0/
*Aug 22 21:59:42.602: PIM(2):

Adding register encap tunnel (Tunnel0) as forwarding interface of (10.40.40.1, 239.1.1.1).

 <<<<< Register Tunnel is created
*Aug 22 21:59:42.602: MRT(2): Set the F-flag for (*, 239.1.1.1)
*Aug 22 21:59:42.602: MRT(2):

Set the F-flag for (10.40.40.1, 239.1.1.1)

                                            <<<<<<< Register(F) flag is set
*Aug 22 21:59:42.602: MRT(2):

Create (10.40.40.1,239.1.1.1), RPF (GigabitEthernet1/0/2, 0.0.0.0, 0/0)

                 <<<<<<< (S,G) is created
*Aug 22 21:59:42.602: MRT(2):

Set the T-flag for (10.40.40.1, 239.1.1.1)

                                            <<<<<<< SPT (T) flag is set
*Aug 22 21:59:42.629: PIM(2): Received v2 Join/Prune on GigabitEthernet0/0/2.100 from 10.40.40.5, to us
*Aug 22 21:59:42.629: PIM(2):

Join-list: (10.40.40.1/32, 239.1.1.1), S-bit set

                                       <<<<<<< (S,G) join is received
```

```
*Aug 22 21:59:42.629: MRT(2): WAVL Insert interface: GigabitEthernet0/0/2.100 in (10.40.40.1,239.1.1.1)

*Aug 22 21:59:42.630: MRT(2): set min mtu for (10.40.40.1, 239.1.1.1) 18010->1500
*Aug 22 21:59:42.630: MRT(2):
```

Add GigabitEthernet0/0/2.100/239.1.1.1 to the olist of (10.40.40.1, 239.1.1.1)

```
, Forward state - MAC built
*Aug 22 21:59:42.630: PIM(2): Add GigabitEthernet0/0/2.100/10.40.40.5 to (10.40.40.1, 239.1.1.1), Forwa
*Aug 22 21:59:42.630: MRT(2): Add GigabitEthernet0/0/2.100/239.1.1.1 to the olist of (10.40.40.1, 239.1
*Aug 22 21:59:42.630: MRT(2): Set the PIM interest flag for (10.40.40.1, 239.1.1.1)

SDA-Fusion2#
```

show ip mroute vrf Campus 239.1.1.1

```
IP Multicast Routing Table

(*, 239.1.1.1), 00:01:17/stopped, RP 192.168.50.1, flags: SPF
  Incoming interface: GigabitEthernet0/0/2.100, RPF nbr 10.40.40.5
  Outgoing interface list: Null

(
```

10.40.40.1, 239.1.1.1

```
), 00:01:17/00:02:14, flags: FT
  Incoming interface: GigabitEthernet1/0/2,
```

RPF nbr 0.0.0.0

```
<<<<<<<< RPF neighbor is 0.0.0.0 as the Source is directly connected
```

Outgoing interface list:

Gi0/0/0.3007

```
, Forward/Sparse, 00:01:17/00:03:10

SDA-Fusion2#

SDA-Fusion2#
```

show interface tunnel 0

```
         <<<<<<<< Register Tunnel is created between FHR and RP
Tunnel0 is up, line protocol is up
 Hardware is Tunnel
 Description:
```

Pim Register Tunnel (Encap) for RP 192.168.50.1 on VRF Campus

```
 Interface is unnumbered. Using address of GigabitEthernet0/0/2.100 (10.40.40.6)
 MTU 9972 bytes, BW 100 Kbit/sec, DLY 50000 usec,
 reliability 255/255, txload 1/255, rxload 1/255
 Encapsulation TUNNEL, loopback not set
 Keepalive not set
 Tunnel linestate evaluation up
 Tunnel source 10.40.40.6 (GigabitEthernet0/0/2.100), destination 192.168.50.1
```

RP(BORDER-1)接收来自FHR的注册，该注册触发向FHR发送的(S，G)加入，以及向FHR发送的注册 — 停止 — 一旦在RP上本地接收到流。

<#root>

SDA-Border1#

debug ip mrouting vrf Campus 239.1.1.1

IP multicast routing debugging is on

*Aug 18 02:29:05.186: PIM(4):

Received v2 Register on Vlan3002 from 10.40.40.6

<<<<<<< PIM Register is received from FHR
*Aug 18 02:29:05.186: for 10.40.40.1, group 239.1.1.1
*Aug 18 02:29:05.187: PIM(4):

Adding register decap tunnel (Tunnel1)

as accepting interface of (10.40.40.1, 239.1.1.1). <<<<<<< Register tunnel is created
*Aug 18 02:29:05.187: MRT(4): (10.40.40.1,239.1.1.1), RPF install from /0.0.0.0 to Vlan3002/10.50.50.6
*Aug 18 02:29:05.188: MRT(4):

Create (10.40.40.1,239.1.1.1), RPF (Vlan3002, 10.50.50.6, 20/0)

<<<<<<< (S,G) is created and RPF is resolved
*Aug 18 02:29:05.188: MRT(4): WAVL Insert LISP interface: LISP0.4099 in (10.40.40.1,239.1.1.1) Next-hop
*Aug 18 02:29:05.188: MRT(4): set min mtu for (10.40.40.1, 239.1.1.1) 18010->17892
*Aug 18 02:29:05.189: MRT(4):

Add LISP0.4099/192.168.10.3 to the olist of (10.40.40.1, 239.1.1.1)

, Forward state - MAC not built <<<<<< LISP OIF is inherited from (*,G)
*Aug 18 02:29:05.189: PIM(4): Insert (10.40.40.1,239.1.1.1) join in nbr 10.50.50.6's queue
*Aug 18 02:29:05.189: PIM(4): Building Join/Prune packet for nbr 10.50.50.6
*Aug 18 02:29:05.189: PIM(4):

Adding v2 (10.40.40.1/32, 239.1.1.1), S-bit Join

*Aug 18 02:29:05.189: PIM(4):

Send v2 join/prune to 10.50.50.6 (Vlan3002)

<<<<<<< (S,G) join is sent towards the Source
*Aug 18 02:29:05.272: PIM(4): J/P Transport Attribute, Transport Type: Unicast
Aug 18 02:29:05.272: PIM(4): Join-list: (, 239.1.1.1), RPT-bit set, WC-bit set, S-bit set
Aug 18 02:29:05.272: PIM(4): Update LISP0.4099/192.168.10.3 to (, 239.1.1.1), Forward state, by PIM *
Aug 18 02:29:05.272: MRT(4): Update LISP0.4099/192.168.10.3 in the olist of (, 239.1.1.1), Forward st
*Aug 18 02:29:05.272: PIM(4): Prune-list: (10.40.40.1/32, 239.1.1.1) RPT-bit set
*Aug 18 02:29:05.273: PIM(4):

Prune LISP0.4099/192.168.10.3 from (10.40.40.1/32, 239.1.1.1)

<<<<<<< (S,G) Prune is received from Edge1
*Aug 18 02:29:05.273: MRT(4):

Delete LISP0.4099/192.168.10.3 from the olist of (10.40.40.1, 239.1.1.1)

*Aug 18 02:29:05.273: PIM(4): Insert (10.40.40.1,239.1.1.1) prune in nbr 10.50.50.6's queue - deleted

*Aug 18 02:29:05.273: PIM(4): Building Join/Prune packet for nbr 10.50.50.6
*Aug 18 02:29:05.273: PIM(4):

Adding v2 (10.40.40.1/32, 239.1.1.1), S-bit Prune

*Aug 18 02:29:05.273: PIM(4):

Send v2 join/prune to 10.50.50.6 (Vlan3002

)
*Aug 18 02:29:05.439: PIM(4): J/P Transport Attribute, Transport Type: Unicast

*Aug 18 02:29:07.193: PIM(4): Received v2 Register on Vlan3002 from 10.40.40.6
*Aug 18 02:29:07.193:   for 10.40.40.1, group 239.1.1.1
*Aug 18 02:29:07.194: PIM(4):

Send v2 Register-Stop to 10.40.40.6 for 10.40.40.1, group 239.1.1.1

<<<<<<< Register-Stop is sent towards FHR

SDA-Border1#

show ip mroute vrf Campus 239.1.1.1

IP Multicast Routing Table

(*, 239.1.1.1), 00:51:28/00:02:44, RP 192.168.50.1, flags: S
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:

LISP0.4099, 192.168.10.3

, Forward/Sparse, 00:51:28/00:02:44

(

10.40.40.1, 239.1.1.1

), 00:09:37/00:01:24,

flags: P

<<<<<<<<<<<< (S,G) is created but Pruned flag is set

Incoming interface: Vlan3002

, RPF nbr 10.50.50.6 <<<<<<<<<<<< Incoming interface and RPF neighbor

Outgoing interface list: Null

SDA-Border1#

show ip rpf vrf Campus 10.40.40.1

RPF information for ? (10.40.40.1)

RPF interface: Vlan3002

<<<<<<<<<< RPF interface towards the Source

RPF neighbor: ? (10.50.50.6)

<<<<<<<<<< RPF neighbor - must be a PIM neighbor

```
  RPF route/mask: 10.40.40.0/30


 RPF type: unicast (bgp 65005)

<<<<<<<<<< RPF information coming from unicast RIB/BGP
  Doing distance-preferred lookups across tables
  RPF topology: ipv4 multicast base,

originated from ipv4 unicast base


SDA-Border1#
SDA-Border1#

show ip route vrf Campus 10.40.40.1



Routing Table: Campus

Routing entry for 10.40.40.0/30




Known via "bgp 65005"

, distance 20, metric 0
  Tag 65004, type external
  Last update from 10.50.50.6 2w6d ago
  Routing Descriptor Blocks:
  * 10.50.50.6, from 10.50.50.6, 2w6d ago
      Route metric is 0, traffic share count is 1
      AS Hops 1
      Route tag 65004
      MPLS label: none
      MPLS Flags: NSF
SDA-Border1#
```

Edge-1正在修剪SPT — 让我们转到LHR了解原因。

(S，G)在LHR上的创建

收到由RP转发的组播数据后，会在LHR上创建(S，G)条目。

接下来，LHR将切换到最短路径树(SPT))向源设备发送(S，G)加入。这在RPF接口上发送到源。

<#root>

```
SDA-Edge1#
*Aug 18 02:19:53.759: MRT(4):

Create (10.40.40.1,239.1.1.1)

, RPF (unknown, 0.0.0.0, 0/0)                    <<<<<<<<< (S,G) is created on LHR
*Aug 18 02:19:53.759: MRT(4): WAVL Insert interface: Vlan1021 in (10.40.40.1,239.1.1.1) Successful
```

```
*Aug 18 02:19:53.759: MRT(4): set min mtu for (10.40.40.1, 239.1.1.1) 18010->1500
*Aug 18 02:19:53.759: MRT(4):

Add Vlan1021/239.1.1.1 to the olist of (10.40.40.1, 239.1.1.1)

, Forward state - MAC not built    <<<<<<< OIL is inherited from (*,G)
*Aug 18 02:19:53.759: MRT(4):

Set the J-flag for (10.40.40.1, 239.1.1.1)

                                    <<<<<<<< SPT Join Flag is set
*Aug 18 02:19:53.762: MRT(4):

(10.40.40.1,239.1.1.1), RPF change from  /0.0.0.0 to LISP0.4099/192.168.10.2

<<<<<<<< RPF interface is resolved
*Aug 18 02:19:53.762: MRT(4): Set the T-flag for (10.40.40.1, 239.1.1.1)
*Aug 18 02:19:53.763: PIM(4): Insert (10.40.40.1,239.1.1.1) join in nbr 192.168.10.2's queue
*Aug 18 02:19:53.763: PIM(4): Building Join/Prune packet for nbr 192.168.10.2
*Aug 18 02:19:53.763: PIM(4):  Adding v2 (10.40.40.1/32, 239.1.1.1), S-bit Join
*Aug 18 02:19:53.763: PIM(4): Adding LISP Unicast transport attribute in join/prune to 192.168.10.2 (LI
*Aug 18 02:19:53.763: PIM(4):

Send v2 join/prune to 192.168.10.2 (LISP0.4099)

                                <<<<<<<< (S,G) Join towards the Source is sent
*Aug 18 02:19:53.826: PIM(4): Building Periodic (*,G) Join / (S,G,RP-bit) Prune message for 239.1.1.1
*Aug 18 02:19:53.826: PIM(4): Insert (*,239.1.1.1) join in nbr 192.168.10.1's queue
*Aug 18 02:19:53.826: PIM(4): Insert (10.40.40.1,239.1.1.1) sgr prune in nbr 192.168.10.1's queue
*Aug 18 02:19:53.826: PIM(4):

Building Join/Prune packet for nbr 192.168.10.1

*Aug 18 02:19:53.826: PIM(4):  Adding v2 (192.168.50.1/32, 239.1.1.1), WC-bit, RPT-bit, S-bit Join
*Aug 18 02:19:53.827: PIM(4):

Adding v2 (10.40.40.1/32, 239.1.1.1), RPT-bit, S-bit Prune

*Aug 18 02:19:53.827: PIM(4): Adding LISP Unicast transport attribute in join/prune to 192.168.10.1 (LI
*Aug 18 02:19:53.827: PIM(4):

Send v2 join/prune to 192.168.10.1 (LISP0.4099)

<<<<<<<<< (S,G) Prune towards the RP is sent
*Aug 18 02:20:08.323: MRT(4): Update (*,239.1.1.1), RPF (LISP0.4099, 192.168.10.1, 1/1)
*Aug 18 02:20:08.323: MRT(4): Update Vlan1021/239.1.1.1 in the olist of (*, 239.1.1.1), Forward state -
*Aug 18 02:20:08.323: MRT(4): Update Vlan1021/239.1.1.1 in the olist of (10.40.40.1, 239.1.1.1), Forwar



SDA-Edge1#

show ip mroute vrf Campus 239.1.1.1

IP Multicast Routing Table

(*, 239.1.1.1), 00:43:35/stopped, RP 192.168.50.1, flags: SJC
  Incoming interface: LISP0.4099,

RPF nbr 192.168.10.1

  Outgoing interface list:
    Vlan1021, Forward/Sparse, 00:43:35/00:02:29

(10.40.40.1, 239.1.1.1), 00:01:45/00:01:14,

flags: JT
```

```
                       <<<<<<<<<<<< (S,G) is created
  Incoming interface: LISP0.4099,
```

RPF nbr 192.168.10.2

```
                      <<<<<<<<<<<< Border-2 is the RPF neighbor towards the Source
  Outgoing interface list:
    Vlan1021, Forward/Sparse, 00:01:47/00:02:27


SDA-Edge1#
```

show lisp eid-table vrf Campus ipv4 map 10.40.40.1

```
                  <<<<<<<< LISP lookup for the Source
LISP IPv4 Mapping Cache for EID-table vrf Campus (IID 4099), 5 entries

0.0.0.0/1, uptime: 2w1d, expires: 18:05:53, via map-reply, forward-native
  Sources: map-reply
  State: forward-native, last modified: 2w1d, map-source: 192.168.10.1
  Active, Packets out: 106458(41136237 bytes) (~ 00:00:38 ago)
```

Encapsulating to proxy ETR

```
                                                <<<<<<<<< No specific entry is known, forwarding to Pro



SDA-Edge1#
```

show ip cef vrf Campus 10.40.40.1 detail

```
0.0.0.0/1, epoch 0, flags [subtree context, check lisp eligibility], per-destination sharing
  SC owned,sourced: LISP remote EID - locator status bits 0x00000000
  LISP remote EID: 106468 packets 41140303 bytes fwd action encap
  LISP source path list
    nexthop 192.168.10.1 LISP0.4099                                    <<<<<<<<<< Load balancing t
    nexthop 192.168.10.2 LISP0.4099
  2 IPL sources [no flags]
  nexthop 192.168.10.1 LISP0.4099
  nexthop 192.168.10.2 LISP0.4099


SDA-Edge1#
```

show ip cef vrf Campus exact-route 192.168.50.2 10.40.40.1

```
          <<<<<<<<< CEF hashing points towards Border-2
192.168.50.2 -> 10.40.40.1 =>
```

IP adj out of GigabitEthernet1/0/11, addr 192.168.23.2

```


SDA-Edge1#
```

show ip rpf vrf Campus 10.40.40.1

```


RPF information for ? (10.40.40.1)
```

RPF interface: LISP0.4099

```
RPF neighbor: ? (192.168.10.2)

<<<<<<<<<< Hence SPT Join is sent towards Border-2
  RPF route/mask: 0.0.0.0/1
  RPF type: unicast ()
  Doing distance-preferred lookups across tables
  RPF topology: ipv4 multicast base
SDA-Edge1#
```

由于(S，G)加入通过LISP接口发送到Border-2，因此在Edge-1上创建新的PIM邻居

<#root>

```
SDA-Edge1#

show ip pim vrf Campus neighbor

PIM Neighbor Table

Neighbor          Interface                Uptime/Expires    Ver   DR
Address                                                            Prio/Mode

192.168.10.2      LISP0.4099

               00:07:32/00:01:22 v2    0 /         <<<<<<<< Neighbor towards Border-2 is created
192.168.10.1      LISP0.4099               2w1d/00:01:58     v2    0 /
```

由于Border-2位于组播流的数据路径中，它必须执行显式RLOC跟踪以跟踪下游XTR-s的RLOC以实现数据包的单播复制。

<#root>

```
SDA-Border2#

show ip mroute vrf Campus 239.1.1.1

IP Multicast Routing Table

(*, 239.1.1.1), 00:23:00/stopped, RP 192.168.50.1, flags: SP
  Incoming interface: LISP0.4099, RPF nbr 192.168.10.1
  Outgoing interface list: Null

(10.40.40.1, 239.1.1.1), 00:12:35/00:02:52,

flags: T

                 <<<<<<< SPT flag is set
  Incoming interface: Vlan3007,

RPF nbr 10.50.50.26

                  <<<<<<< RPF neighbor is based on RPF towards the Source - must be a PIM neighbor
  Outgoing interface list:
```

LISP0.4099, 192.168.10.3

, Forward/Sparse, 00:12:35/00:02:45   <<<<<<< OIL created from (S,G) join received from LHR and cont

SDA-Border2#

show ip mfib vrf Campus 239.1.1.1 10.40.40.1

```
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.
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:   FS Pkt Count/PS Pkt Count
VRF Campus
 (10.40.40.1,239.1.1.1) Flags: HW
   SW Forwarding: 0/0/0/0, Other: 0/0/0
```

HW Forwarding: 176/0/122/0

, Other: 0/0/0   <<<<<<< Multicast stream is forwarded in h/w

```
   Vlan3007 Flags: A
   LISP0.4099, 192.168.10.3 Flags: F NS
     Pkts: 0/0
```

SDA-Border2#

sh ip mfib vrf Campus 239.1.1.1 10.40.40.1 count

```
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 Campus
 6 routes, 2 (*,G)s, 3 (*,G/m)s
Group: 239.1.1.1
  Source: 10.40.40.1,
   SW Forwarding: 0/0/0/0, Other: 0/0/0
```

HW Forwarding: 182/0/122/0

, Other: 0/0/0   <<<<<<<< Counter is incrementing

```
  Totals - Source count: 1, Packet count: 182

Groups: 1, 1.00 average sources per group
SDA-Border2#
```

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