SDA园区交换矩阵环境中的任意源组播(ASM)概述

目录

简介

本文档介绍软件定义访问(SD-Access)环境中具有单个交汇点*(RP*)的任意源组播(ASM)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

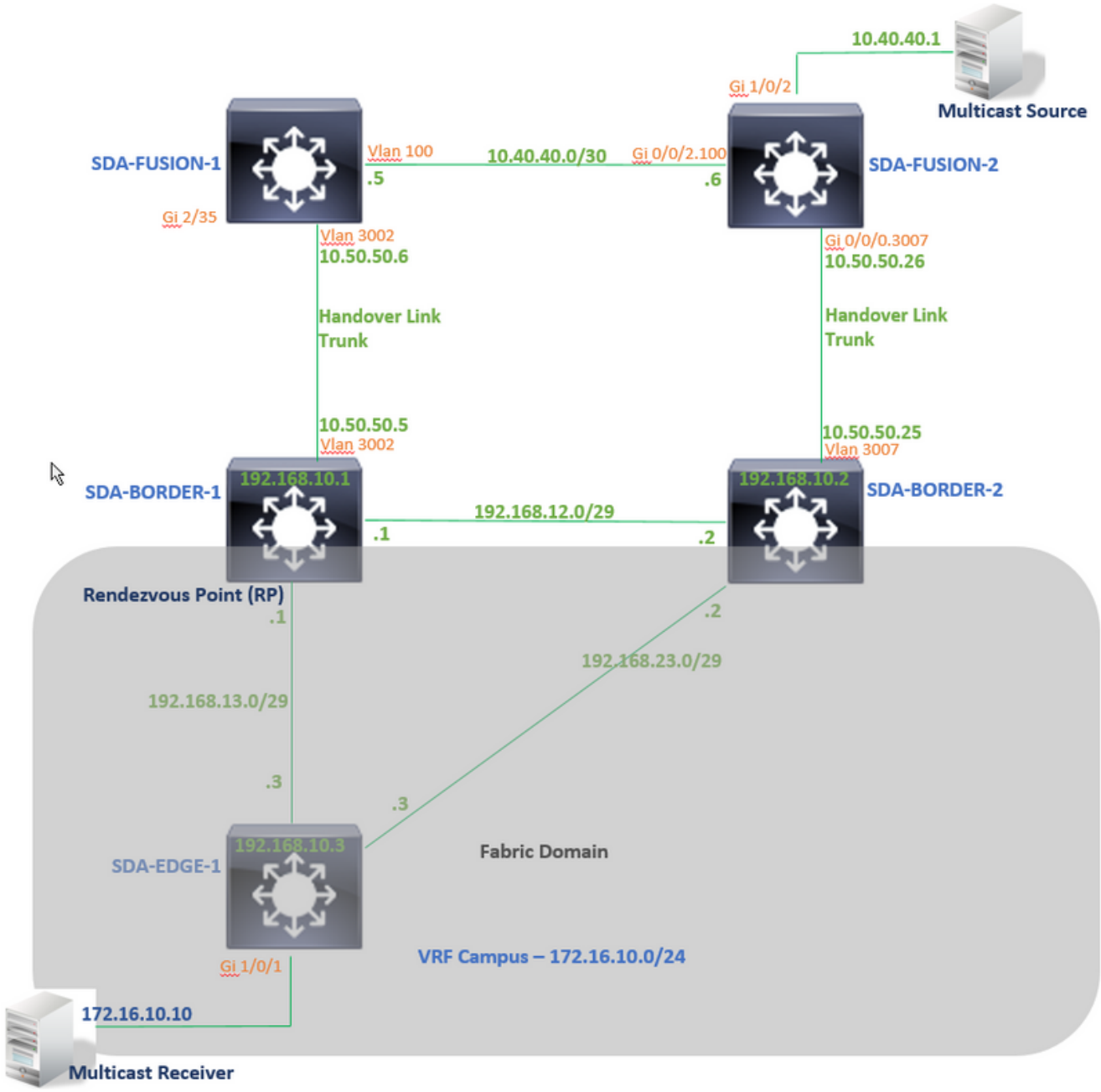
边缘和边界 — Cat3k思科交换机

Fusion — 支持VRF间（虚拟路由转发）漏洞的思科路由器

配置

网络图

本文使用的拓扑包括两个边界路由器（两个边界路由器都配置为外部边界）和两个Fusion路由器（每个边界路由器都连接）。Border-1配置为RP，组播源连接到Fusion-2，组播接收器连接到Edge-1。



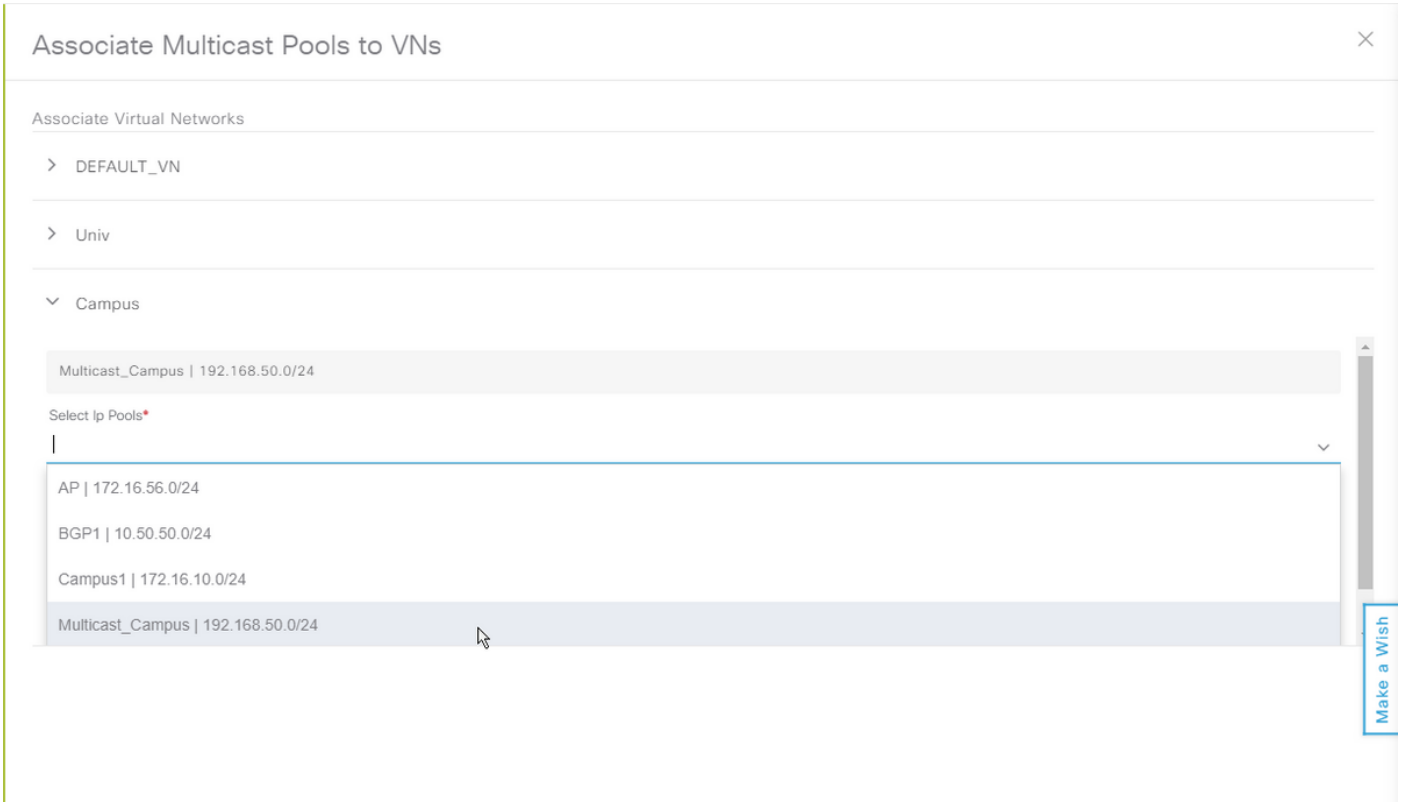
配置

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，并从说明在特定VN的交换矩阵域中配置组播的步骤开始。

步骤1：从DNAC在交换矩阵设备上配置组播

在DNAC图形用户界面(GUI)中，在Provision -> Fabric Workflow。组播由SDA-BORDER-1设备上的“启用交汇点”选项配置。

然后，在本*示例中*，选择要用于特定VN下的组播配置的Internet协议(IP)池。“园区”。



步骤2：验证在设备上推送的配置

本节介绍交换矩阵设备上组播配置的验证。

SDA-BORDER-1

```
interface Loopback4099 <<<<<<<<<<<< Loopback Interface is created and assigned an IP from Pool
selected
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 default address
range 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 default
```

```
address range

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 advertised
.....
```

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

在本例中，组播源连接到交换矩阵外部的Fusion-2。 对于要流动的组播流，请确保存在从RP到源的PIM路径，以及从接收方到源的PIM路径（路径可能不同！）。

SDA-BORDER-1和SDA-FUSION-1之间的PIM对等

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

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与SDA-FUSION-2之间的PIM对等

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

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

组播接收方在某一时刻向最后一跳路由器(LHR)发送IGMP(Internet Group Management Protocol)Join，以接收特定组的流，组播源(Server)开始向第一跳路由器(First Hop Router，FHR)发送组播流。 在本例中，FHR为SDA-FUSION-2,LHR为SDA-EDGE-1，控制平面过程在接收方首先请求流，然后源开始为该组进行流传输的场景中进行说明。

LHR上的IGMP加入

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

```
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 0 sources
*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
present
SDA-Edge1#
```

新的**多路由监**视服务确定指向RP（共享树）和源(最短路径树(SPT))的反向路径转发(RPF)信息。对于LISP可到达地址，下一跳邻居由上游站点的远程路由定位器(RLOC)地址表示。

```
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 set towards Receiver
```

接下来，LHR向RP发送PIM(*,G)连接（以一分钟间隔） — 如果LHR是该网段的DR。

```
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 (LISP0.4099)
*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
(LISP0.4099) *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

获取指向LISP接口的RPF信息后，PIM必须为相应RLOC显式创建邻居结构。这是必要的，因为上游隧道路由器(xTR)不发送hello消息。当连接/修剪之间的标准间隔时间为2倍后，未向邻居发送加入/修剪消息时，新邻居块将过期。

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

```
SDA-Edge1#show ip pim vrf Campus neighbor
PIM Neighbor Table

Neighbor          Interface                Uptime/Expires    Ver   DR
Address                                                            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

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

```
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
(*, 239.1.1.1).
*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（边界1）不通过LISP接口发送任何加入，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，并由于定期收到的PIM Hello数据包而形成。

```
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邻居通过非LISP接口，因此也根据收到的定期PIM Hello-s创建。

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)在收到来自源的第一个组播数据包后向RP注册(S，G)，如果FHR是该网段上的DR。

```
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
GigabitEthernet1/0/2/0.0.0.0
*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) Successful

*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), Forward state, by PIM SG Join
*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: 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)从FHR接收寄存器，当在RP上本地接收流时，该寄存器触发(S，G)加入以发送到FHR，并且触发向FHR的寄存器停止。

```
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: 192.168.10.3 Outer-source: 0.0.0.0 Successful
*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 *G Join
*Aug 18 02:29:05.272: MRT(4): Update LISP0.4099/192.168.10.3 in the olist of (*, 239.1.1.1),
Forward state - MAC not built
*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#
```

SPT正被Edge-1修剪 — 让我们转到LHR了解原因。

(S，G)在LHR上的创建

收到RP转发的组播数据后，在LHR上创建(S，G)条目。

接下来，LHR将切换到最短路径树(SPT))向源发送(S，G)加入。这在RPF接口上向源发送。

```
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 (LISP0.4099)
*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 (LISP0.4099)
*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 - MAC not built
*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),
Forward state - MAC not built
```

```
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 Proxy ETR



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 towards 2 Proxy ETR-s
    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接口发送到边界2，因此在边缘1上创建新的PIM邻居

```
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 /
```

由于边界2在组播流的数据路径中，它必须执行显式RLOC跟踪以跟踪下行XTR-s的RLOC，以便单播复制数据包。

```
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 containing LHR's RLOC info which has to be tracked

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#
```