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The bridge to possible

Multicast in an SDN World

Multicasting across SDA & SD-WAN

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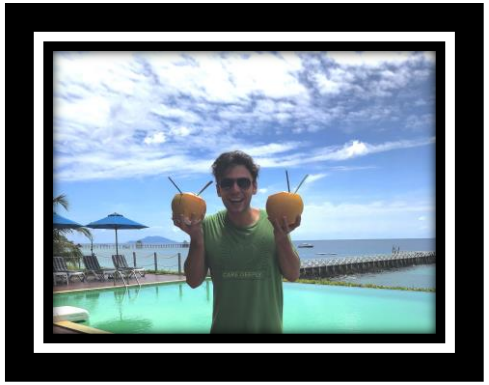
Roger Milnes – Customer Success Specialist

BRKXAR-1005

Who are we?



Enzo Di Fronzo
Customer Success Specialist
CCIE #58440 (EI)

- ✓ TAC Escalation engineer
- ✓ Customer Success Specialist

Speaker & Proctor at CiscoLive since 2017

Roger Milnes
Customer Success Specialist

- ✓ Executive Briefing Centre presenter
- ✓ Customer Success Specialist

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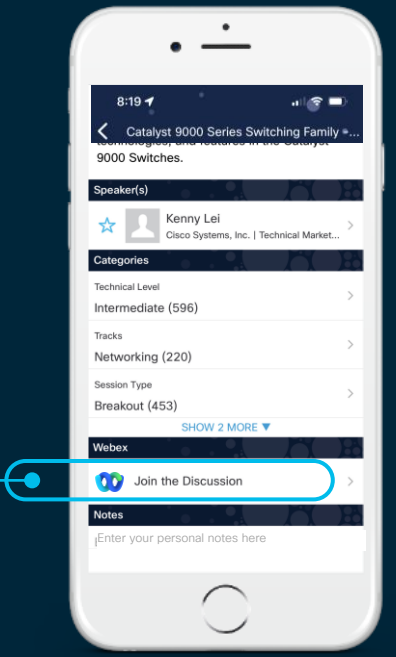


https://ciscolive.ciscoevents.com/ciscolivebot/#BRKXAR-1005

Agenda

- Multicast refresher
- Multicast in SDA
- Multicast in SDWAN
- Multicast in Multidomain

Unicast vs Multicast Forwarding

Multicast Refresher

Unicast routing: “forwarding traffic toward a destination”

Multicast routing: “forwarding traffic away from a source”

Common multicast services

Multicast Refresher

IPTV

CCTV

Video Conferencing

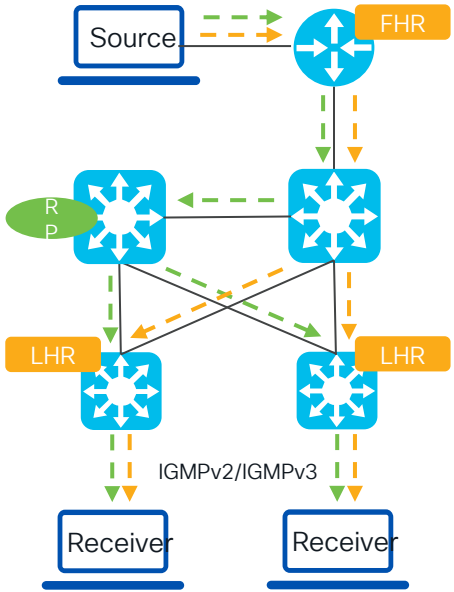
IoT

Wireless sharing

PIM ASM vs SSM

Multicast Refresher

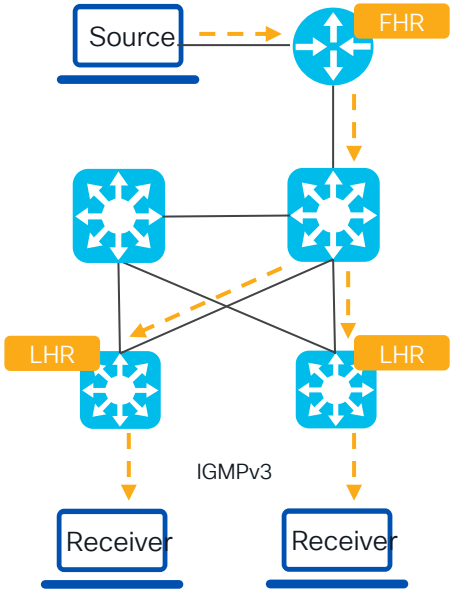
Any Source Multicast (ASM)



Shared Tree

Shortest Path Tree

Source Specific Multicast (SSM)



Multicast terminology

Multicast Refresher

Source	“a source initiates a multicast stream”
Group	“a source initiates a multicast stream to a group address”
First Hop Router (FHR) FHR”	“a source initiates a multicast stream to a group address toward the
Tree	“the FHR forwards the stream down the multicast tree”
Internet Group Management Protocol (IGMP)	“a host requests a multicast stream for a group via IGMP”
Last Hop Router (LHR) toward the LHR”	“a host requests a multicast stream for a group via IGMP
Protocol Independent Multicast (PIM)	“the LHR requests the stream by sending a PIM join toward the FHR”
Mroute	“a received PIM join will add an mroute to the multicast routing table”
Rendezvous Point (RP)	“the LHR sends a PIM join towards the RP”/
	“the FHR sends a PIM register towards the RP”
Outgoing Interface List (OIL)	“the stream is forwarded out the OIL”

Multicast in SDA

Deployment models

Multicast in SDA

Recommended

Head-End Replication

- Forwarding in overlay
- Multicast over Unicast with VXLAN encap
- Config fully automated by Cisco DNA Center

Native Multicast

- Forwarding in underlay
- Multicast over Multicast with VXLAN encap
- Config fully automated by Cisco DNA Center only when LAN Automation is used

Underlay: No need for multicast support

Underlay: Multicast SSM support is a must

Overlay: Both support ASM and SSM

When sources, receivers and/or RP's are located outside the Fabric, multicast-routing and PIM need to be manually enabled all the way up/down

Requirements for deployment

Multicast in SDA

Head-End Replication

ASM

IP Pool per VN 

Non-RP fabric devices: 1 IP each (PIM over LISP)

RP fabric devices: 1 IP each (PIM over LISP + MSDP)
1 common IP for all RP's (Anycast RP)

RP(s) located outside the Fabric (*"External RP's"*):
- Maximum of 2 external anycast RP's supported
- MSDP is not automated by Cisco DNA Center

SSM

IP Pool per VN 

1 IP for each fabric device (PIM over LISP)

LHR's and Receivers' (hosts) applications need to support IGMPv3

Multicast group range per VN for SSM (overlay)
- Valid SSM ranges: 225.0.0.0/8 – 239.255.255.255/8
- Default: 232.0.0.0/8

+

Native Multicast

All fabric devices, including intermediate nodes need to run multicast in the underlay (Global Routing Table)

Global: ip multicast-routing
ip pim ssm default

L3 interfaces: ip pim sparse-mode

It can be enabled manually by CLI or using Templates in Cisco DNA Center, or using the LAN Automation feature ("Enable Multicast" checkbox)

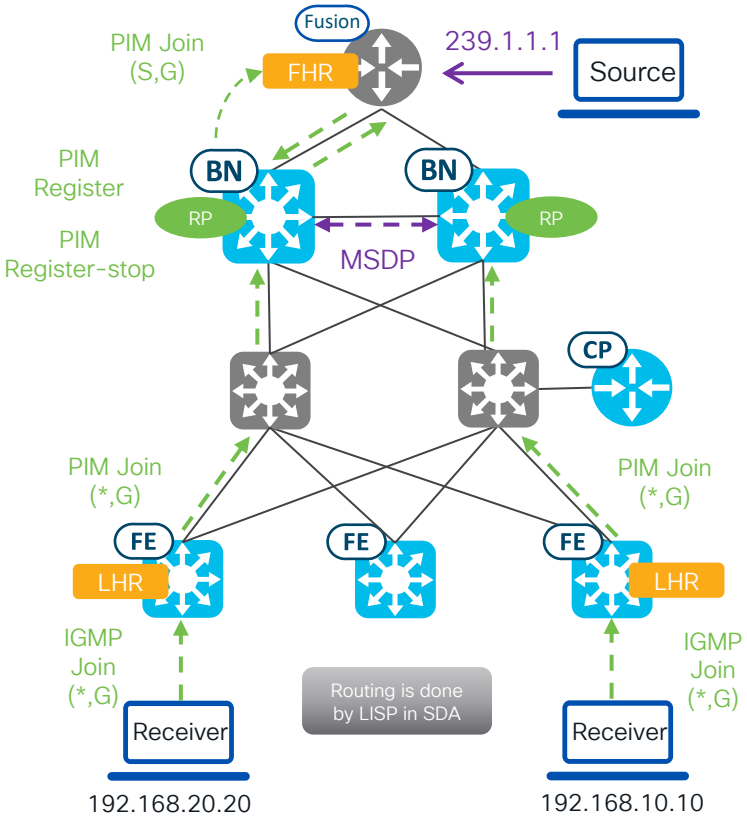
SDA: Control Plane traffic flow for ASM

Multicast in SDA

1 **PIM Register**
FHR → RP

2 **PIM Register-stop**
RP → FHR

3 **IGMP Join (*,G)**
Receivers → LHR



4 **PIM Join (*,G)**
LHR → RP

5 **PIM Join (S,G)**
RP → FHR

6 **Shared Tree built Mroutes populated**

SDA: Control Plane traffic flow for ASM

Multicast in SDA

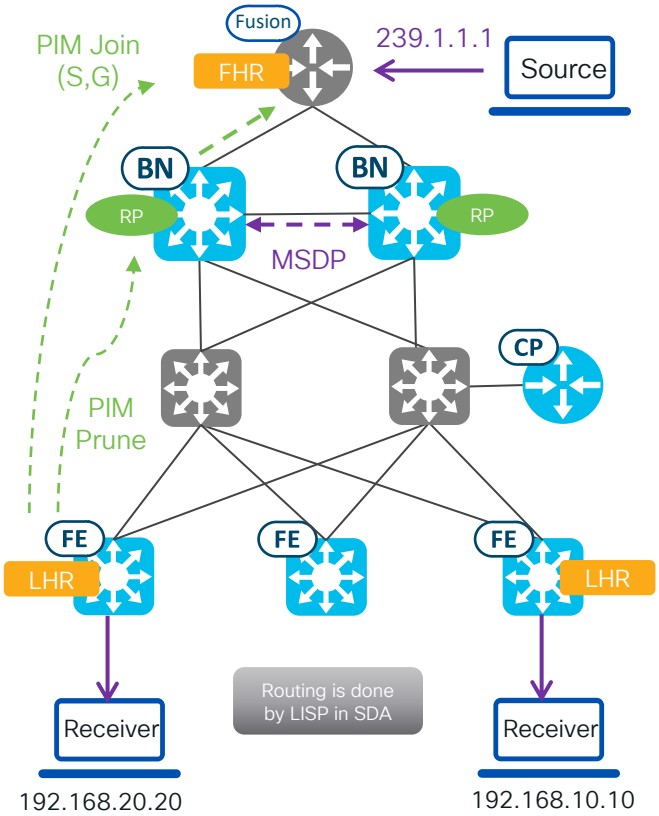
7 FHR send multicast data down the Shared Tree

Data Plane

8 PIM Join (S,G)

LHR → FHR

9 Switching from Shared Tree to SPT happens



10 FHR only sends data down the SPT

Data Plane

11 PIM Prune

LHR → RP and RP → FHR

12 Mroutes are updated

Detailed traffic flow

SDA: Control Plane traffic flow for ASM

Multicast in SDA

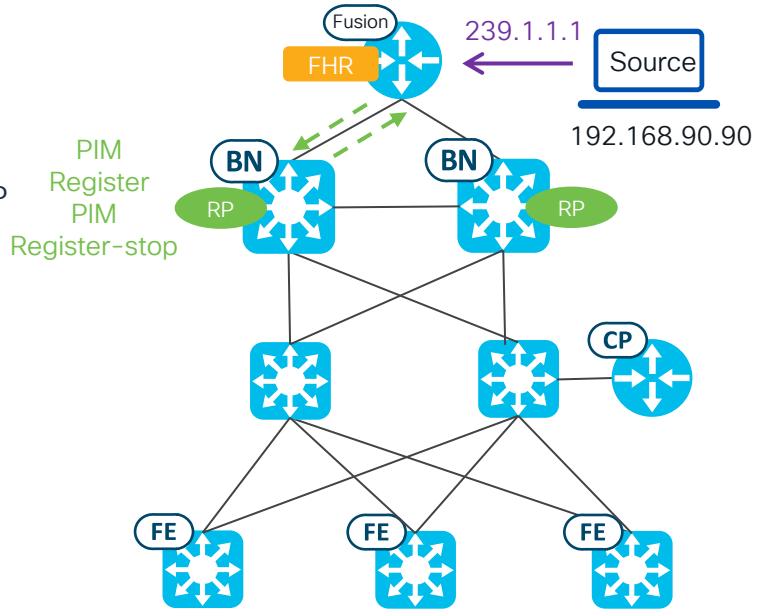
1. Source starts sending multicast traffic to group 239.1.1.1

2. FHR receives the traffic and sends the first packet encapsulated in a PIM Register message towards the RP (if it's the DR of that segment). The RP now waits as it doesn't know where to forward the traffic out yet

```
> Internet Protocol Version 4, Src: 100.64.111.2 (FHR)  Dst: 172.16.100.11 (RP)
v Protocol Independent Multicast
    0010 .... = Version: 2
    .... 0001 = Type: Register (1)
    Reserved byte(s): 00
    Checksum: 0xdeff [correct]
    [Checksum Status: Good]
  > PIM Options
> Internet Protocol Version 4, Src: 192.168.90.90, Dst: 239.1.1.1
> Internet Control Message Protocol
```

3. The RP will send back a PIM Register-stop message towards the FHR if it has already built the SPT to the source -or- when it has not heard about active receivers.

```
> Internet Protocol Version 4, Src: 172.16.100.11 (RP)  Dst: 100.64.111.2
v Protocol Independent Multicast
    0010 .... = Version: 2
    .... 0010 = Type: Register-stop (2)
    Reserved byte(s): 00
    Checksum: 0xd0d9 [correct]
    [Checksum Status: Good]
  > PIM Options
```



Detailed traffic flow

SDA: Control Plane traffic flow for ASM

Multicast in SDA

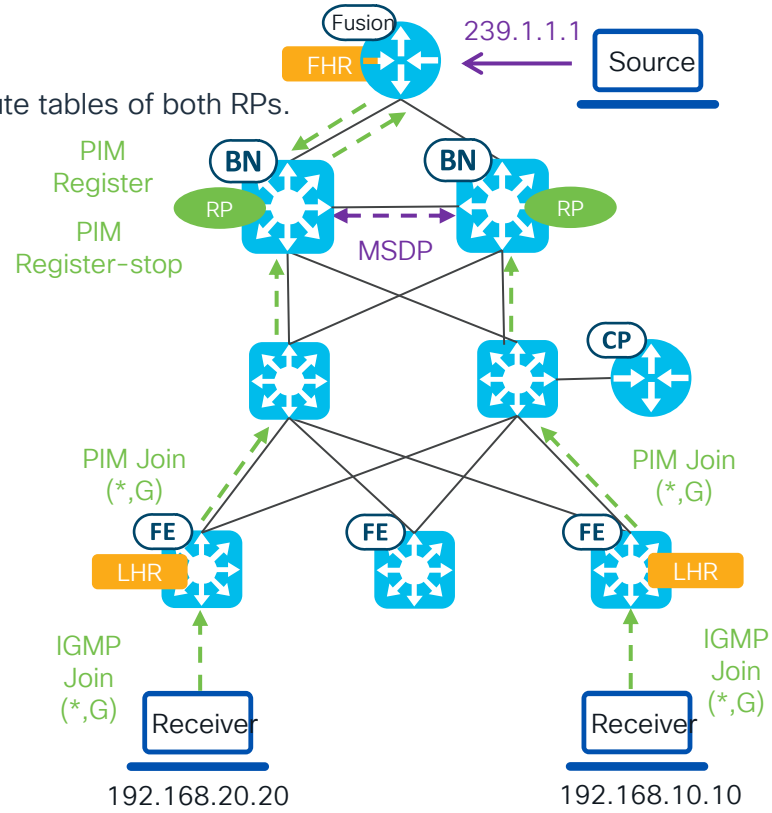
4 If MSDP is running between RPs, it will sync the entries in the mroute tables of both RPs.

5 Now, Receivers want to get multicast data from group 239.1.1.1, so they send IGMP Join (*,G) messages to LHRs.

```
> Internet Protocol Version 4, Src: 192.168.20.20, Dst: 239.1.1.1
v Internet Group Management Protocol
    [IGMP Version: 2]
    Type: Membership Report (0x16)
    Max Resp Time: 0.0 sec (0x00)
    Checksum: 0xf9fc [correct]
    [Checksum Status: Good]
    Multicast Address: 239.1.1.1
```

6 LHRs then send PIM Join (*,G) messages towards RP to let them know they have receivers interested in this traffic.

```
> Internet Protocol Version 4, Src: 172.16.13.15, Dst: 224.0.0.13
v Protocol Independent Multicast
    0010 .... = Version: 2                                  LHR
    .... 0011 = Type: Join/Prune (3)
    Reserved byte(s): 00
    Checksum: 0x18ae [correct]
    [Checksum Status: Good]
  v PIM Options
    v Upstream-neighbor: 172.16.13.14
        Address Family: IPv4 (1)
        Encoding Type: Native (0)
        Unicast: 172.16.13.14
      Reserved byte(s): 00
      Num Groups: 1
      Holdtime: 210
    v Group 0
      > Group 0: 239.1.1.1/32
      v Num Joins: 1
        > IP address: 172.16.100.11/32 (SWR)
      Num Prunes: 0
                                                            RP
```



Detailed traffic flow

SDA: Control Plane traffic flow for ASM

Multicast in SDA

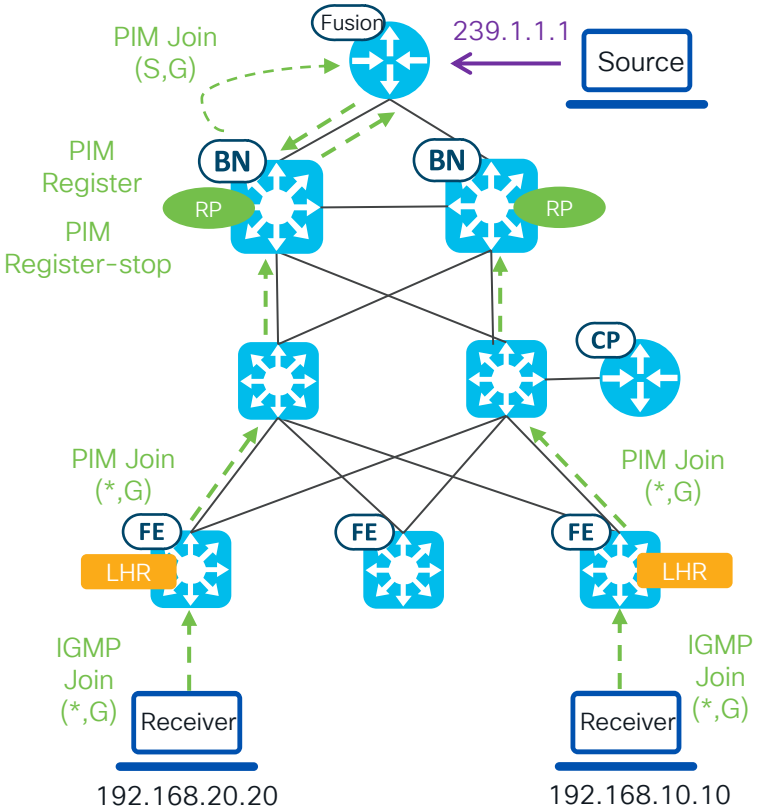
7 Since RP knows the source who's sending that traffic (for that group), it creates a PIM Join (S,G) packet and sends it to the FHR

```
> Internet Protocol Version 4, Src: 100.64.111.1, Dst: 224.0.0.13
v Protocol Independent Multicast
    0010 .... = Version: 2
    .... 0011 = Type: Join/Prune (3)
    Reserved byte(s): 00
    Checksum: 0xf6a2 [correct]
    [Checksum Status: Good]
  v PIM Options
    v Upstream-neighbor: 100.64.111.2
        Address Family: IPv4 (1)
        Encoding Type: Native (0)
        Unicast: 100.64.111.2
      Reserved byte(s): 00
      Num Groups: 1
      Holdtime: 210
    v Group 0
      > Group 0: 239.1.1.1/32
      v Num Joins: 1
        > IP address: 192.168.90.90/32 (S)
        Num Prunes: 0
```

RP Non-fabric interface

8 The FHR now builds the OIL and send out the multicast traffic for group 239.1.1.1

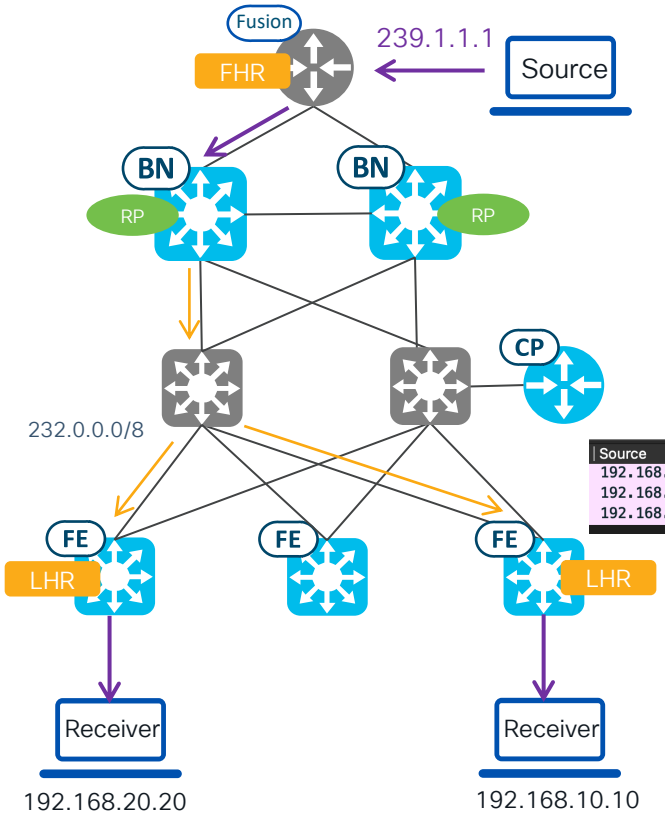
```
(192.168.90.90, 239.1.1.1), 00:00:04/00:03:29, flags: FT
  Incoming interface: GigabitEthernet0/2, RPF nbr 0.0.0.0
  Outgoing interface list:
    GigabitEthernet0/0, Forward/Sparse, 00:00:04/00:03:27
```



SDA: Data Plane traffic flow for Native Multicast ASM

Multicast in SDA

1. Multicast data is sent down the SPT
2. Border encapsulates in VXLAN
3. Multicast in Multicast encapsulation (232.x.x.x)



4. Replication/copy of packets happens in the underlay and closer to LHRs with Receivers

Source	Destination	Protocol	Length	Info
192.168.90.90	239.1.1.1	ICMP	114	Echo (ping) request
192.168.20.20	192.168.90.90	ICMP	164	Echo (ping) reply
192.168.10.10	192.168.90.90	ICMP	164	Echo (ping) reply

5. Bandwidth usage is optimized in Native Multicast

Detailed traffic flow

SDA: Data Plane traffic flow for Native Multicast ASM

Multicast in SDA

1. Source sends multicast traffic for group 239.1.1.1

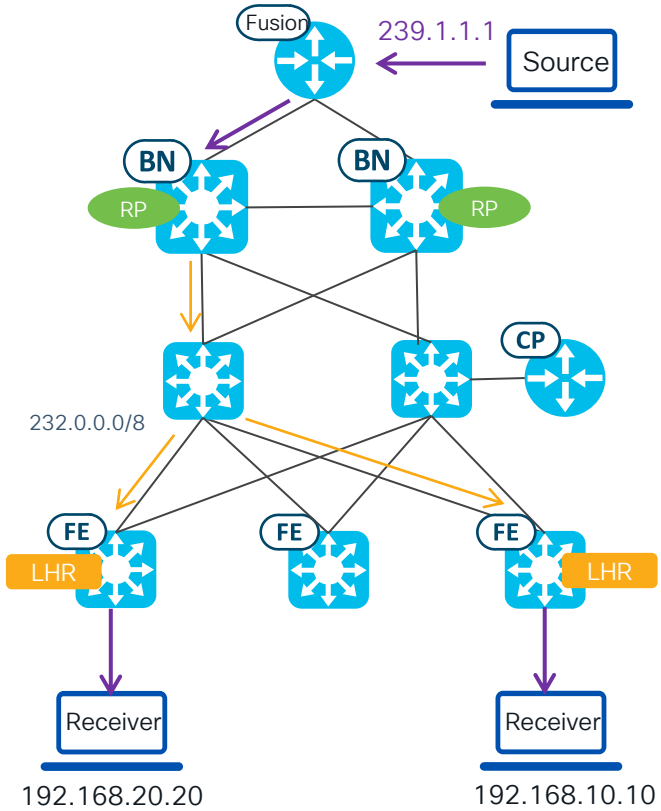
2. The FHR forwards the multicast traffic down the OIL as it was already populated after the PIM signalling process

```
> Internet Protocol Version 4, Src: 192.168.90.90, Dst: 239.1.1.1
> Internet Control Message Protocol
```

3. The Border node encapsulates the multicast packet in another multicast packet header using underlay group 232.x.x.x for replication/copy of packets in the underlay network

```
> Internet Protocol Version 4, Src: 172.16.100.11, Dst: 232.100.100.247
> User Datagram Protocol, Src Port: 30194, Dst Port: 4789
> Virtual eXtensible Local Area Network
> Ethernet II, Src: ba:25:cd:f4:ad:38 (ba:25:cd:f4:ad:38), Dst: IPv4mcast_01:01:01 (01:00:5e:01:01:01)
> Internet Protocol Version 4, Src: 192.168.90.90, Dst: 239.1.1.1
> Internet Control Message Protocol
```

4. The common (and closest) node to the receivers joining the original multicast group 239.1.1.1, in this case the intermediate node, will be the one in charge of replicating the packets down. This lowers the bandwidth usage from the Border/Source side of the network

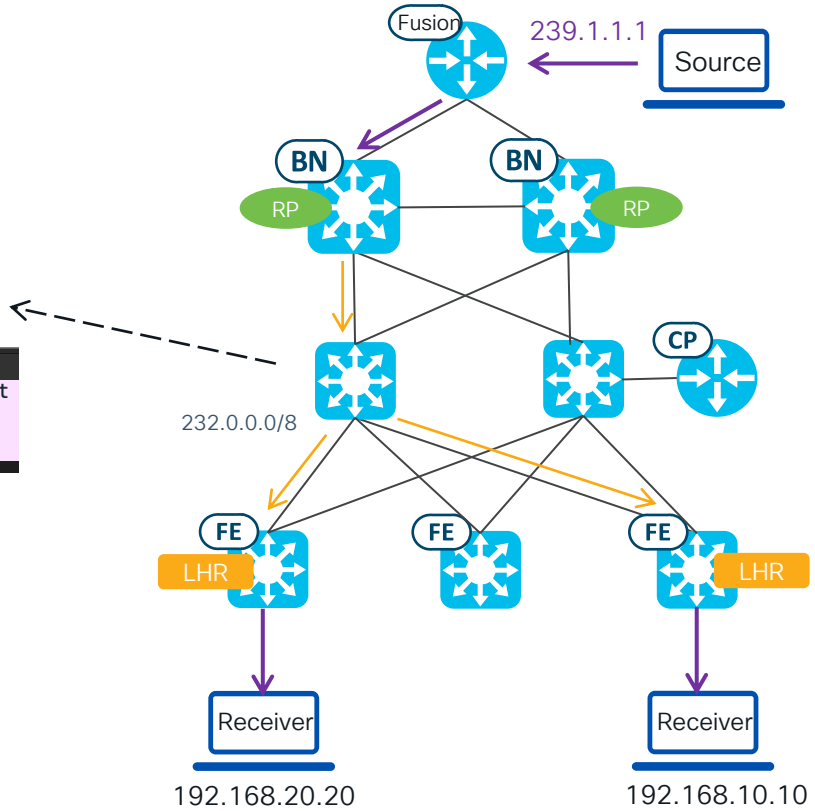


SDA: Data Plane traffic flow for Native Multicast ASM

Multicast in SDA

A capture in this link will show a single ICMP request for both receivers and a reply from each of them

Source	Destination	Protocol	Length	Info
192.168.90.90	239.1.1.1	ICMP	114	Echo (ping) request
192.168.20.20	192.168.90.90	ICMP	164	Echo (ping) reply
192.168.10.10	192.168.90.90	ICMP	164	Echo (ping) reply

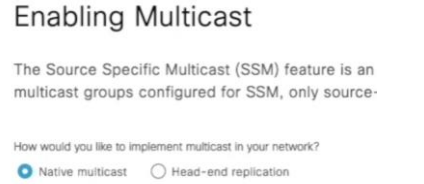


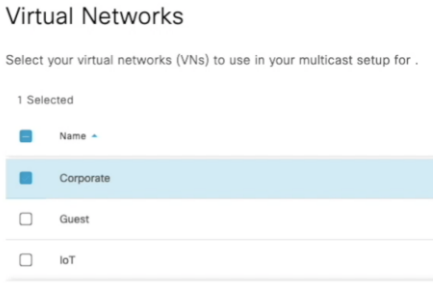
Cisco DNA Center: Enabling Native Multicast in SDA

Workflow

- ✓ IP Pools per VN
- ✓ SDA Fabric built
- ✓ Multicast-routing enabled in GRT
- ✓ PIM SSM enabled in GRT

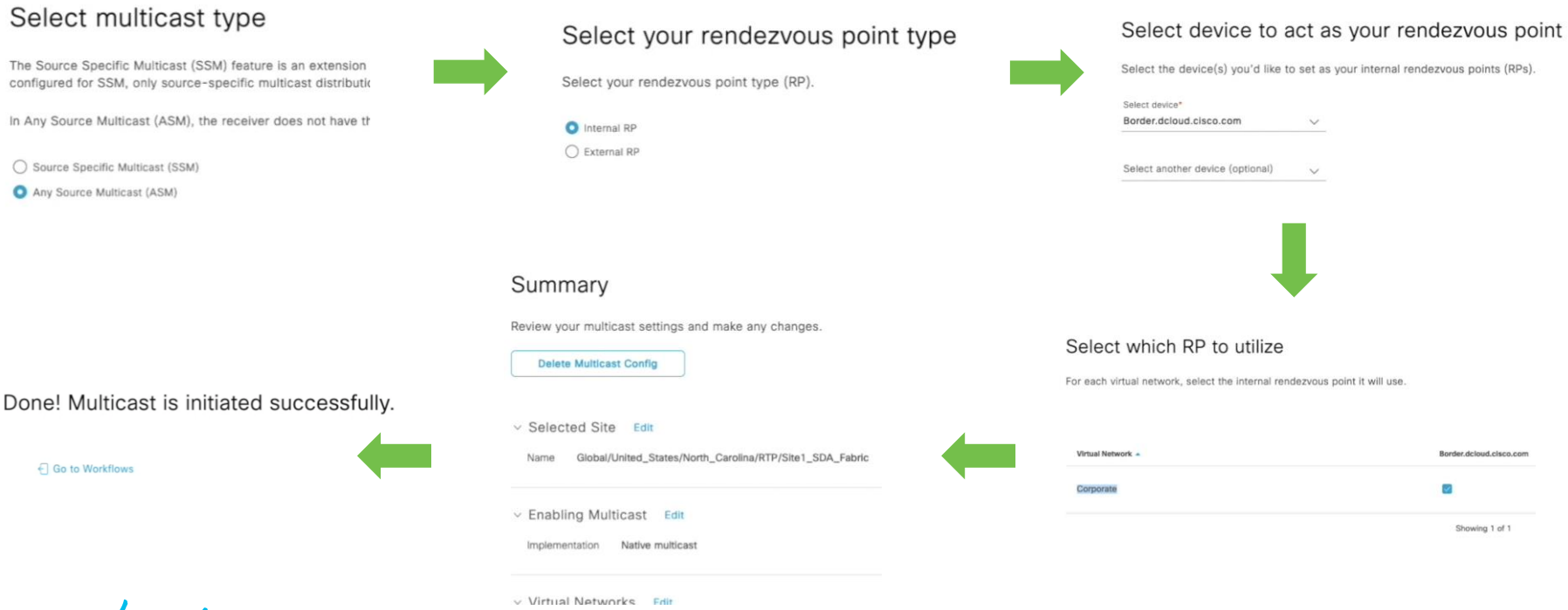
Menu > Workflows





Cisco DNA Center: Enabling Native Multicast in SDA

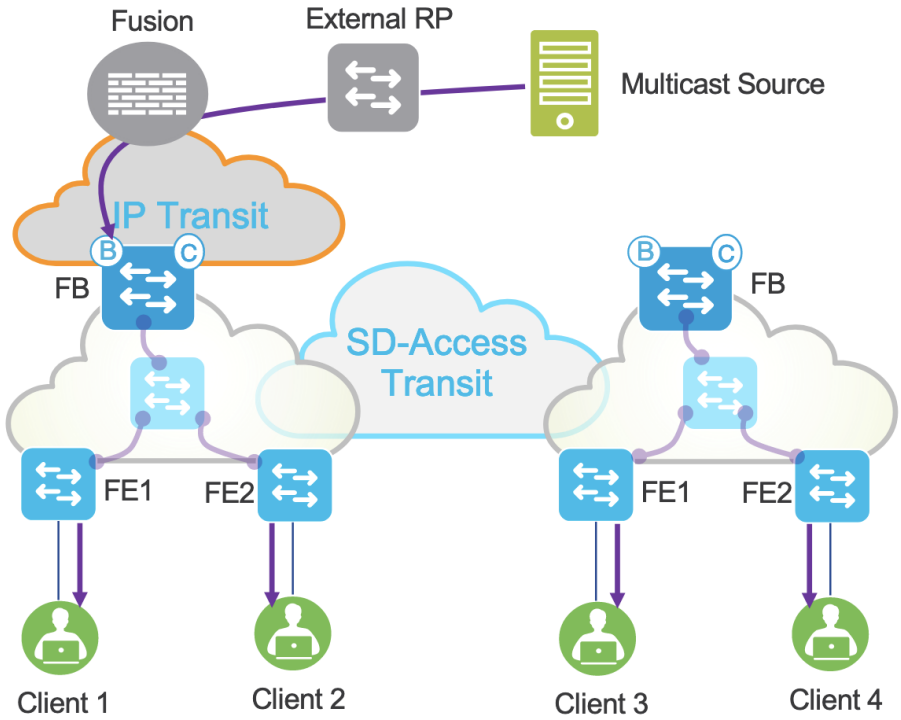
Workflow



Multicast over SDA Transit

Multicast in SDA

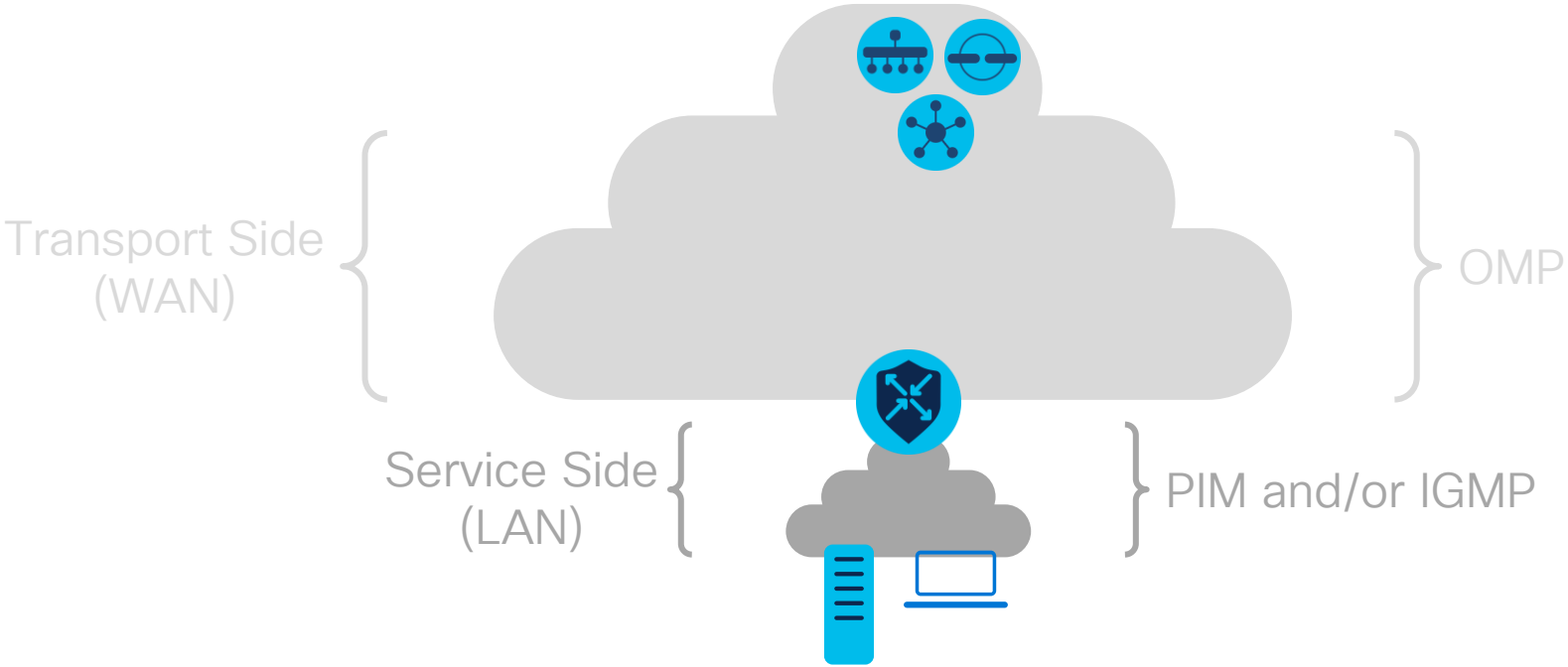
- No support if the RP is within any Fabric site (internal RP).
- Supported only if VN from all the fabric sites has same External RP address.
- For every fabric site running multicast with SDA Transit, a unique multicast address pool needs to be assigned to the respective VN.
- All the Fabric sites should run either Native Multicast or Head-End Replication but not the combination of both.



Multicast in SDWAN

Overview

Multicast in SDWAN



Roles
Multicast in SDWAN

WAN-Edge

- TLOC advertisement
- OMP multicast-Autodiscover
- OMP multicast-route
- VPN

vSmart

- Control Plane
- Connects PIM domains
- Policy*

Replicator

- Unicast replication
- Optimise MDT
- Strategic placement (CPU/bandwidth/Geo)

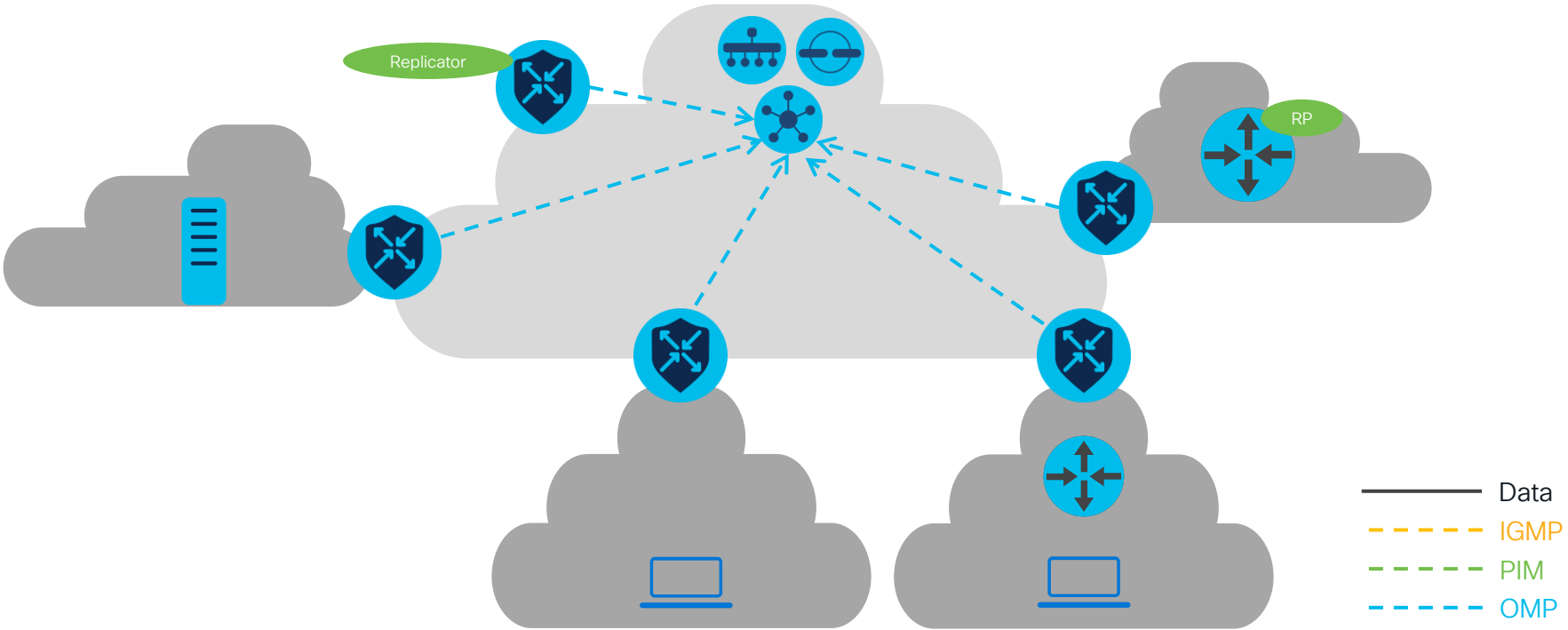
PIM neighbour

- Service-Side
- PIMv2
- First-Hop-Router
- IGMPv2/ IGMPv3*

Control Plane

Multicast in SDWAN

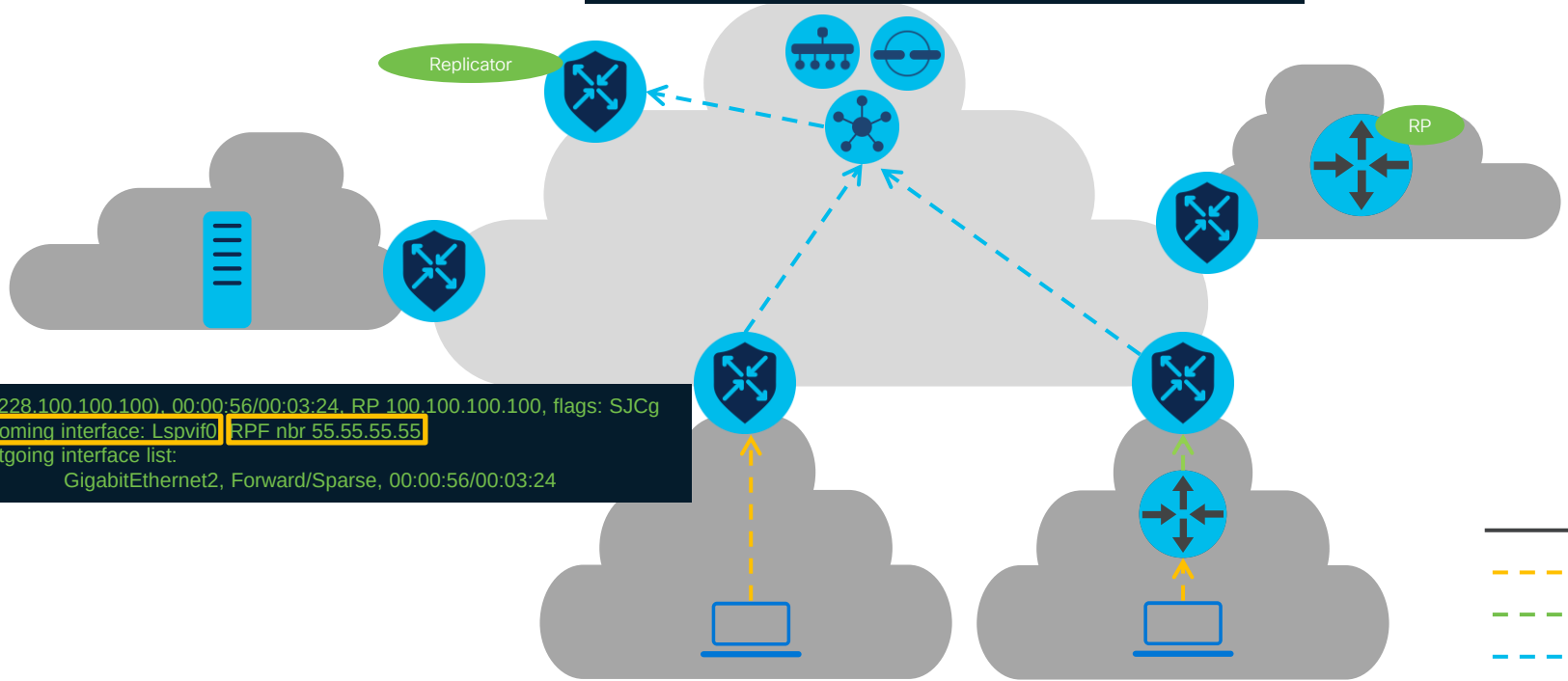
```
vSmart_1# show omp multicast-auto-discover detail

ADDRESS                SOURCE
FAMILY   VPN           ORIGINATOR       FROM PEER        STATUS        TO PEER
-------------------------------------------------------------------------------
ipv4     10            100.100.1.1      100.100.1.1      C,R           100.100.10.2
                                                                       100.100.100.2
```



Control Plane

Multicast in SDWAN

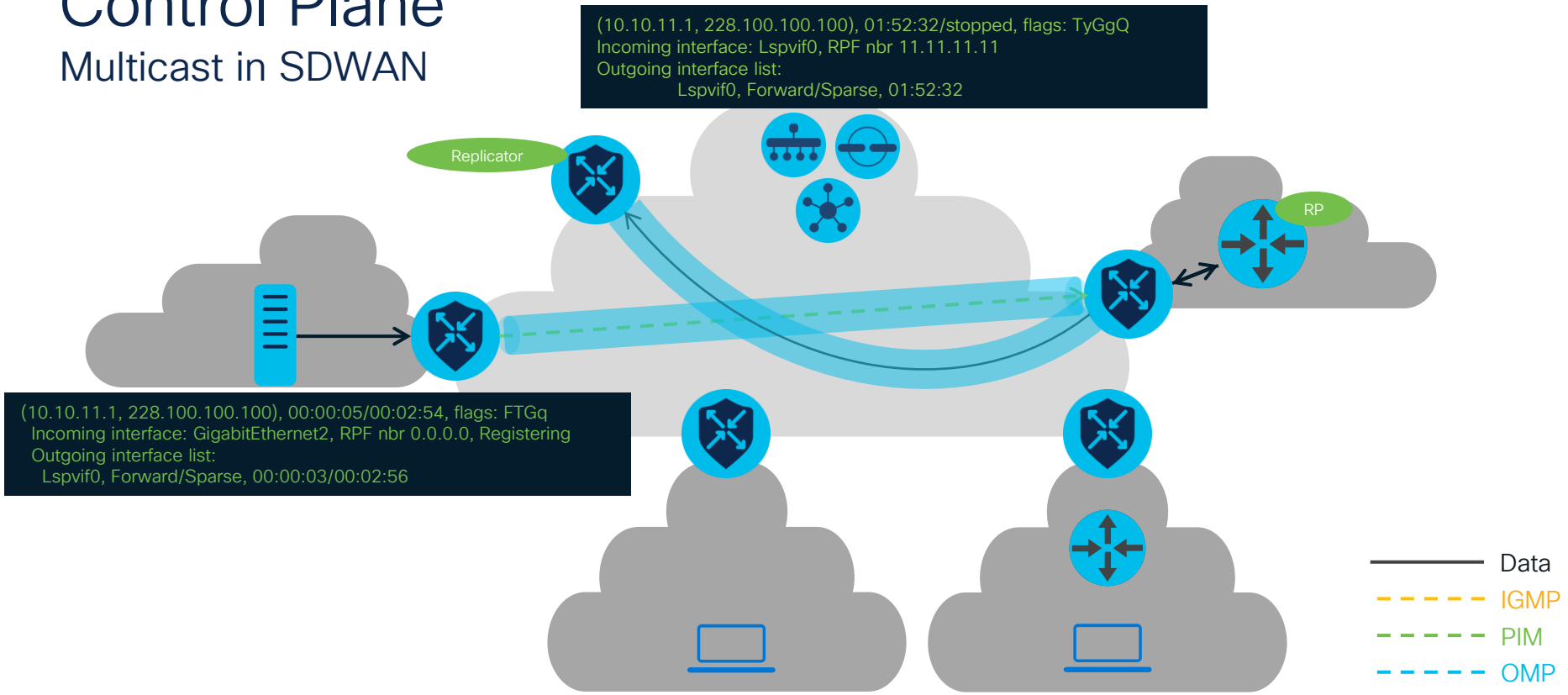
```
(*, 228.100.100.100), 00:01:23/00:01:36, RP 100.100.100.100, flags: SGg
Incoming interface: Lspvif0, RPF nbr 31.31.31.31
Outgoing interface list:
        Lspvif0, Forward/Sparse, 00:01:23/00:01:36
```




```
(*, 228.100.100.100), 00:00:56/00:03:24, RP 100.100.100.100, flags: SJCg
Incoming interface: Lspvif0, RPF nbr 55.55.55.55
Outgoing interface list:
        GigabitEthernet2, Forward/Sparse, 00:00:56/00:03:24
```

Control Plane

Multicast in SDWAN

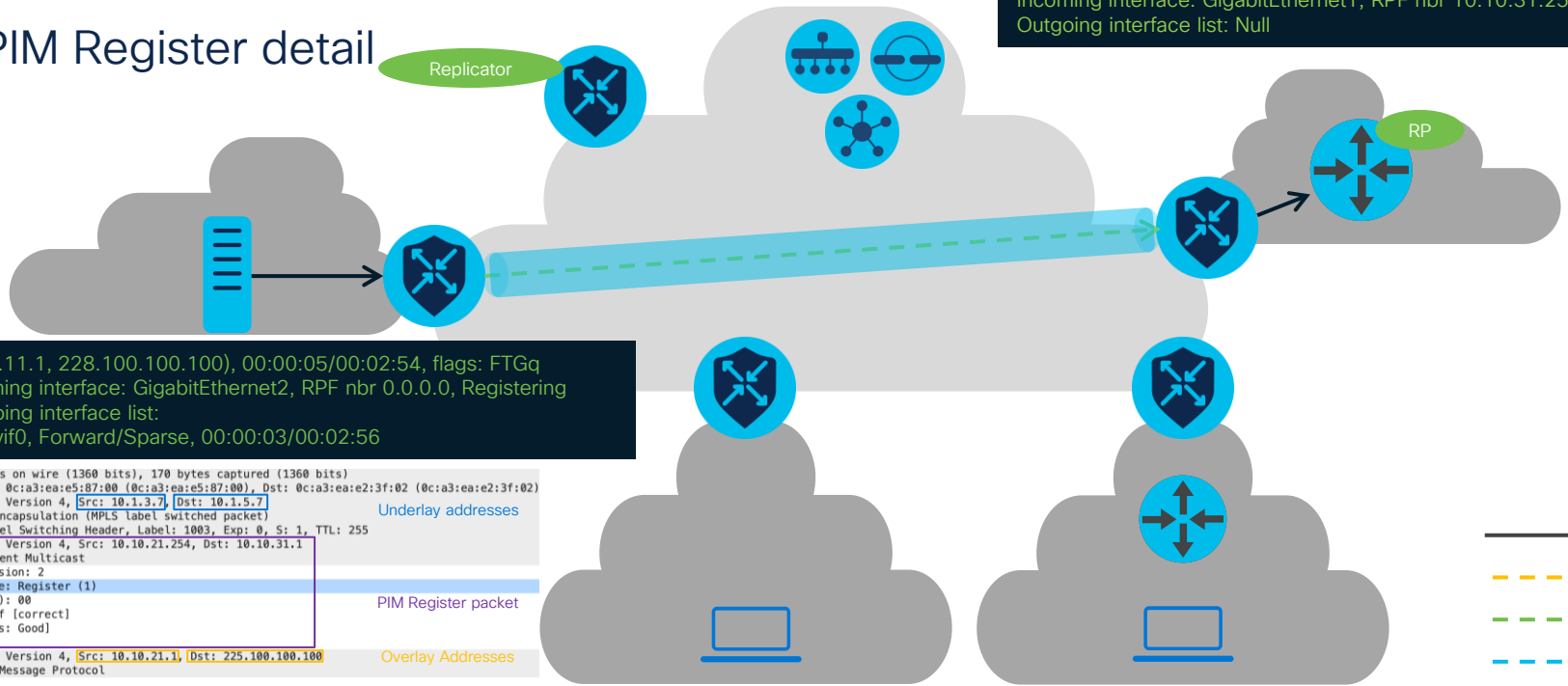


Control Plane

Multicast in SDWAN

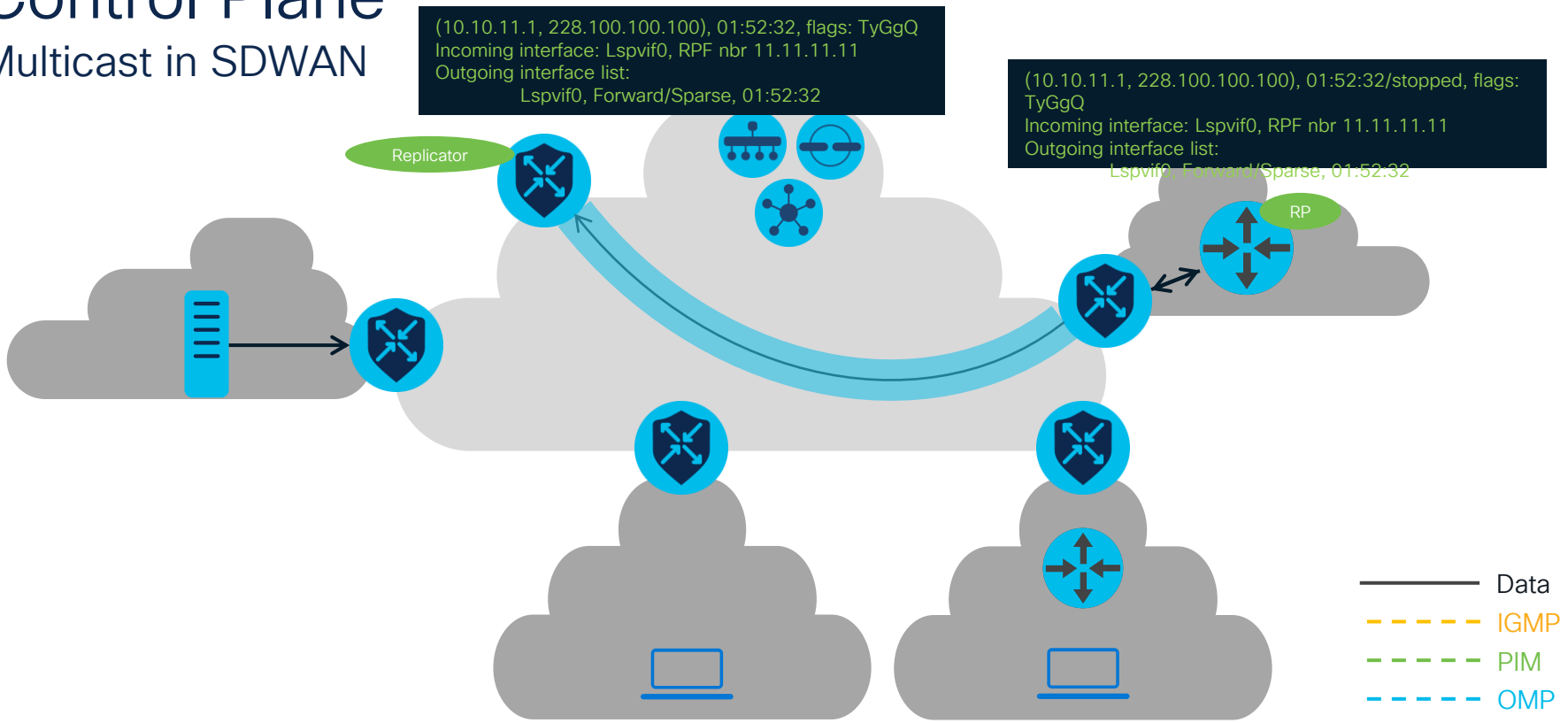
PIM Register detail

```
(*, 225.100.100.100), 1d02h/stopped, RP 10.10.31.1, flags: S
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
   GigabitEthernet1, Forward/Sparse, 1d00h/00:02:38

(10.10.21.1, 225.100.100.100), 00:00:03/00:02:58, flags: PTX
Incoming interface: GigabitEthernet1, RPF nbr 10.10.31.254
Outgoing interface list: Null
```



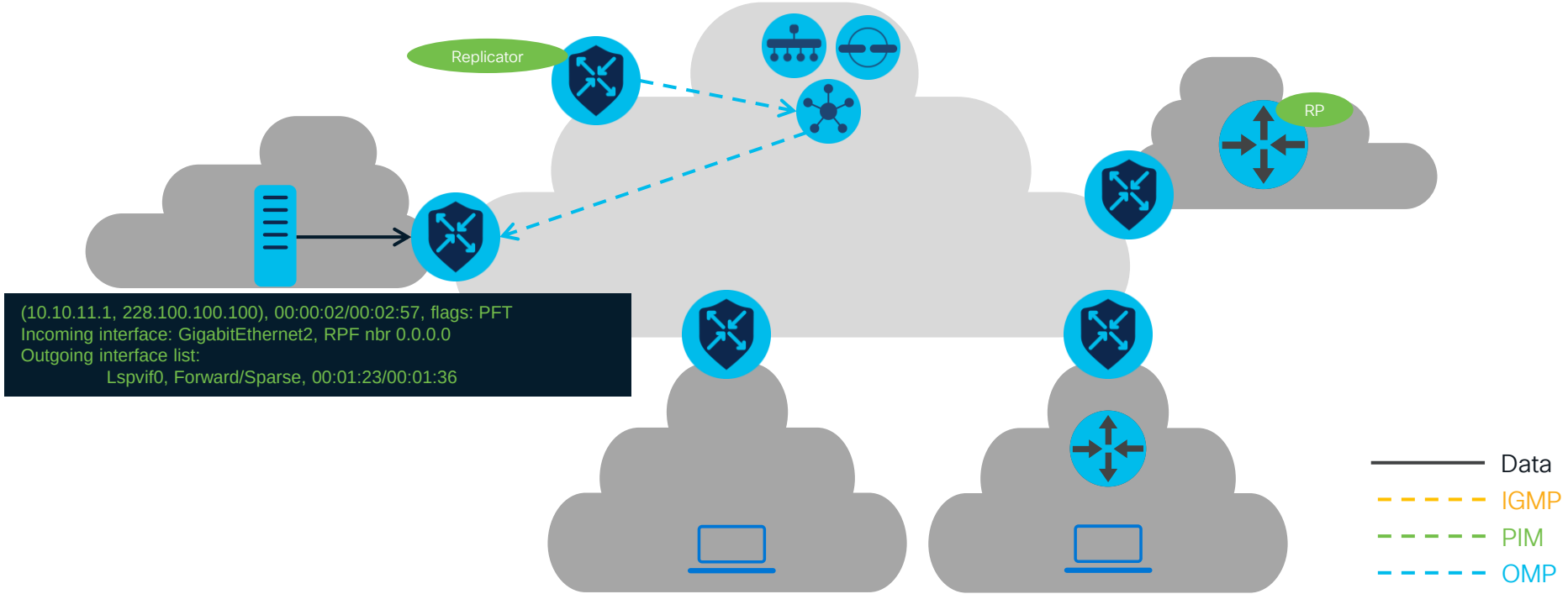
Control Plane

Multicast in SDWAN



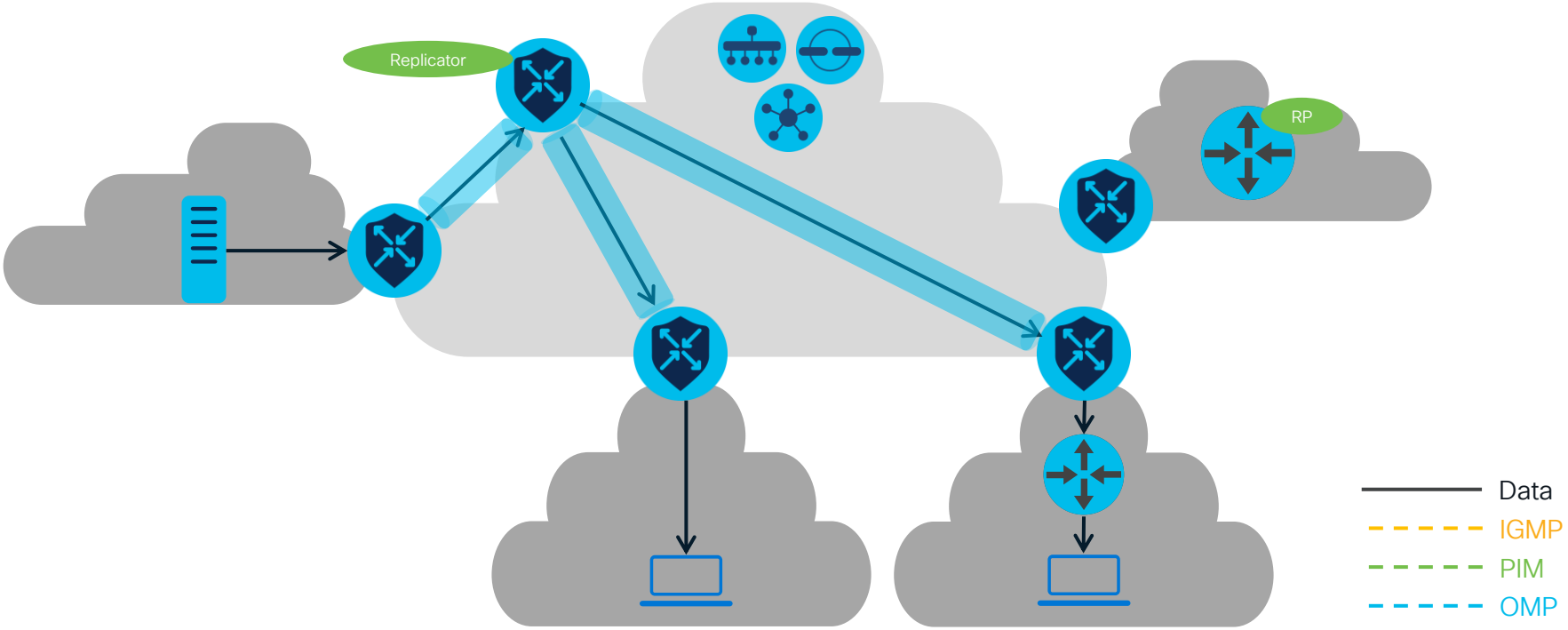
Control Plane

Multicast in SDWAN



Data Plane

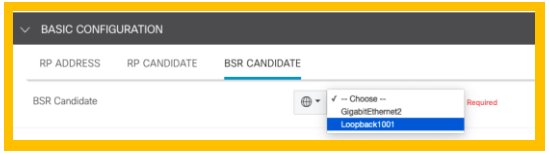
Multicast in SDWAN

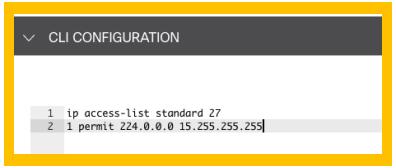


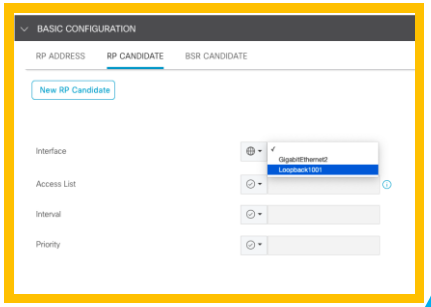
Multicast Configuration - Prerequisites

Multicast in SD-WAN

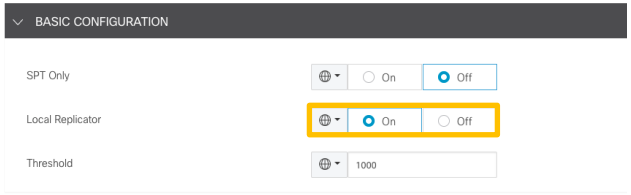
Group-RP mapping



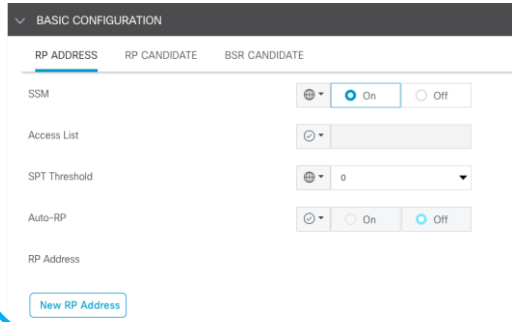




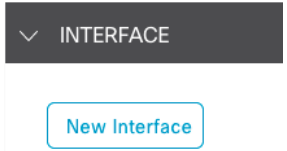
The multicast template:



PIM options:



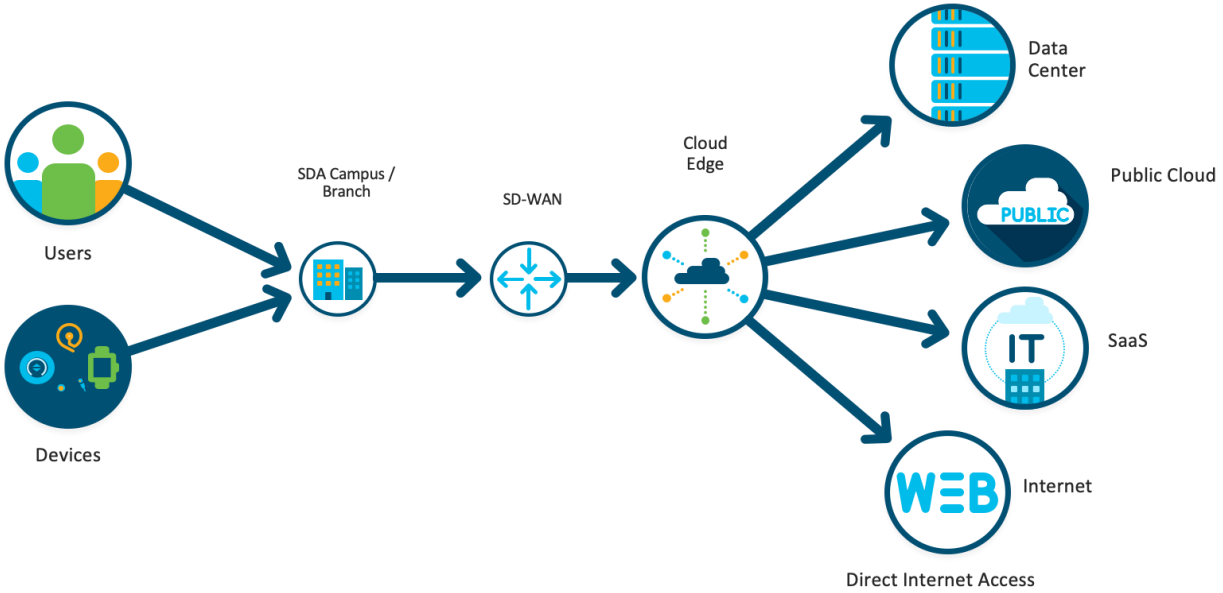
+



Multicast in Multidomain (SDA & SDWAN)

End-to-end Segmented Network Architecture

Multicast in Multidomain



Bring "Context – Segmentation and Policy" to entire enterprise

Definition of Domains

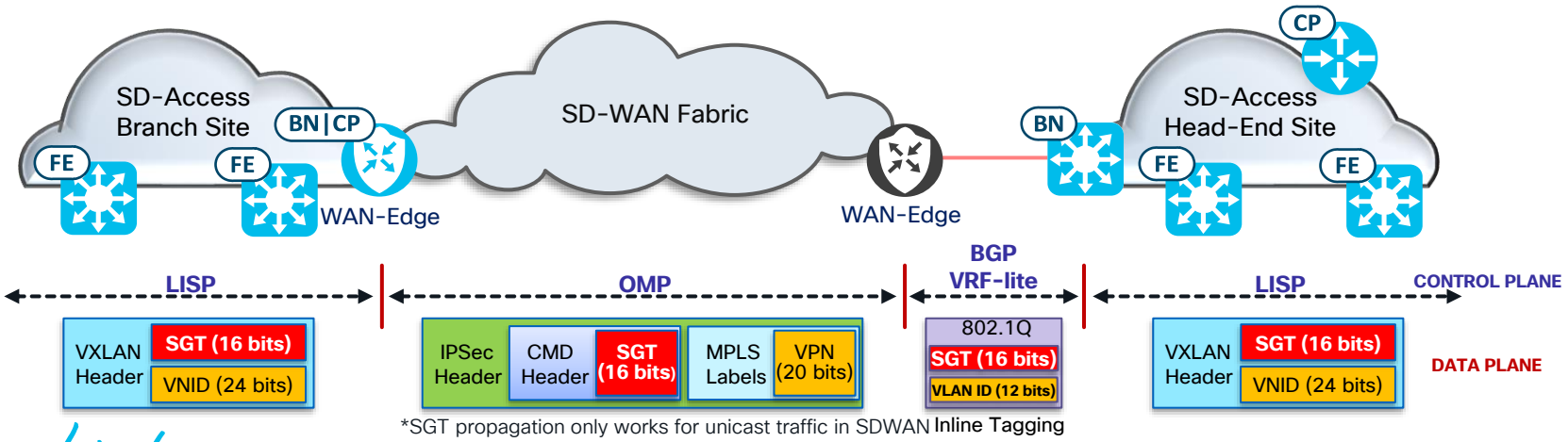
Multicast in Multidomain

Integrated Domains
"One-box" solution

Preferred for Branches

Independent Domains
"Two-box" solution

Preferred for Head-End Sites



Definition of Domains

Multicast in Multidomain

Integrated Domains
“One-box” solution

Ease of management:
Cisco DNA Center -
vManage integrated

End-to-end automation
(including SD-Access VN
to SD-WAN VPN mapping)

✗ Multicast is not supported

Independent Domains
“Two-box” solution

Flexibility and independent
controllers

Deployment and operational
simplicity: Software upgrades
and maintenance

✓ **IPv4 Multicast is supported**

(Cisco DNA Center ≥2.1.2.6
IOS XE ≥17.3.3)

SD-WAN Forwarding Interoperability

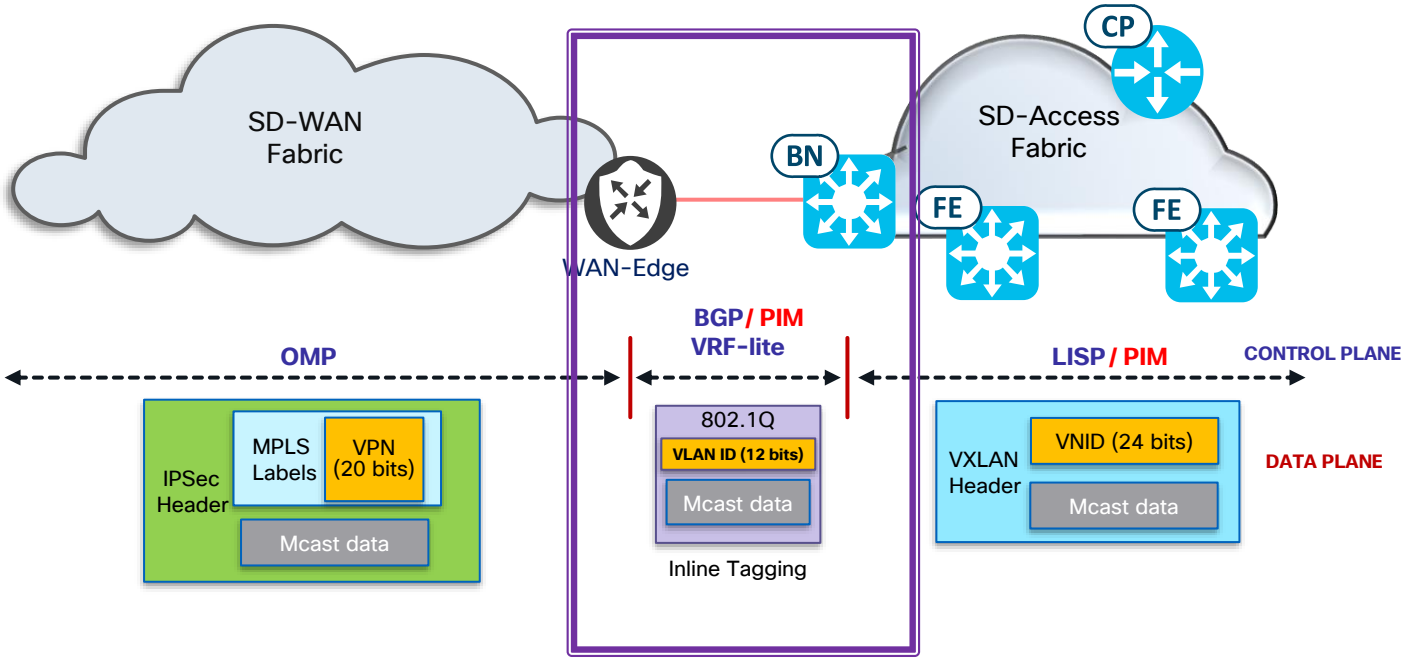
Multicast in Multidomain

Traffic From \ Traffic To	≥IOS XE 17.3.x SD-WAN (CTS[1] Enabled)	≥IOS XE 17.3.x SD-WAN (CTS[1] **NOT** Enabled)	<IOS XE 17.2.x SD-WAN	Colocated SD-Access IOS XE WAN Edge	vEdge Router
≥IOS XE 17.3.x SD-WAN (CTS[1] Enabled)	SGT carried in MDATA Header.	IP and SGT are carried; SGT is discarded.	Traffic is sent without SGT.	SGT carried in MDATA Header.	Traffic is sent without SGT.
≥IOS XE 17.3.x SD-WAN (CTS[1] **NOT** Enabled)	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.
<IOS XE 17.2.x SD-WAN	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.
Colocated SD-Access IOS XE WAN Edge	SGT carried in MDATA Header.	IP and SGT are carried; SGT is discarded.	Traffic is sent without SGT.	SGT carried in MDATA Header.	Traffic is sent without SGT.
vEdge Router	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.	Traffic is sent without SGT.

[1] Cisco TrustSec

Multicast forwarding in “Two-box” deployments

Multicast in Multidomain



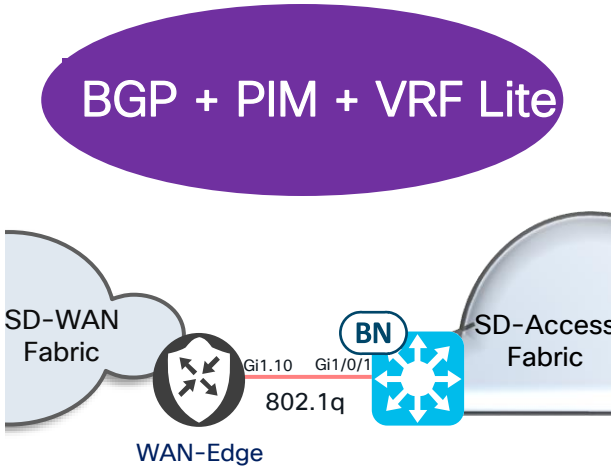
Basic config in “Two-box” deployments

Multicast in Multidomain

```
hostname cEdge
!
vrf definition Corporate
 rd 1:4088
 address-family ipv4
  route-target export 1:4088
  route-target import 1:4088
!
ip multicast-routing
ip multicast-routing vrf Corporate
!
```

```
interface GigabitEthernet1
 no ip address
!
interface GigabitEthernet1.10
 vrf forwarding Corporate
 encapsulation dot1Q 10
 ip address 10.10.10.1 255.255.255.252
 ip pim sparse-mode
!
```

```
router bgp 65001
 <snip>
  address-family ipv4 vrf Corporate
   neighbor 10.10.10.2 remote-as 65002
   neighbor 10.10.10.2 update-source GigabitEthernet1.10
   neighbor 10.10.10.2 activate
```




```
hostname SDA-Border
!
vrf definition Corporate
 rd 1:4099
 address-family ipv4
  route-target export 1:4099
  route-target import 1:4099
!
ip multicast-routing
ip multicast-routing vrf Corporate
!
```

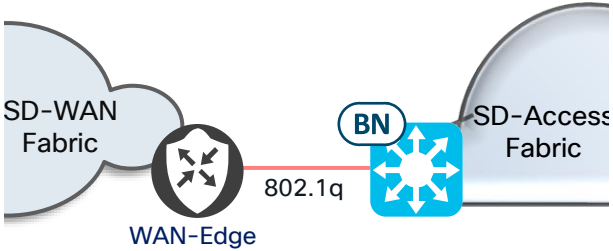
```
vlan 10
!
interface GigabitEthernet1/0/1
  switchport mode trunk
!
interface Vlan10
  vrf forwarding Corporate
  ip address 10.10.10.2 255.255.255.252
  ip pim sparse-mode
!
```

```
router bgp 65002
 <snip>
  address-family ipv4 vrf Corporate
   neighbor 10.10.10.1 remote-as 65001
   neighbor 10.10.10.1 update-source Vlan10
   neighbor 10.10.10.1 activate
```

Packet capture in 802.1q link

Multicast in Multidomain

Multicast data packet from multicast Source to multicast destination Group



vlan 10

Multicast group

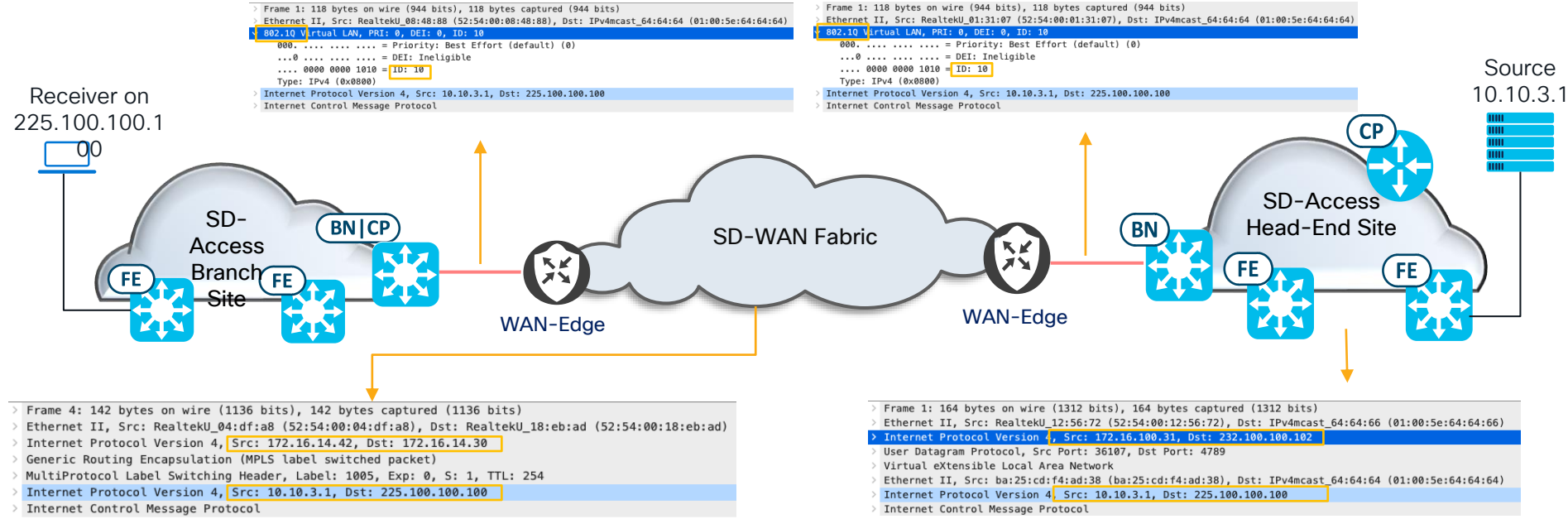
```
> Frame 1: 118 bytes on wire (944 bits), 118 bytes captured (944 bits)
> Ethernet II, Src: RealtekU_01:31:07 (52:54:00:01:31:07), Dst: IPv4mcast_64:64:64 (01:00:5e:64:64:64)
> 802.1Q Virtual LAN, PRI: 0, DEI: 0, ID: 10
    000. .... .... .... = Priority: Best Effort (default) (0)
    ...0 .... .... .... = DEI: Ineligible
    .... 0000 0000 1010 = ID: 10
    Type: IPv4 (0x0800)
> Internet Protocol Version 4, Src: 172.16.10.1 Dst: 225.100.100.100
> Internet Control Message Protocol
```

802.1q encapsulation

Multicast source

End-to-end packet walk

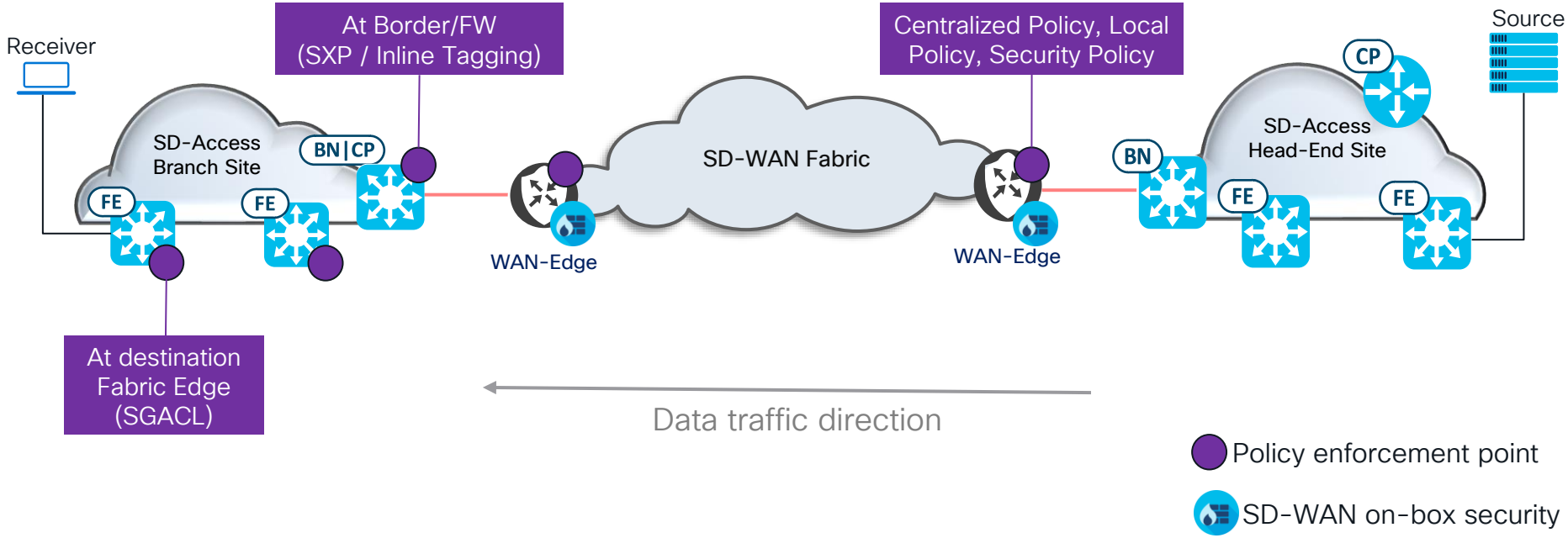
Multicast in Multidomain



*IPSec encapsulation disabled for WAN interfaces (not recommended!)

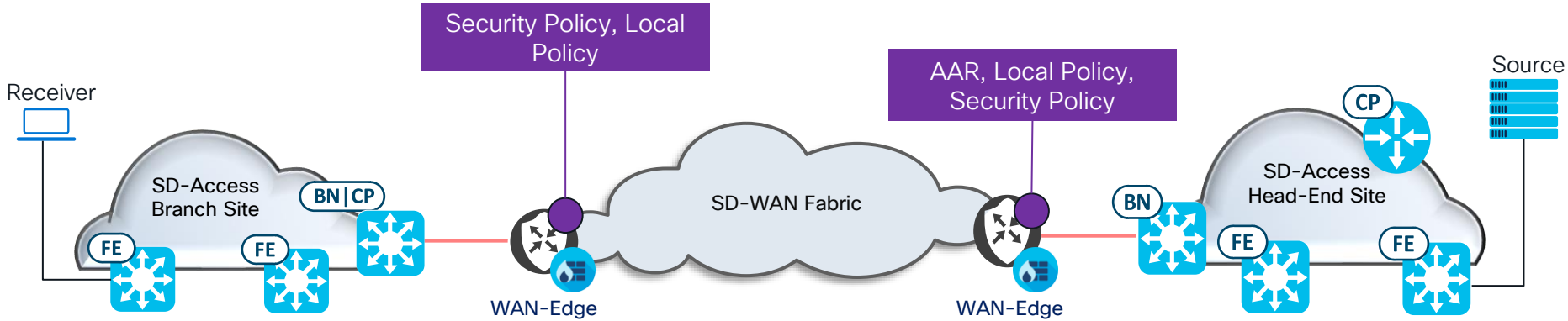
Policy enforcement – Unicast

Multicast in Multidomain



Policy enforcement – Multicast

Multicast in Multidomain



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LABENT-2348 - Introduction to Multicast in SD-Access

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