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a Hewlett Packard Enterprise company

AOS-CX MULTICAST DEPLOYMENT AND TROUBLESHOOTING GUIDE

Contents

Introduction

This document provides guidance on deploying and troubleshooting an IPv4 or IPv6 multicast Campus or Data Center (DC) network based on AOS-CX switches.

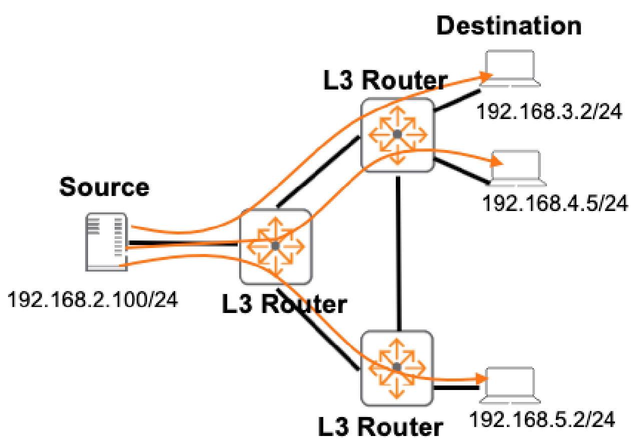
Multicast fundamentals will also be covered in order to have a foundation to deploy and troubleshoot multicast networks correctly.

Multicast Fundamentals

Multicast Overview

Multicast provides efficient one-to-many or many-to-many communication among hosts on a network. Typical applications of multicast communication include: audio and video streaming, desktop conferencing, collaborative computing, and similar applications.

Figure 1. Multiple unicast streams



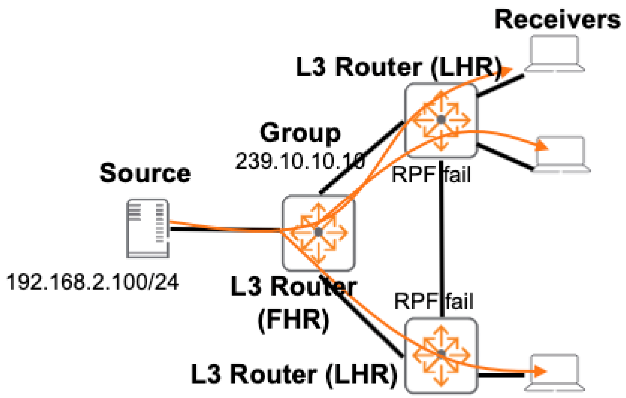
As shown in Figure 1:

- Unicast is an inefficient and non scalable method of sending duplicate copies of the same data
- Traffic is replicated and sent from source to multiple destination IPs
- Uses unicast routing table based on destinations
    - Source needs to have unicast routes to destinations

As shown in Figure 2:

- Multicast provides efficient bandwidth utilization when sending the same data (no duplicate)
- Traffic is sent from Source to multicast Group (S, G)
- Uses multicast routing table based on source
    - Receivers need to have a unicast route to source
    - Multicast routing uses Reverse Path Forwarding (RPF) based on unicast routing table to discard packets and avoid loops
- Receivers must join a group to receive its data
- Sources do not need to join a group to send to a group
- Receivers are able to receive data from source even if source does not have a unicast route to the receivers

Figure 2. Single multicast stream



- These are important acronyms that will be used throughout the guide
  - FHR = First Hop Router attached to source subnet
  - LHR = Last Hop Router attached to receiver subnet

Multicast Addressing

For IPv4 multicast, the 224.0.0.0/4 range is used and the 239.0.0.0/8 address range is recommended for multicast usage within an administratively scoped domain (e.g. a private network). 01-00-5E-00-00-00 through 01-00-5E-7F-FF-FF is the Ethernet MAC range used to forward IPv4 multicast traffic on L2 switches.

For IPv6 multicast, the ff00::/8 range is used and the ffx8::/16 address range is recommended for multicast usage within an administratively scoped domain. 33-33-00-00-00-00 through 33-33-FF-FF-FF-FF is the Ethernet MAC range used to forward IPv6 multicast traffic on L2 switches.

The multicast group IPs are inserted into multicast MAC addresses, take note that Group IP to Ethernet address overlaps are possible, e.g. 224.1.1.1, 225.1.1.1, 238.1.1.1, 239.1.1.1 are mapped to 0100.5E01.0101.

Host-Router Signaling

Internet Group Management Protocol (IGMP) is used by IPv4 receivers/hosts to inform L3 routers about group membership (which groups they are interested in joining) as shown in Figure 3.

Routers solicit group membership from directly connected hosts by sending IGMP queries if hosts are still interested in a group.

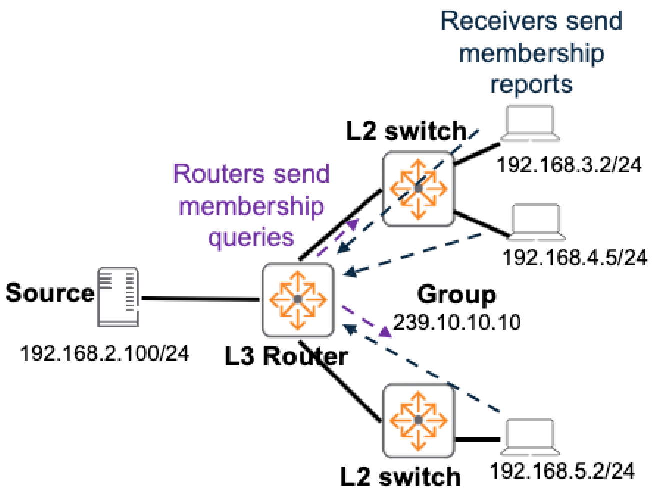
These are the IGMP versions and their main differences:

- IGMP Version 1
  - No notification mechanism to leave group
- IGMP Version 2
  - Notification mechanism to leave group
- IGMP Version 3
  - Notification mechanism to leave group
  - Ability to specify source IP of the group

Multicast Listener Discovery (MLD) is the IPv6 equivalent of IPv4 IGMP.

MLD version 2 is the equivalent of IGMP version 3.

Figure 3. Host-Router Signaling



For IPv4, default IGMP version 3 in AOS-CX is recommended.

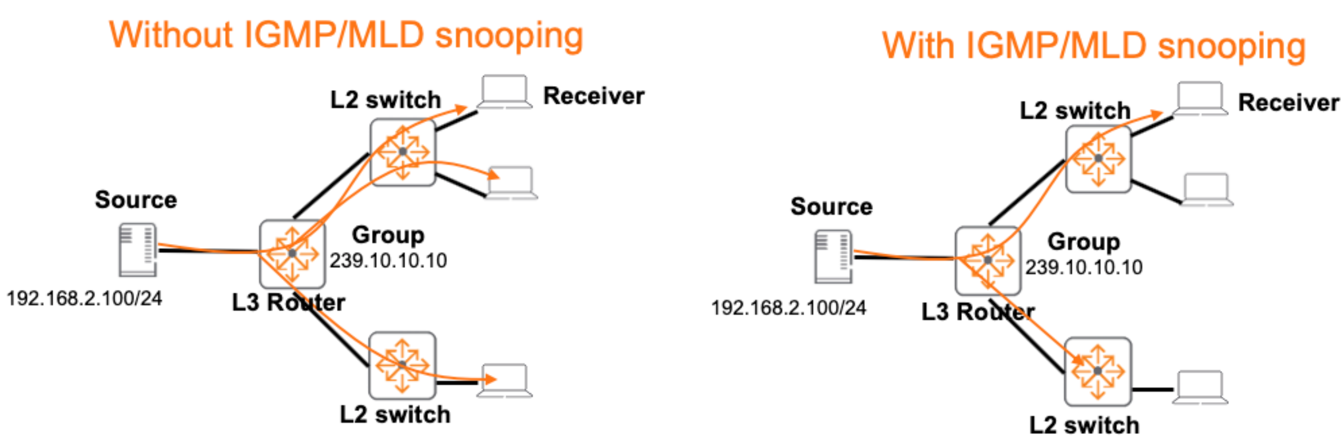
For IPv6, default MLD version 2 in AOS-CX is recommended.

IGMP version 3/ MLD version 2 are compatible with receivers who do not specify their desired source when joining a group.

IGMP/MLD Snooping

IGMP/MLD snooping is a multicast constraining mechanism that runs on L2 switches to manage and control multicast groups as shown in Figure 4.

Figure 4. IGMP/MLD Snooping



Only hosts who want to be receivers will receive traffic from the multicast group, IGMP/MLD snooping is recommended on all AOS-CX L2 switches.

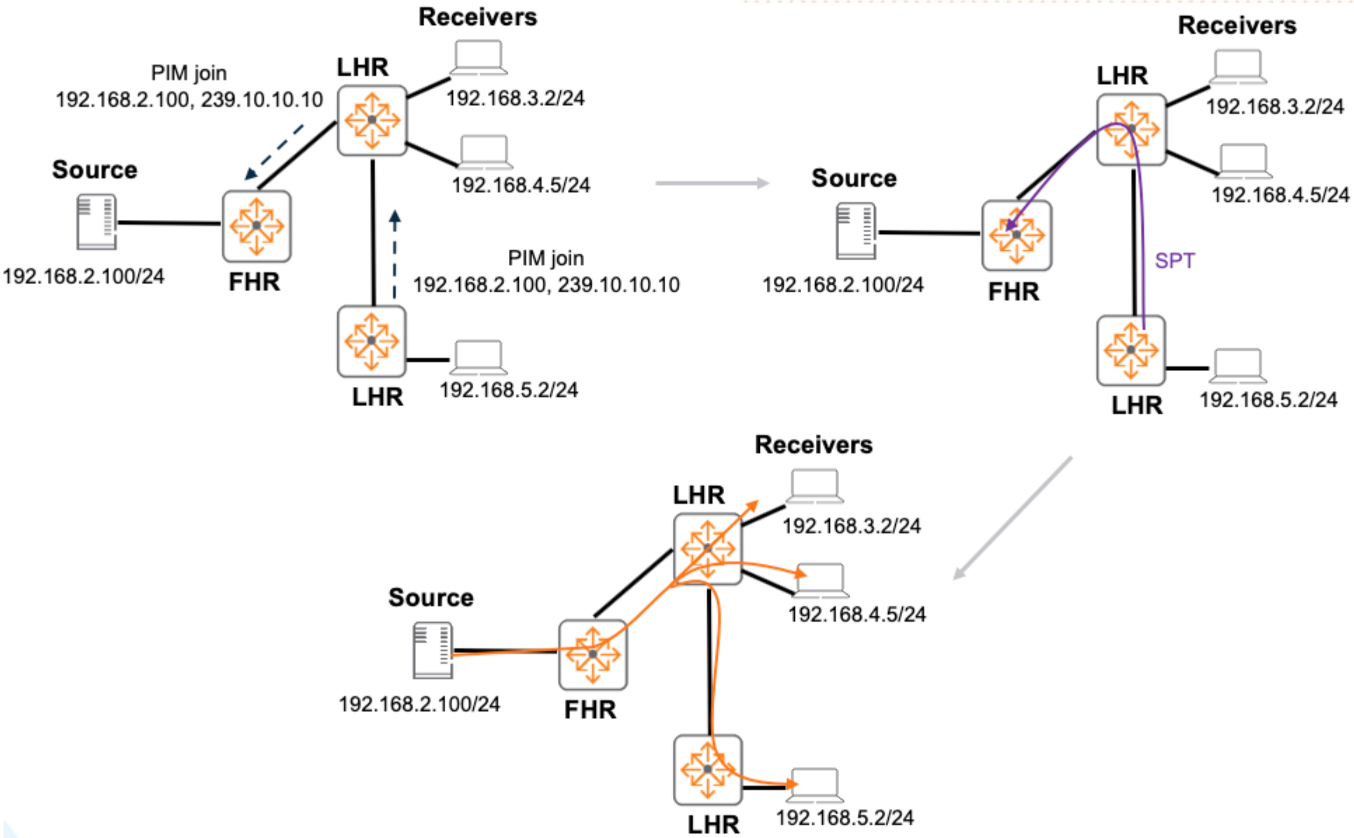
Router-Router Signaling

Multicast routers convert IGMP/MLD messages into Protocol Independent Multicast (PIM) joins to build a loop free multicast tree hop by hop toward the source as shown in Figure 5.

This is known as the Source Tree or Shortest Path Tree (SPT) as the source is known and the best route is used.

After the tree is built to the FHR, traffic from the active source will flow down the path towards the receivers

Figure 5. Router-Router Signaling



Rendezvous Point (RP)

RP is used when source is not specified (*, G) during an IGMP/MLD join or when PIM sparse mode (SM) is used as shown in Figure 6.

PIM SM is recommended for new deployments as PIM Dense Mode (DM) is considered legacy, doesn't use RP, uses flood/prune mechanism and is not recommended for new deployments. PIM DM should only be used when trying to interop with an existing PIM DM network.

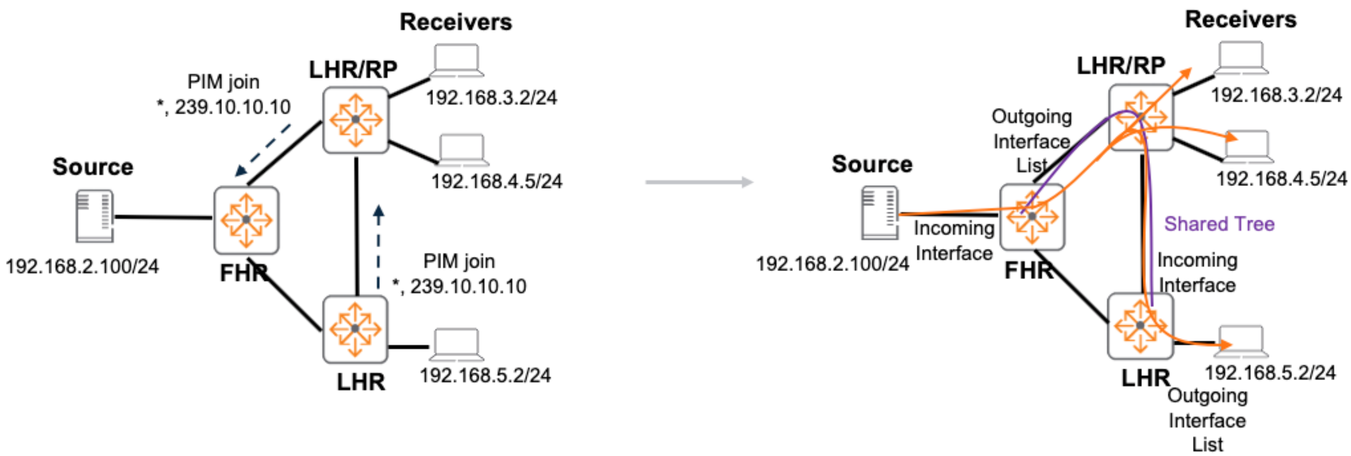
When a source starts sending traffic to FHR, it will register the source with the RP.

After PIM joins from LHR and source registers are sent from FHR, a shared tree is built to the RP from both LHR/FHR, traffic will flow down shared tree from source to receivers.

The incoming interface on FHR always points towards source while the incoming interface on non-FHR on a shared tree always points towards RP.

An outgoing interface list (OIL) is used on the path towards receivers.

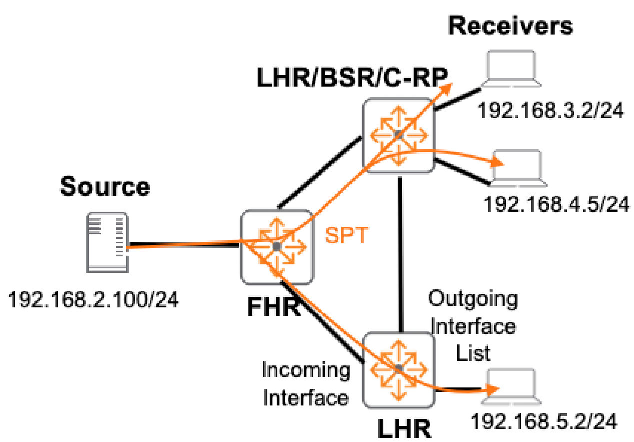
Figure 6. PIM SM, RP and shared tree



After some time, if SPT is available, traffic will switch over from shared tree to SPT as shown in Figure 7.

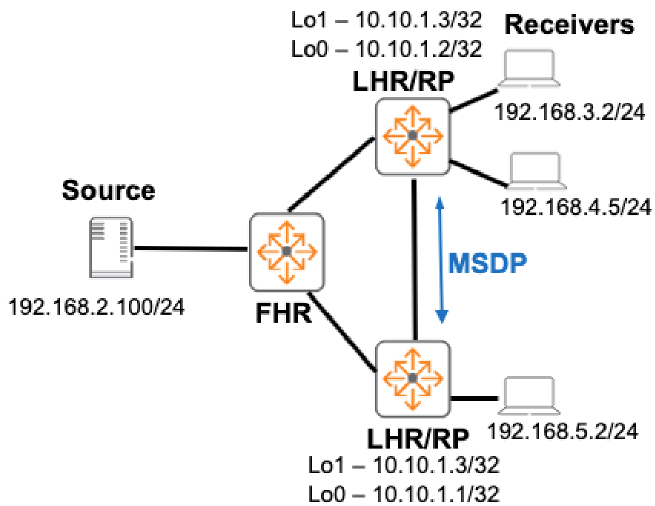
The incoming interface on non-FHR switches on a SPT always points towards source and the Boot Strap Router (BSR) protocol is used to advertise candidate RP (C-RP) info to all PIM routers.

Figure 7. PIM SM, RP and SPT



Multicast Source Discovery Protocol (MSDP) provides IPv4 RP redundancy within a multicast domain using anycast loopback addresses as shown in Figure 8. The RP in this example would be Lo1 (10.10.1.3/32) and MSDP peers would peer to each other using unique Lo0.

Figure 8. MSDP



For details on Multicast, refer to ArubaOS-CX Multicast Guide

Multicast Deployment Summary

The IPv4/IPv6 multicast deployment steps listed in this guide are applicable to both Campus and Data Center environments as LHR/FHR are generic terms used to describe the switches connected to sources and receivers, here is a summary of the deployment steps for a single domain multicast network as shown in Figure 9.

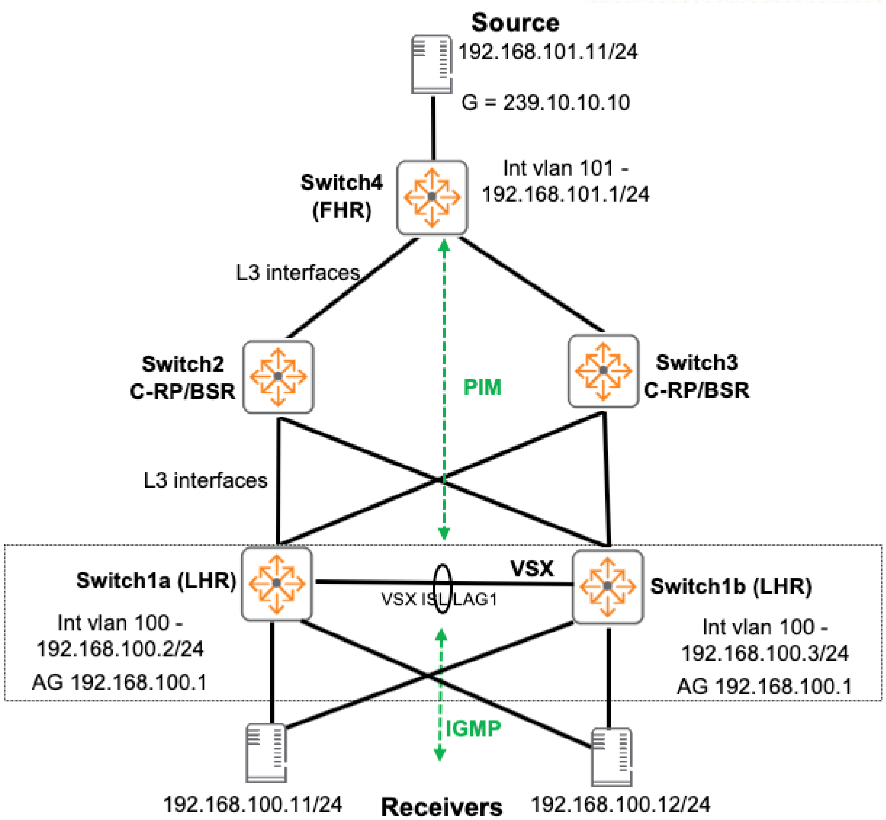
1. Deploy unicast routing (OSPF or BGP) throughout network
2. Enable PIM-SM/PIM6-SM on L3 interfaces between switches, towards source and receivers
3. Enable Candidate RPs (C-RP)
4. Enable MSDP for RP load sharing and redundancy (IPv4 only)
5. Enable BSR to advertise candidate RPs to all PIM routers
6. Enable IGMP/MLD on L3 interfaces towards receiver subnets
7. On VSX switches with VSX LAGs towards other PIM routers, enable PIM active-active to speed up switch failover
   - 1 VSX switch acting as a proxy-DR (Designated Router) monitors DR failure
   - Both DR and proxy DR VSX switches maintain the same multicast tables and build the multicast tree
   - Upon detecting DR failure, proxy-DR changes role to DR, forwards traffic downstream to PIM router on VSX LAG
8. Enable IGMP/MLD snooping on L2 switches

Multicast sources typically originate from the DC, but could also start from campus networks depending on the application, Switch4 (FHR) in the topology could represent access switches in a campus network or ToR (Top of Rack) switches in a DC network.

C-RP/BSR would typically be enabled on the core switches in a campus network or core/spine switches in a DC network, these are shown as Switch2/3 in the topology.

Multicast receivers are typically connected to access switches in a campus network or ToR switches in a DC network, these are shown as Switch1a/1b (LHR) in the topology. In campus access switches, VSX is not typically enabled as the majority of campus hosts/devices do not have dual homing capability, the sample configs are still applicable on Virtual Switching Framework (VSF) switch stacks or standalone switches (without VSX related configs).

Figure 9. Multicast topology



Take note, AOS-CX 10.4:

- Does not support IPv4 multi domain multicast routing using MSDP
- Does not support IPv6 multi domain multicast routing using embedded RP
- Does not support inter VRF multicast routing
- Does not support multicast routing on VXLAN/EVPN overlay networks

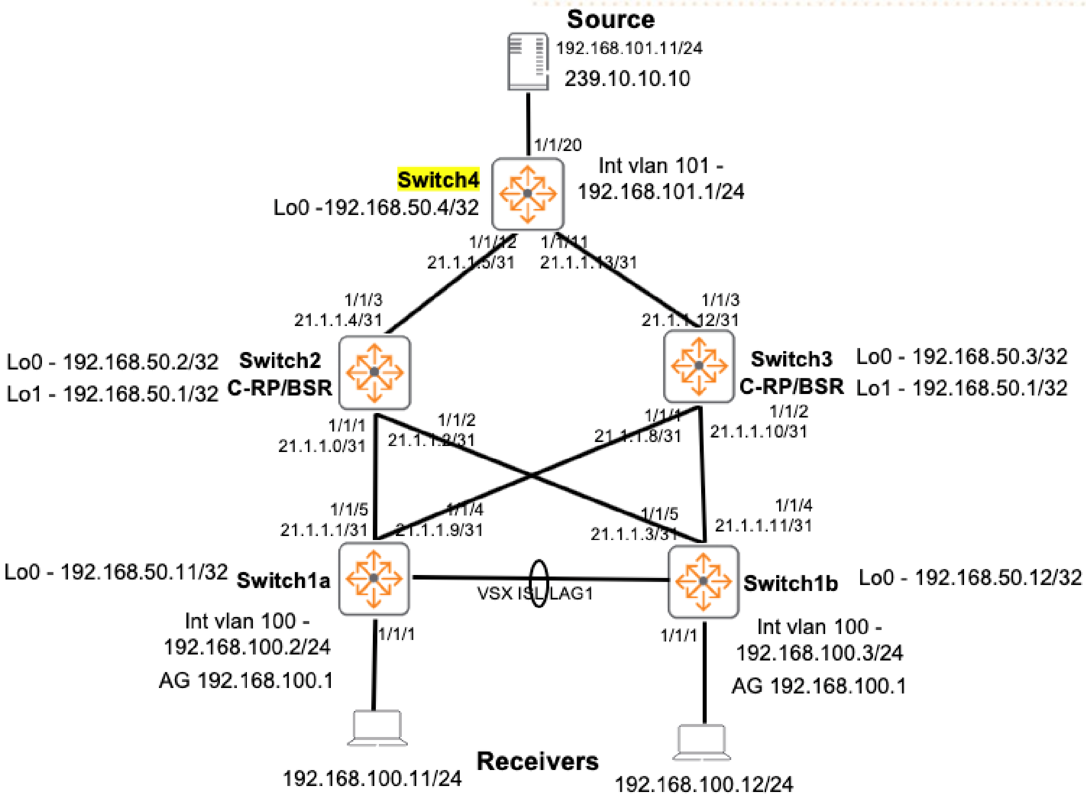
IPv4 Multicast Deployment

Switch4 (FHR) Sample Configs

These are the deployment steps required on Switch4 as shown in Figure 10.

1. Deploy unicast routing (OSPF or BGP) throughout network
2. Enable PIM-SM/PIM6-SM on L3 interfaces between switches, towards source and receivers

Figure 10. IPv4 multicast topology



Here are sample configs for Switch4.

```
vlan 101

router pim
 enable

router ospf 1
 router-id 192.168.50.4
 area 0.0.0.0

interface loopback 0
 ip address 192.168.50.4/32
 ip ospf 1 area 0.0.0.0

interface 1/1/20
 no shutdown
 no routing
 vlan access 101

interface 1/1/12
 no shutdown
 ip address 21.1.1.5/31
 ip ospf 1 area 0.0.0.0
 ip ospf network point-to-point
```

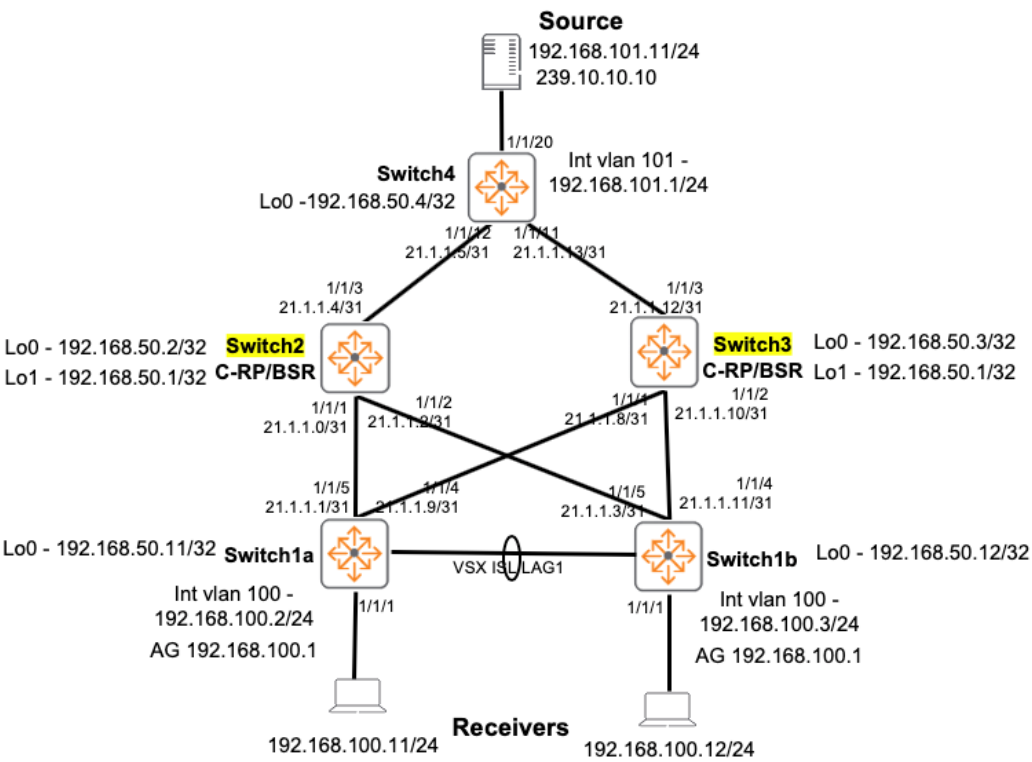
```
 ip pim-sparse enable
interface 1/1/11
 no shutdown
 ip address 21.1.1.13/31
 ip ospf 1 area 0.0.0.0
 ip ospf network point-to-point
 ip pim-sparse enable

interface vlan101
 ip address 192.168.101.1/24
 ip ospf 1 area 0.0.0.0
 ip ospf passive
 ip pim-sparse enable
! IGMP only required if receivers are expected on the subnet
! BOTH PIM/IGMP should be enabled if you are unsure
```

Switch2/3 (BSR/C-RP) Sample Configs

These are the deployment steps required on Switch2/Switch3 as shown in Figure 11.

1. Deploy unicast routing (OSPF or BGP) throughout network
2. Enable PIM-SM/PIM6-SM on L3 interfaces between switches, towards source and receivers
3. Create Candidate RPs (C-RP)
4. Enable MSDP for RP load sharing and redundancy (IPv4 only)
5. Enable BSR to advertise candidate RPs to all PIM routers

Figure 11. IPv4 multicast topology



Here are sample configs for Switch2.

Switch3 will have similar configs, except for the IPs.

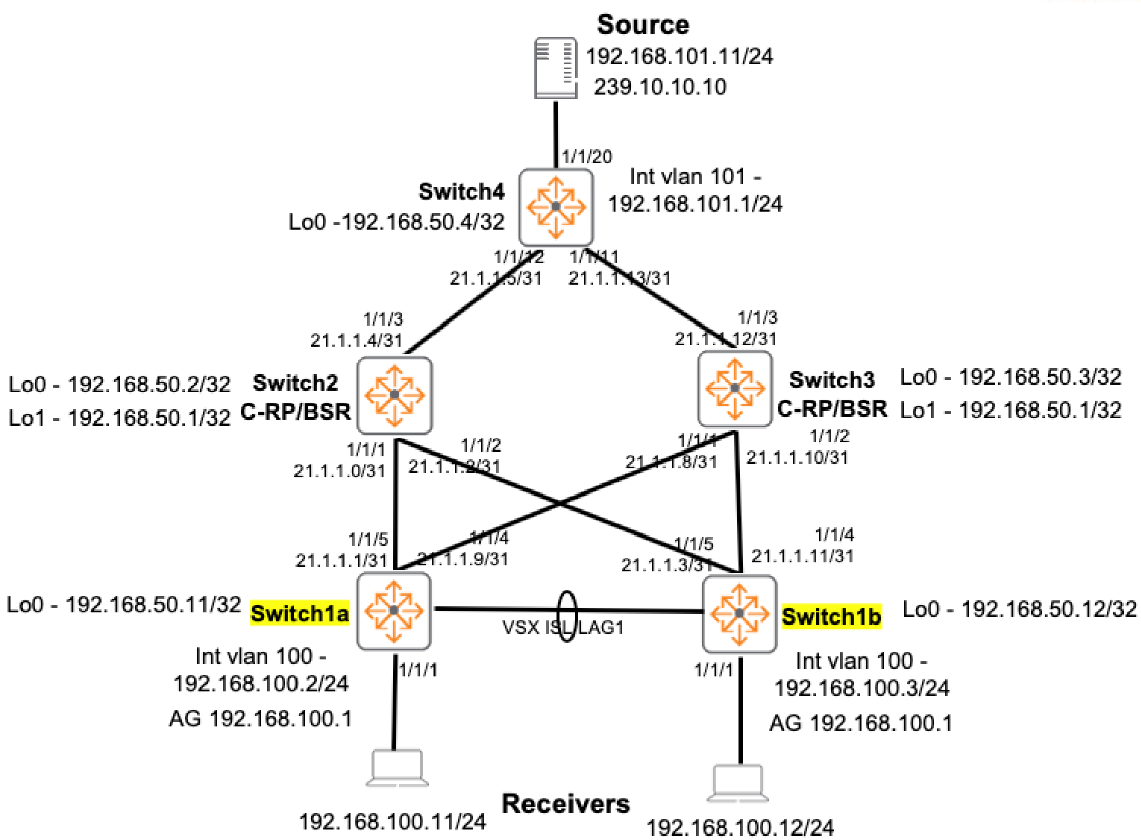
```
router ospf 1
 router-id 192.168.50.2
 area 0.0.0.0

interface loopback 0
 ip address 192.168.50.2/32
 ip ospf 1 area 0.0.0.0
 ip pim-sparse enable
! PIM only required on loopbacks of BSR/C-RP
interface loopback 1
 ip address 192.168.50.1/32
 ip ospf 1 area 0.0.0.0
 ip pim-sparse enable
! Anycast Loopback 1 IP

router pim
 enable
! Advertise RP using anycast Lo1
 rp-candidate source-ip-interface loopback1
 rp-candidate group-prefix 224.0.0.0/4
 bsr-candidate source-ip-interface loopback0
! Advertise BSR using unique Lo0

router msdp
 enable
  ip msdp peer 192.168.50.3
   connect-source loopback0
   enable
   mesh-group 1
! MSDP peer using Lo0
! Mesh group used to reduce Source Active message flooding

interface 1/1/1
 no shutdown
 ip address 21.1.1.0/31
 ip ospf 1 area 0.0.0.0
 ip ospf network point-to-point
 ip pim-sparse enable
interface 1/1/2
 no shutdown
 ip address 21.1.1.2/31
 ip ospf 1 area 0.0.0.0
 ip ospf network point-to-point
 ip pim-sparse enable
interface 1/1/3
 no shutdown
 ip address 21.1.1.4/31
 ip ospf 1 area 0.0.0.0
 ip ospf network point-to-point
 ip pim-sparse enable
```

Switch1a (LHR) Sample Configs

These are the deployment steps required on Switch1a/1b as shown in Figure 12.

1. Deploy unicast routing (OSPF or BGP) throughout network
2. Enable PIM-SM/PIM6-SM on L3 interfaces between switches, towards source and receivers
6. Enable IGMP/MLD on L3 interfaces towards receiver subnets
7. On VSX switches with VSX LAGs towards other PIM routers, enable PIM active-active to speed up switch failover
    - 1 VSX switch acting as a proxy-DR (Designated Router) monitors DR failure
    - Both DR and proxy DR VSX switches maintain the same multicast tables and build the multicast tree
    - Upon detecting DR failure, proxy-DR changes role to DR, forwards traffic downstream to PIM router on VSX LAG
8. Enable IGMP/MLD snooping on L2 switches

Figure 12. IPv4 multicast topology



Here are sample configs for Switch1a.

Switch1b will have similar configs, except for the IPs.

```
router pim
 enable
 active-active
! PIM active-active is recommended on VSX switches for fast PIM failover
```

```
vlan 100
 ip igmp snooping enable
! IGMP snooping for L2 switches with receivers

vlan 4000

interface 1/1/1
 no shutdown
 no routing
 vlan access 100

router ospf 1
 router-id 192.168.50.11
 area 0.0.0.0

interface loopback 0
 ip address 192.168.50.11/32
 ip ospf 1 area 0.0.0.0

interface 1/1/4
 no shutdown
 ip address 21.1.1.11/31
 ip ospf 1 area 0.0.0.0
 ip ospf network point-to-point
 ip pim-sparse enable
interface 1/1/5
 no shutdown
 ip address 21.1.1.3/31
 ip ospf 1 area 0.0.0.0
 ip ospf network point-to-point
 ip pim-sparse enable

interface vlan100
 ip address 192.168.100.2/24
 active-gateway ip mac 12:00:00:00:01:00
 active-gateway ip 192.168.100.1
 ip ospf 1 area 0.0.0.0
 ip ospf passive
 ip igmp enable
 ip pim-sparse enable
! VSX with active gateway

interface vlan4000
 description transit
 ip address 192.168.51.0/31
 ip ospf 1 area 0.0.0.0
 ip ospf network point-to-point
 ip pim-sparse enable
! Transit VLAN between VSX switches used for multicast routing if uplinks fail

interface lag 1
 no shutdown
 description ISL Link
 no routing
```

```
 vlan trunk native 1 tag
 vlan trunk allowed all
 lacp mode active
```

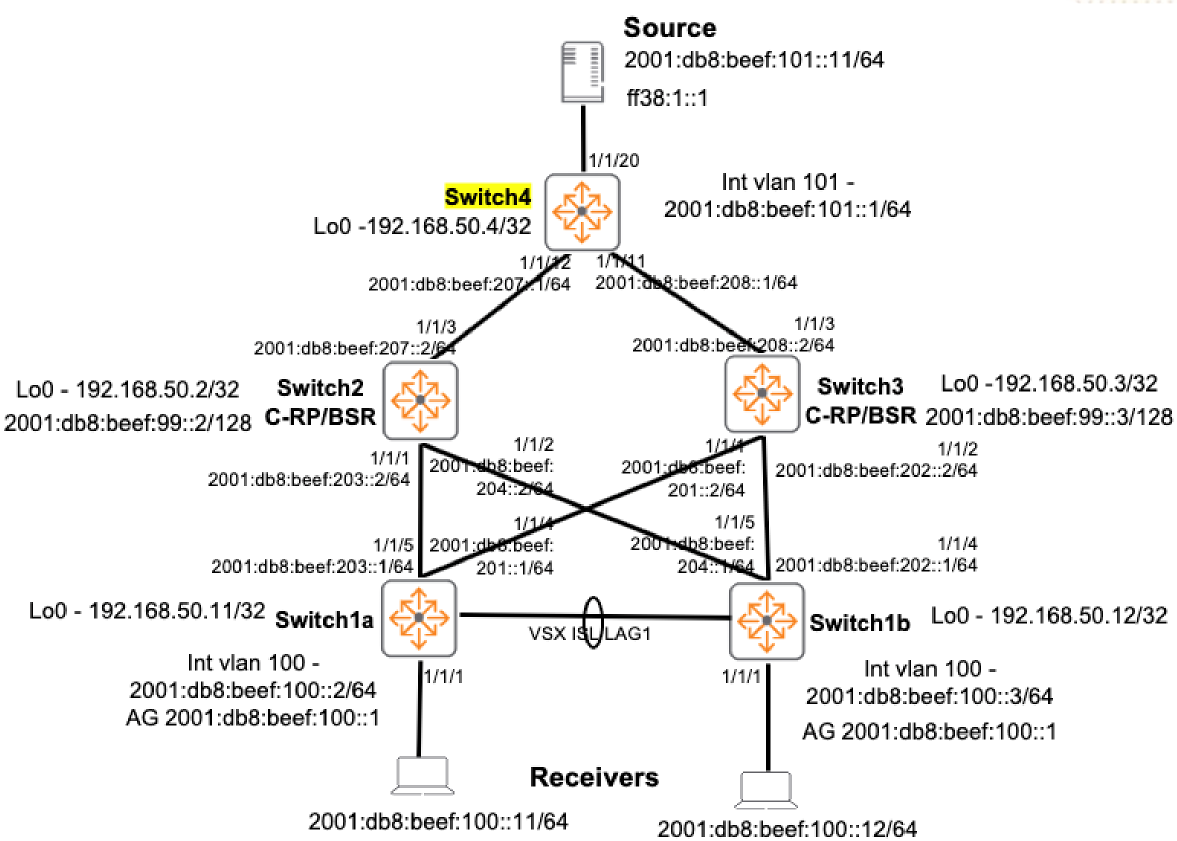
IPv6 Multicast Deployment

Switch4 (FHR) Sample Configs

These are the deployment steps required on Switch4 as shown in Figure 13.

1. Deploy unicast routing (OSPF or BGP) throughout network
2. Enable PIM-SM/PIM6-SM on L3 interfaces between switches, towards source and receivers

Figure 13. IPv6 multicast topology



Here are sample configs for Switch4.

```
router ospfv3 1
! ospfv3 requires IPv4 router ID
 router-id 192.168.50.4
 area 0.0.0.0

interface loopback 0
 ip address 192.168.50.4/32
```

```
vlan 101

router pim6
 enable

interface 1/1/11
 no shutdown
 ipv6 address 2001:db8:beef:208::1/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 network point-to-point
interface 1/1/12
 no shutdown
 ipv6 address 2001:db8:beef:207::1/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 network point-to-point
! Dual stack IPv4/IPv6 is typically used
! These are configs that would be added to the earlier IPv4 configs
! AOS-CX does not support PIM6-SM without IPv6 Global Unicast addresses

interface 1/1/20
 no shutdown
 no routing
 vlan access 101

interface vlan101
 ipv6 address 2001:db8:beef:101::1/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 passive
! MLD only required if receivers are expected on the subnet
! BOTH PIM6/MLD should be enabled if you are unsure
```

Switch2/3 (BSR/C-RP) Sample Configs

These are the deployment steps required on Switch2/Switch3 as shown in Figure 14.

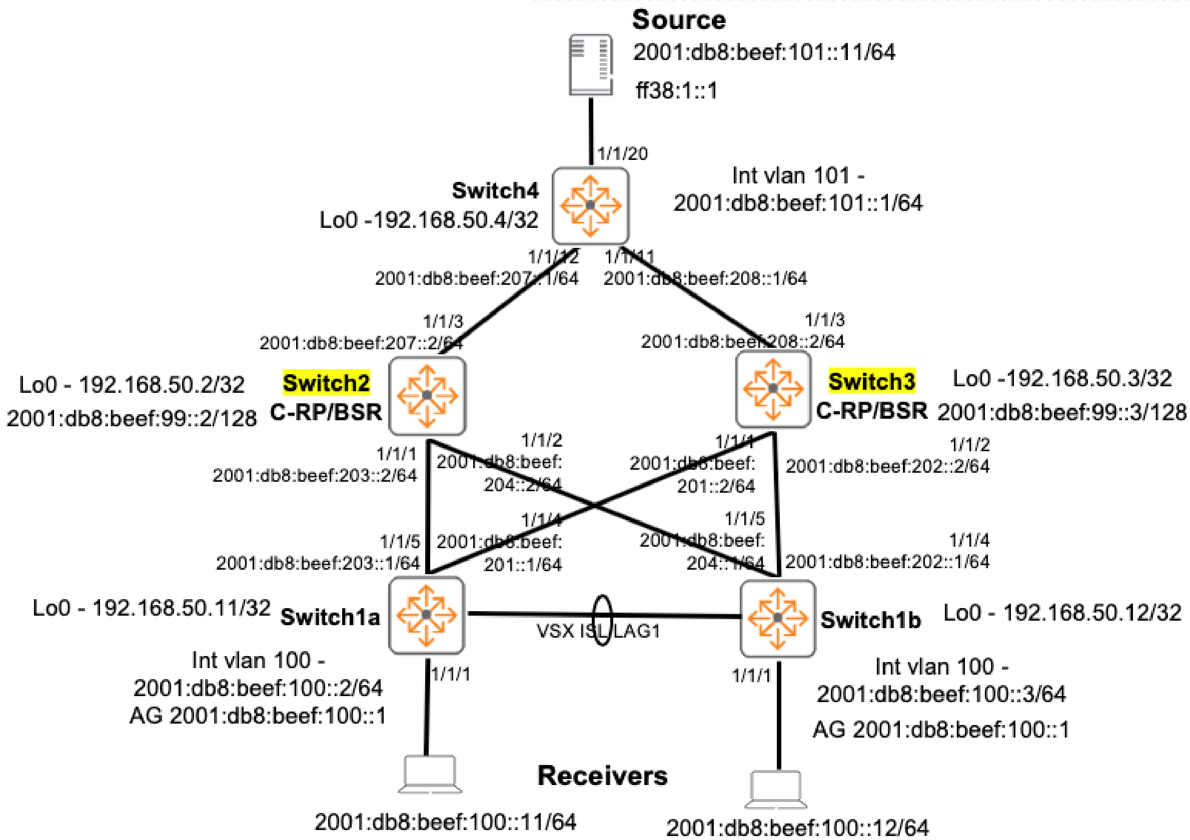
1. Deploy unicast routing (OSPF or BGP) throughout network
2. Enable PIM-SM/PIM6-SM on L3 interfaces between switches, towards source and receivers
3. Create Candidate RPs (C-RP)
5. Enable BSR to advertise candidate RPs to all PIM routers

Here are sample configs for Switch2.

Switch3 will have similar configs, except for the IPs.

```
router ospfv3 1
 router-id 192.168.50.2
 area 0.0.0.0
```

Figure 14. IPv6 multicast topology




```
interface loopback 0
 ip address 192.168.50.2/32
 ipv6 address 2001:db8:beef:99::2/128
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
! PIM and IPv6 only required on loopbacks of BSR/C-RP

router pim6
 enable
 rp-candidate source-ip-interface loopback0
 rp-candidate group-prefix ff00::/8
 rp-candidate priority 1
 bsr-candidate source-ip-interface loopback0
! Advertise BSR and RP using Lo0

interface 1/1/1
 no shutdown
 ipv6 address 2001:db8:beef:203::2/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 network point-to-point
interface 1/1/2
```

```
 no shutdown
 ipv6 address 2001:db8:beef:204::2/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 network point-to-point
interface 1/1/3
 no shutdown
 ipv6 address 2001:db8:beef:207::2/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 network point-to-point
```

Switch1a (LHR) Sample Configs

These are the deployment steps required on Switch1a/1b as shown in Figure 15.

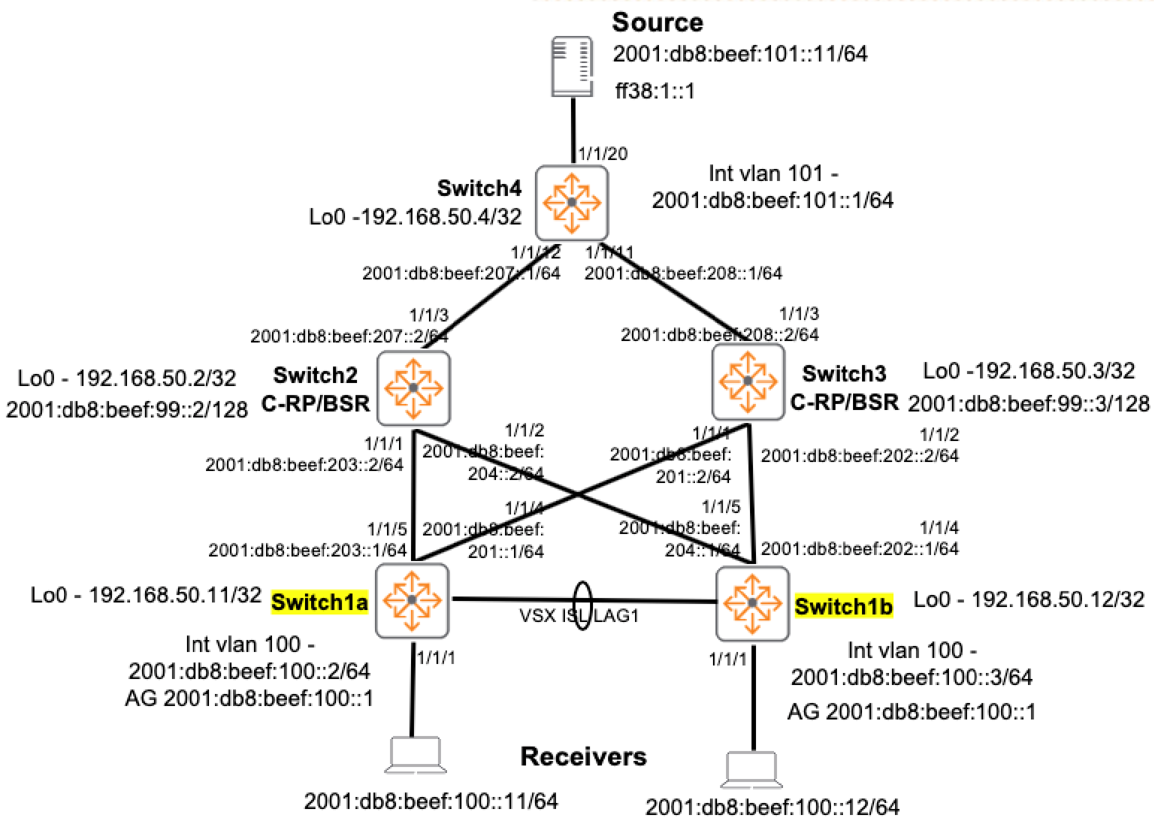
1. Deploy unicast routing (OSPF or BGP) throughout network
2. Enable PIM-SM/PIM6-SM on L3 interfaces between switches, towards source and receivers
6. Enable IGMP/MLD on L3 interfaces towards receiver subnets
7. On VSX switches with VSX LAGs towards other PIM routers, enable PIM active-active to speed up switch failover
   - 1 VSX switch acting as a proxy-DR (Designated Router) monitors DR failure
   - Both DR and proxy DR VSX switches maintain the same multicast tables and build the multicast tree
   - Upon detecting DR failure, proxy-DR changes role to DR, forwards traffic downstream to PIM router on VSX LAG
8. Enable IGMP/MLD snooping on L2 switches

Here are sample configs for Switch1a.

Switch1b will have similar configs, except for the IPs.

```
router ospfv3 1
 router-id 192.168.50.11
 area 0.0.0.0

interface loopback 0
 ip address 192.168.50.11/32

router pim6
 enable
 active-active
! PIM active-active is recommended on VSX switches for fast PIM failover

vlan 100
 ipv6 mld snooping enable
! MLD snooping for L2 switches with receivers

interface 1/1/1
 no shutdown
 no routing
 vlan access 100
```

Figure 15. IPv6 multicast topology




```
interface 1/1/4
 no shutdown
 ipv6 address 2001:db8:beef:201::1/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 network point-to-point
interface 1/1/5
 no shutdown
 ipv6 address 2001:db8:beef:203::1/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 network point-to-point

interface vlan100
 ipv6 address 2001:db8:beef:100::2/64
 active-gateway ipv6 mac 12:00:00:00:01:00
 active-gateway ipv6 2001:db8:beef:100::1
 ipv6 mld enable
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 passive
! VSX with active gateway
```

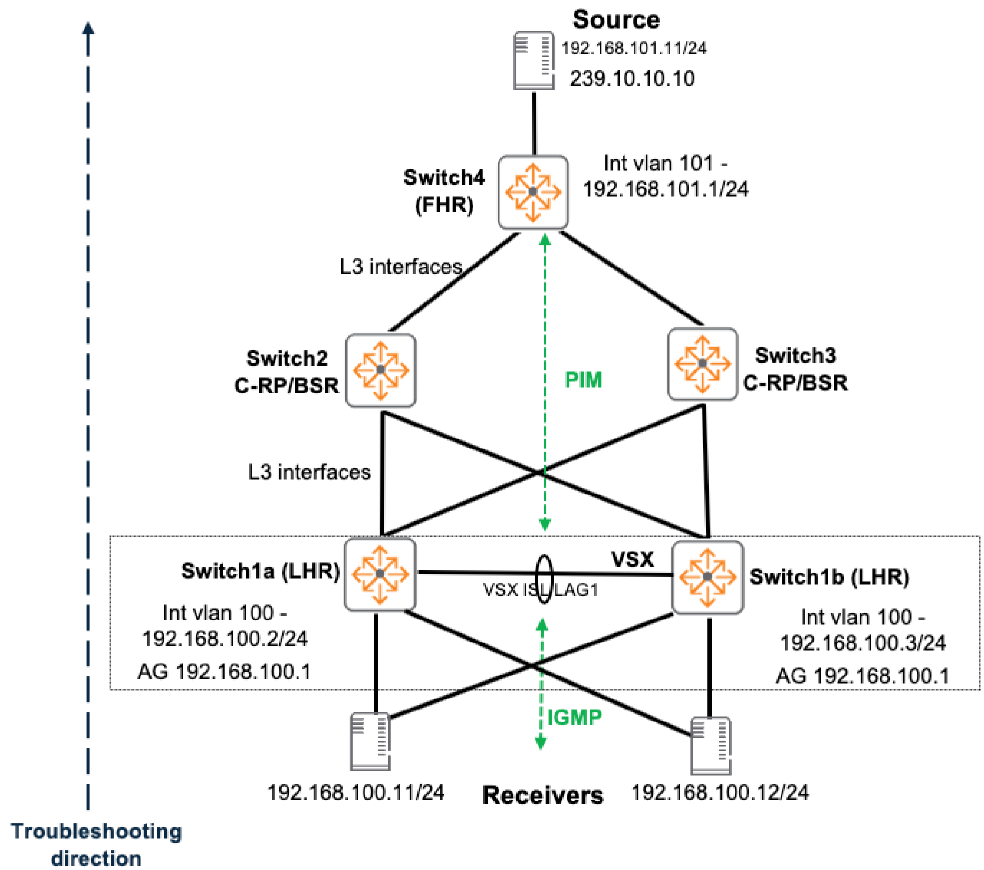
```
interface vlan4000
 ipv6 address 2001:db8:beef:4000::2/64
 ipv6 pim6-sparse enable
 ipv6 ospfv3 1 area 0.0.0.0
 ipv6 ospfv3 network point-to-point
! Transit VLAN between VSX switches used for multicast routing if uplinks fail

interface lag 1
 no shutdown
 description ISL Link
 no routing
 vlan trunk native 1 tag
 vlan trunk allowed all
 lacp mode active
```

Multicast Troubleshooting and Verification Overview

Multicast Troubleshooting Flow

Always troubleshoot from receivers towards the source (applicable to both IPv4/IPv6 multicast) as shown in Figure 16.

Figure 16. Multicast troubleshooting direction



Here are some recommended checks and suggested next steps.

Check IGMP/MLD joins on LHR

- Joins seen, check PIM next
- No joins seen, check receivers
- IGMP/MLD/PIM are required on receiver subnet

Check PIM on LHR

- RP known, check multicast routing for “Incoming Interface”, “Outgoing Interface List”
- No RP known, check BSR/C-RPs, check PIM neighbor establishment

Check BSR/RP

- Check PIM neighbor establishment
- MSDP established between them? Only applicable to IPv4
- Check multicast routing for “Incoming Interface”, “Outgoing Interface List”

Check FHR

- Check PIM neighbor establishment
- Check RPs are known
- PIM required on source subnet
- Check multicast routing for “Incoming Interface”, “Outgoing Interface List”

Always remember multicast routing depends on unicast routing, if receivers are unable to connect to source via unicast, multicast will not work.

Useful Troubleshooting Commands

Here are some commonly used multicast verification commands

```
sh ip mroute
sh ip pim rp-set
sh ip pim pending
sh ip pim nei
sh ip igmp groups
```

and some unicast verification commands

```
sh ip os nei
sh ip route
ping
```

Here are some diag-dump and debug related commands

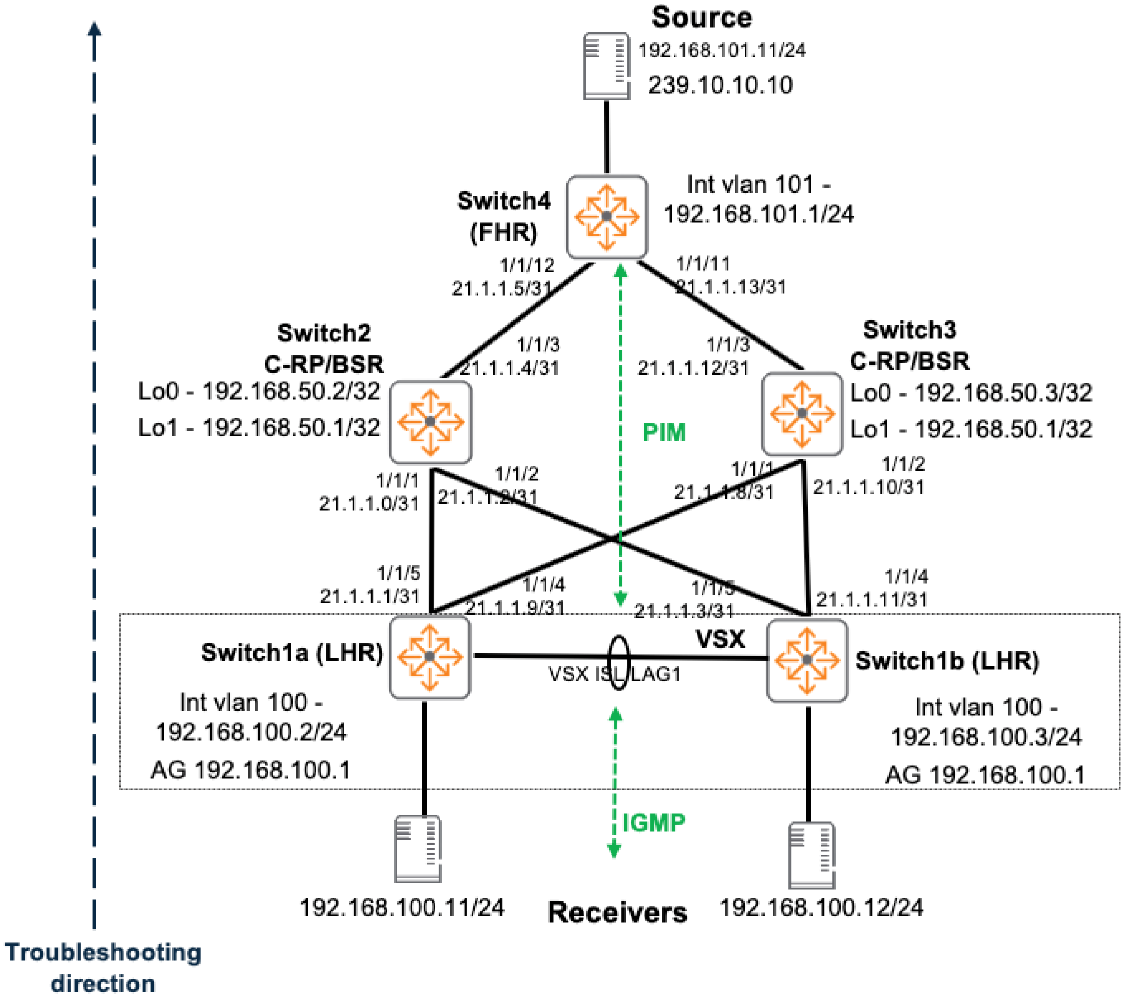
```
Switch# diagnostics
Switch# diag-dump pim basic
Switch# diag-dump igmp basic
Switch# diag-dump msdp basic
Switch# diag-dump mcast-mtm basic
```

```
Switch# debug pim ?
Switch# show debug buffer
Switch# no debug all
Switch# sh debug
```

IPv4 Multicast Troubleshooting and Verification

You might be informed of a problem (receivers unable to receive multicast stream), but there could be multiple reasons that cause the problem, this section will provide examples using Figure 17 and troubleshoot starting from receivers towards the source.

Figure 17. IPv4 multicast troubleshooting examples



Example #1

Verify receivers are able to reach source via unicast.

If problem exists, fix unicast routing issues.

Command Prompt

```
C:\>ipconfig

Windows IP Configuration


Ethernet adapter Ethernet0:

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2001:db8:beef:100::11
   Link-local IPv6 Address . . . . . : fe80::c13b:3266:9102:8174%13
   IPv4 Address. . . . . . . . . . . : 192.168.100.11
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 2001:db8:beef:100::1
                                       192.168.100.1

C:\>ping 192.168.101.11

Pinging 192.168.101.11 with 32 bytes of data:
Reply from 192.168.100.2: Destination net unreachable.
Reply from 192.168.100.2: Destination net unreachable.
Reply from 192.168.100.2: Destination net unreachable.

Ping statistics for 192.168.101.11:
    Packets: Sent = 3, Received = 3, Lost = 0 (0% loss),
```

Example #2

Verify IGMP joins are seen on LHR

```
Switch1a# sh ip igmp groups
```

Verify IGMP and PIM are enabled on LHR L3 interface facing receivers

```
Switch1a# sh ip igmp interface vlan100
IGMP is not enabled
```

```
Switch1a# sh ip pim int vlan100
```

If not enabled, make sure both IGMP/PIM are enabled

This is what you expect to see on LHR when a receiver sends IGMP joins

```
Switch1a# sh ip igmp groups

IGMP group information for group 239.10.10.10

Interface Name    : vlan100
VRF Name          : default

Group Address     : 239.10.10.10
Last Reporter     : 192.168.100.11

                              V1        V2        Sources   Sources
Vers Mode Uptime    Expires   Timer     Timer     Forwarded Blocked
---- ---- --------- --------- --------- --------- --------- --------
3    EXC  0m 16s    4m 19s
```

Example #3

Verify IGMP snooping on LHR is active on the expected VLAN with receivers

```
Switch1a# sh ip igmp snooping vlan 100
IGMP Snooping Protocol Info
Total VLANs with IGMP enabled             : 1
Current count of multicast groups joined  : 1

IGMP Drop Unknown Multicast               : Global
VLAN ID : 100
VLAN Name : VLAN100
IGMP Configured Version : 3
IGMP Operating Version : 3
Querier Address [this switch] : 192.168.100.2
Querier Port :
Querier UpTime :1h 56m
Querier Expiration Time :0m 27s

Active Group Address    Tracking  Vers Mode Uptime    Expires
--------------------- ---------- ---- ---- --------- ----------
239.10.10.10           Filter     3    EXC  1h 55m    2m 47s
```

Verify IGMP snooping is active on the expected VLAN/ports with receivers

```
Switch1a# sh ip igmp snooping vlan 100 group 239.10.10.10
IGMP ports and group information for group 239.10.10.10
VLAN ID   : 100
VLAN Name : VLAN100

Group Address : 239.10.10.10
Last Reporter : 192.168.100.11
Group Type    : Filter
```

```
                                                  V1         V2         Sources   Sources
Port      Vers Mode Uptime    Expires   Timer      Timer      Forwarded Blocked
--------- ---- ---- --------- --------- --------- --------- --------- --------
1/1/1     3    EXC  1h 56m    4m 20s                          0         0
```

You might need to packet capture receiver traffic to see if they are really sending IGMP joins.

Example #4

Verify mroute to source is seen on LHR.

Note: AOS-CX doesn't show mroute without an active source

```
Switch1a# sh ip mr
```

Verify PIM is enabled on LHR uplinks and VSX L3 transit interface (if it exists)

```
Switch1a# sh ip pim int

PIM Interfaces

VRF: default

Interface          IP Address        mode
------------------ ----------------- ----------
1/1/5              21.1.1.1/31       sparse
vlan100            192.168.100.2/24  sparse
vlan4000           192.168.51.1/31   sparse
1/1/4              21.1.1.9/31       sparse
```

Verify all PIM neighbors are up as expected

```
Switch1a# sh ip pim nei

PIM Neighbor

VRF                    : default
IP Address             : 21.1.1.0
Interface              : 1/1/5
Up Time (sec)          : 70901
Expire Time (sec)      : 77
DR Priority            : 1
```

Verify RP is known

```
Switch1a# sh ip pim rp-set
```

Check BSR/C-RP if RP is not known.

This is what you expect to see when verifying the learnt RP, MSDP with anycast Lo1 is used as RP in this example.

```
Switch1a# sh ip pim rp-set
VRF: default
Status and Counters - PIM-SM Learned RP-Set Information
Group Address     Group Mask        RP Address        Hold Time  Expire Time
---------------   ---------------   ---------------   ---------  -----------
224.0.0.0         240.0.0.0         192.168.50.1      150        105
```

Repeat the mroute/ PIM interface/ PIM neighbor/ RP checks as you move up the tree towards the source.

Example #5

Verify FHR is able to see mroute with source

```
Switch4# sh ip mr
```

Verify PIM is enabled on required interfaces on FHR, “int VLAN 101” with source is missing in this example.

```
Switch4# sh ip pim int
PIM Interfaces
VRF: default
Interface          IP Address         mode
------------------ -----------------  ----------
1/1/11             21.1.1.13/31       sparse
1/1/12             21.1.1.5/31        sparse
```

This example shows mroute with source after PIM is enabled on “int vlan 101”

```
Switch4# sh ip mr
IP Multicast Route Entries

VRF : default
Total number of entries : 1

Group Address            : 239.10.10.10
Source Address           : 192.168.101.11
Incoming interface       : vlan101
Outgoing Interface List :
Interface      State
---------      -----
1/1/12         forwarding
```

After FHR starts sending multicast stream down the multicast tree, check the next switch in the path, Switch2 and Switch3 in this example.

Verify the incoming interface and outgoing interface list.

```
Switch2# sh ip mr
IP Multicast Route Entries

VRF : default
Total number of entries : 1

Group Address            : 239.10.10.10
Source Address           : 192.168.101.11
Neighbor                 : 21.1.1.5
Incoming interface       : 1/1/3
Outgoing Interface List :
Interface      State
---------      -----
1/1/2          forwarding
```

Switch3 mroute is empty in this example as Switch3 is not part of the multicast tree.

```
Switch3# sh ip mr
```

After FHR starts sending multicast stream down the multicast tree, check the LHRs, 1 of them should have an OIL towards the receivers (if the LHRs are 2 VSX switches).

Verify the incoming interface and outgoing interface list on LHR#1.

```
Switch1a# sh ip mr
IP Multicast Route Entries

VRF : default
Total number of entries : 1

Group Address            : 239.10.10.10
Source Address           : 192.168.101.11
Neighbor                 : 192.168.100.3
Incoming interface       : vlan100
```

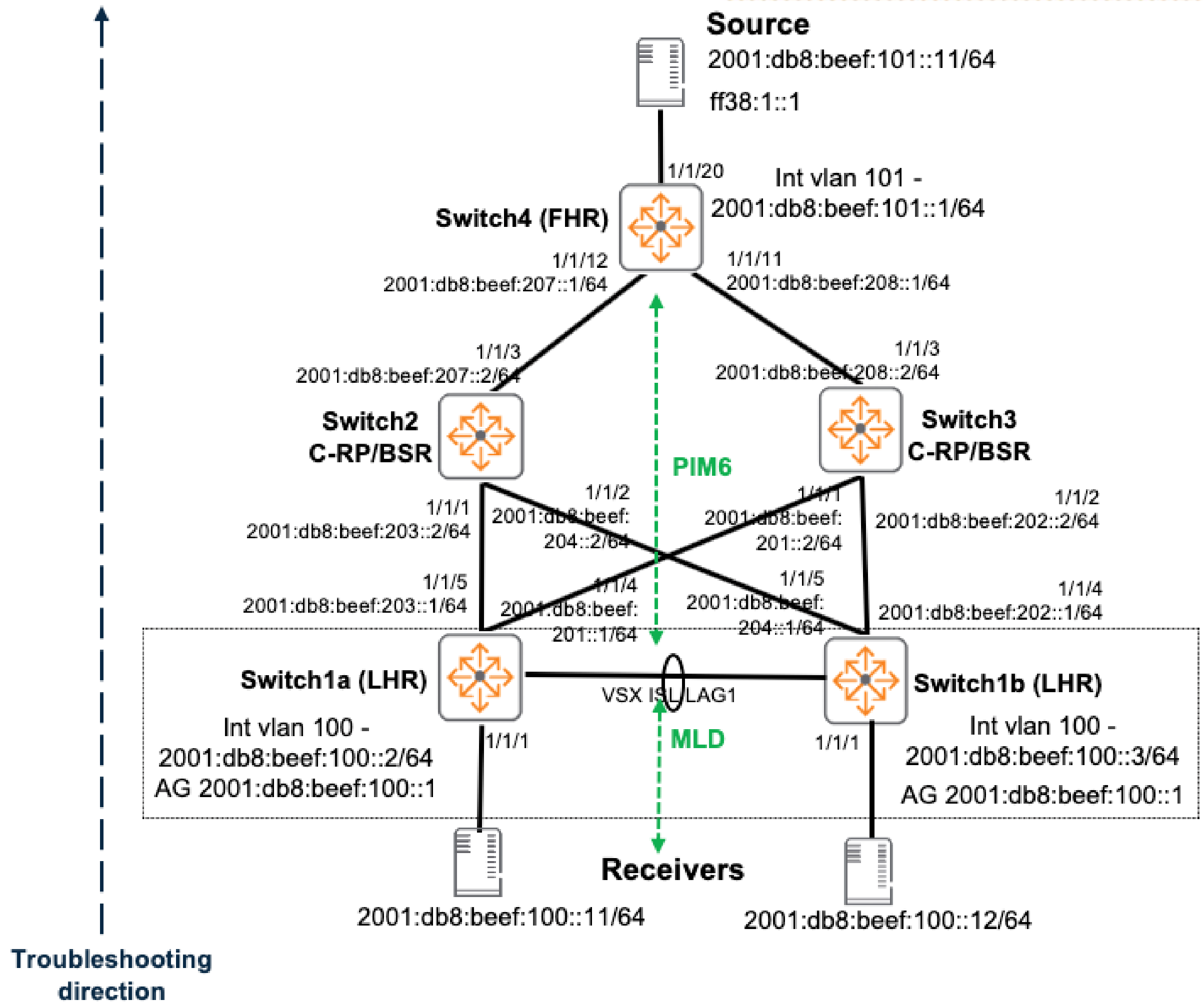
Verify the incoming interface and outgoing interface list on LHR#2.

```
Switch1b# sh ip mr
IP Multicast Route Entries

VRF : default
Total number of entries : 1

Group Address            : 239.10.10.10
Source Address           : 192.168.101.11
Neighbor                 : 21.1.1.2
Incoming interface       : 1/1/5
Outgoing Interface List :
Interface      State                     By_Proxy_Dr
---------      -----                     -----------
vlan100        forwarding                false
```

IPv6 Multicast Troubleshooting and Verification

You might be informed of a problem (receivers unable to receive multicast stream), but there could be multiple reasons that cause the problem, this section will provide examples using Figure 18 and troubleshoot starting from receivers towards the source. You will notice the knowledge learnt from IPv4 multicast is also applicable to IPv6 multicast troubleshooting and verification.

Figure 18. IPv6 multicast troubleshooting examples



Example #1

Verify receivers are able to reach source via unicast

Command Prompt

```
C:\>ipconfig

Windows IP Configuration


Ethernet adapter Ethernet0:

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2001:db8:beef:100::11
   Link-local IPv6 Address . . . . . : fe80::c13b:3266:9102:8174%13
   IPv4 Address. . . . . . . . . . . : 192.168.100.11
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 2001:db8:beef:100::1
                                       192.168.100.1

C:\>ping 2001:db8:beef:101::11

Pinging 2001:db8:beef:101::11 with 32 bytes of data:
Reply from 2001:db8:beef:101::11: time<1ms
Reply from 2001:db8:beef:101::11: time=4ms
Reply from 2001:db8:beef:101::11: time=3ms
Reply from 2001:db8:beef:101::11: time=4ms

Ping statistics for 2001:db8:beef:101::11:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 4ms, Average = 2ms
```

If problem exists, fix unicast routing issues

Example #2

Verify MLD joins are seen on LHR

```
Switch1a# sh ipv6 mld groups
```

Verify MLD and PIM6 are enabled on LHR L3 interface facing receivers

```
Switch1a# sh ipv6 mld int vlan100
MLD is not enabled

Switch1a# sh ipv6 pim6 int vlan100
```

If not enabled, make sure both MLD/PIM6 are enabled

This is what you expect to see when a receiver sends MLD joins

```
Switch1a# sh ipv6 mld int vlan100

MLD Configured Version   : 2
MLD Operating Version    : 2
Querier State              : Querier
Querier IP [this switch]   : fe80::9020:c280:64ba:c500
Querier Uptime             : 1d 13h 1m
Querier Expiration Time    : 1m 52s
MLD Snoop Enabled on VLAN  : True

Active Group Address                    Vers Mode Uptime    Expires
--------------------------------------- ---- ---- --------- ---------
ff02::c                                 2    EXC  1d 13h 1m 4m 11s
ff02::fb                                2    EXC  1d 13h 1m 4m 12s
ff38:1::1                               2    EXC  1d 13h 1m 4m 13s
```

Example #3

Verify MLD snooping is active on the expected VLAN with receivers

```
Switch1a# sh ipv6 mld snooping vlan 100
MLD Snooping Protocol Info

Total VLANs with MLD enabled              : 1
Current count of multicast groups joined  : 0

MLD Drop Unknown Multicast               : Global
VLAN ID : 100
VLAN Name : VLAN100
MLD Configured Version : 2
MLD Operating Version : 2
Querier Address : fe80::9020:c280:64bb:4100
Querier Port : lag256
Querier UpTime :6m 48s
Querier Expiration Time :2m 11s
```

Verify MLD snooping is active on the expected VLAN/ports with receivers

```
Switch1a# sh ipv6 mld snooping vlan 100 group ff38:1::1
MLD ports and group information for group ff38:1::1
VLAN ID   : 100
VLAN Name : VLAN100

Group Address : ff38:1::1
Last Reporter : fe80::c13b:3266:9102:8174
Group Type    : Filter

                                        V1         Sources    Sources
```

```
Port      Vers Mode Uptime    Expires   Timer     Forwarded Blocked
--------- ---- ---- --------- --------- --------- --------- --------
1/1/1     2    EXC  0m 59s    3m 22s              0         0
lag256    2    EXC  1m 2s     3m 18s              0         0
```

You might need to packet capture receiver traffic to see if they are really sending MLD joins.

Example #4

Verify mroute to source is seen on LHR.

Note: AOS-CX doesn't show mroute without an active source

```
Switch1a# sh ipv6 mr
```

Verify PIM is enabled on LHR uplinks and VSX L3 transit interface (if it exists)

```
Switch1a# sh ipv6 pim int
PIM Interfaces

VRF: default

Interface          IPv6 Address                            mode
------------------ --------------------------------------- ----------
1/1/5              fe80::9020:c221:5ba:c500/64             sparse
vlan100            fe80::9020:c280:64ba:c500/64            sparse
1/1/4              fe80::9020:c221:4ba:c500/64             sparse
vlan4000           fe80::9020:c28f:a0ba:c500/64            sparse
```

Verify all PIM neighbors are up as expected

```
Switch1a# sh ipv6 pim nei

PIM Neighbor

VRF                    : default
IPv6 Address           : fe80::d067:2621:1e2:b6d2
Interface              : 1/1/5
Up Time (sec)          : 135095
Expire Time (sec)      : 89
DR Priority            : 1
```

Verify RP is known

```
Switch1a# sh ipv6 pim6 rp-set
```

Check BSR/C-RP if RP is not known.

This is what you expect to see when verifying the learnt RP.

```
Switch1a# sh ipv6 pim6 rp-set

VRF: default

Status and Counters - PIM-SM(IPv6) Learned RP-Set Information

Group Prefix        : ff00::/8
RP Address          : 2001:db8:beef:99::3
Hold Time (sec)     : 150
Expire Time (sec)   : 107

Group Prefix        : ff00::/8
RP Address          : 2001:db8:beef:99::2
Hold Time (sec)     : 150
Expire Time (sec)   : 107
```

Repeat the mroute/ PIM6 interface/ PIM neighbor/ RP checks as you move up the tree towards the source.

Example #5

Verify FHR is able to see mroute with source

```
Switch4# sh ipv6 mr
```

Verify PIM is enabled on required interfaces on FHR (Int VLAN 101 with source is missing in this example)

```
Switch4# sh ipv6 pim6 int
PIM Interfaces

VRF: default

Interface           IPv6 Address                    mode
------------------ ------------------------------   ----------
1/1/12              fe80::d067:2621:c49:ccf2/64     sparse
1/1/11              fe80::d067:2621:b49:ccf2/64     sparse
```

This example shows mroute with source after PIM is enabled on “int vlan 101”

```
Switch4# sh ipv6 mr
IP Multicast Route Entries

VRF : default
Total number of entries : 1

Group Address            : ff38:1::1
Source Address           : 2001:db8:beef:101::11
Incoming interface       : vlan101
Outgoing Interface List  :
```

```
Interface      State
---------      -----
1/1/12         forwarding
```

After FHR starts sending multicast stream down the multicast tree, check the next switch in the path (Switch2 and Switch3 in this example)

Verify the incoming interface and outgoing interface list

```
Switch2# sh ipv6 mr
IP Multicast Route Entries

VRF : default
Total number of entries : 2

Group Address            : ff38:1::1
Source Address           : 2001:db8:beef:101::11
Incoming interface       : loopback0

Group Address            : ff38:1::1
Source Address           : 2001:db8:beef:101::11
Neighbor                 : fe80::d067:2621:c49:ccf2
Incoming interface       : 1/1/3
Outgoing Interface List :
Interface      State
---------      -----
1/1/2          forwarding
```

Switch3 mroute is empty in this example as Switch3 is not part of the multicast tree

```
Switch3# sh ipv6 mr
```

After FHR starts sending multicast stream down the multicast tree, check the LHRs, 1 of them should have an OIL towards the receivers (if the LHRs are 2 VSX switches).

Verify the incoming interface and outgoing interface list

```
Switch1a# sh ipv6 mr
IP Multicast Route Entries

VRF : default
Total number of entries : 1

Group Address            : ff38:1::1
Source Address           : 2001:db8:beef:101::11
Neighbor                 : fe80::9020:c280:64bb:4100
Incoming interface       : vlan100
```

Verify the incoming interface and outgoing interface list

```
Switch1b# sh ipv6 mr
IP Multicast Route Entries

VRF : default
Total number of entries : 1

Group Address           : ff38:1::1
Source Address          : 2001:db8:beef:101::11
Neighbor                : fe80::d067:2621:2e2:b6d2
Incoming interface      : 1/1/5
Outgoing Interface List :
Interface      State                By_Proxy_Dr
---------      -----                -----------
vlan100        forwarding           false
```

Appendix

Switch4 (FHR) sample configs

```
hostname Switch4
user admin group administrators password ciphertext AQBap!snip
!
ssh server vrf mgmt
!
router ospf 1
    router-id 192.168.50.4
    area 0.0.0.0
router ospfv3 1
    router-id 192.168.50.4
    area 0.0.0.0
vlan 1
vlan 101
interface mgmt
    no shutdown
    ip static 10.10.10.141/24
    default-gateway 10.10.10.254
interface 1/1/11
    no shutdown
    description Switch3
    ip address 21.1.1.13/31
    ipv6 address 2001:db8:beef:208::1/64
    ip ospf 1 area 0.0.0.0
    ip ospf network point-to-point
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 network point-to-point
interface 1/1/12
    no shutdown
    description Switch4
```

```
    ip address 21.1.1.5/31
    ipv6 address 2001:db8:beef:207::1/64
    ip ospf 1 area 0.0.0.0
    ip ospf network point-to-point
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 network point-to-point
interface 1/1/20
    no shutdown
    no routing
    vlan access 101
interface loopback 0
    ip address 192.168.50.4/32
    ip ospf 1 area 0.0.0.0
interface vlan101
    description Source
    ip address 192.168.101.1/24
    ipv6 address 2001:db8:beef:101::1/64
    ip ospf 1 area 0.0.0.0
    ip ospf passive
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 passive
router pim
    enable
router pim6
    enable
https-server rest access-mode read-write
https-server vrf mgmt
```

Switch2 (BSR/C-RP) sample configs

```
hostname Switch2
user admin group administrators password ciphertext AQBap!snip
!
ssh server vrf mgmt
!
!
router ospf 1
    router-id 192.168.50.2
    redistribute bgp
    area 0.0.0.0
router ospfv3 1
    router-id 192.168.50.2
    area 0.0.0.0
vlan 1
interface mgmt
    no shutdown
    ip static 10.10.10.124/24
    default-gateway 10.10.10.254
interface 1/1/1
```

```
    no shutdown
    description Switch1a
    ip address 21.1.1.0/31
    ipv6 address 2001:db8:beef:203::2/64
    ip ospf 1 area 0.0.0.0
    ip ospf network point-to-point
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 network point-to-point
interface 1/1/2
    no shutdown
    description Switch1b
    ip address 21.1.1.2/31
    ipv6 address 2001:db8:beef:204::2/64
    ip ospf 1 area 0.0.0.0
    ip ospf network point-to-point
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 network point-to-point
interface 1/1/3
    no shutdown
    description Switch4
    ip address 21.1.1.4/31
    ipv6 address 2001:db8:beef:207::2/64
    ip ospf 1 area 0.0.0.0
    ip ospf network point-to-point
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 network point-to-point
interface loopback 0
    ip address 192.168.50.2/32
    ipv6 address 2001:db8:beef:99::2/128
    ip ospf 1 area 0.0.0.0
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
interface loopback 1
    ip address 192.168.50.1/32
    ip ospf 1 area 0.0.0.0
    ip pim-sparse enable
!
router pim
    enable
    rp-candidate source-ip-interface loopback1
    rp-candidate group-prefix 224.0.0.0/4
    bsr-candidate source-ip-interface loopback0
router pim6
    enable
    rp-candidate source-ip-interface loopback0
    rp-candidate group-prefix ff00::/8
    rp-candidate priority 1
```

```
    bsr-candidate source-ip-interface loopback0
https-server rest access-mode read-write
https-server vrf mgmt
router msdp
    enable
    ip msdp peer 192.168.50.5
        connect-source loopback0
        enable
    ip msdp peer 192.168.50.3
        connect-source loopback0
        enable
        mesh-group 1
```

Switch1a (LHR) sample configs

```
hostname Switch1a
user admin group administrators password ciphertext AQBap!snip
!
ssh server vrf mgmt
!
!
router ospf 1
    router-id 192.168.50.11
    area 0.0.0.0
router ospfv3 1
    router-id 192.168.50.11
    area 0.0.0.0
vlan 1
vlan 100
    ip igmp snooping enable
    ipv6 mld snooping enable
vlan 4000
interface mgmt
    no shutdown
    ip static 10.10.10.65/24
    default-gateway 10.10.10.254
system interface-group 1 speed 10g
    !interface group 1 contains ports 1/1/1-1/1/12
system interface-group 2 speed 10g
    !interface group 2 contains ports 1/1/13-1/1/24
system interface-group 3 speed 10g
    !interface group 3 contains ports 1/1/25-1/1/36
system interface-group 4 speed 10g
    !interface group 4 contains ports 1/1/37-1/1/48
interface lag 256
    no shutdown
    description ISL Link
    no routing
    vlan trunk native 1 tag
    vlan trunk allowed all
    lacp mode active
interface 1/1/1
    no shutdown
    no routing
```

```
    vlan access 100
interface 1/1/4
    no shutdown
    description Switch3
    ip address 21.1.1.9/31
    ipv6 address 2001:db8:beef:201::1/64
    ip ospf 1 area 0.0.0.0
    ip ospf network point-to-point
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 network point-to-point
interface 1/1/5
    no shutdown
    description Switch2
    ip address 21.1.1.1/31
    ipv6 address 2001:db8:beef:203::1/64
    ip ospf 1 area 0.0.0.0
    ip ospf network point-to-point
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 network point-to-point
interface 1/1/55
    no shutdown
    mtu 9100
    description VSX Keepalive
    ip address 192.168.0.1/31
interface 1/1/56
    no shutdown
    mtu 9198
    description ISL Physical Link
    lag 256
interface loopback 0
    ip address 192.168.50.11/32
    ip ospf 1 area 0.0.0.0
interface vlan100
    description Multicast Receivers
    ip address 192.168.100.2/24
    active-gateway ip mac 12:00:00:00:01:00
    active-gateway ip 192.168.100.1
    ipv6 address 2001:db8:beef:100::2/64
    active-gateway ipv6 mac 12:00:00:00:01:00
    active-gateway ipv6 2001:db8:beef:100::1
    ip ospf 1 area 0.0.0.0
    ip ospf passive
    ip igmp enable
    ipv6 mld enable
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 passive
interface vlan4000
    description transit
```

```
    ip address 192.168.51.1/31
    ipv6 address 2001:db8:beef:4000::2/64
    ip ospf 1 area 0.0.0.0
    ip ospf network point-to-point
    ip pim-sparse enable
    ipv6 pim6-sparse enable
    ipv6 ospfv3 1 area 0.0.0.0
    ipv6 ospfv3 network point-to-point
vsx
    system-mac 12:01:01:01:01:02
    inter-switch-link lag 256
    role secondary
    vsx-sync vsx-global
router pim
    enable
    active-active
router pim6
    enable
    active-active
https-server rest access-mode read-write
```

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www.arubanetworks.com

3333 Scott Blvd. Santa Clara, CA 95054
1.844.472.2782 | T: 1.408.227.4500 | FAX: 1.408.227.4550 | info@arubanetworks.com