



# Configuring the Underlay

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## IP Fabric Underlay

### Underlay Considerations

#### Unicast Underlay:

The primary purpose of the underlay in the VXLAN EVPN fabric is to advertise the reachability of Virtual Tunnel End Points (VTEPs) and BGP peering addresses. The primary criterion for choosing an underlay protocol is fast convergence in the event of node failures. Other criteria are:

- Simplicity of configuration.
- Ability to delay the introduction of a node into the network on boot up.

This document details the two primary protocols supported and tested by Cisco, IS-IS and OSPF. It will also illustrate the use of the eBGP protocol as an underlay for the VXLAN EVPN fabric.

For Configuring VXLAN with IPv6 in the Underlay (VXLANv6), see [Configure VXLAN with IPv6 in the Underlay \(VXLANv6\)](#).

#### Underlay and Overlay Packet Flow and Deployment Considerations

From an underlay/overlay perspective, the packet flow from a server to another over the Virtual Extensible LAN (VXLAN) fabric as mentioned below:

1. The server sends traffic to the source VXLAN tunnel endpoint (VTEP). The VTEP performs Layer-2 or Layer-3 communication based on the destination MAC and derives the nexthop (destination VTEP).



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**Note** When a packet is bridged, the target end host's MAC address is stamped in the DMAC field of the inner frame. When a packet is routed, the default gateway's MAC address is stamped in the DMAC field of the inner frame.

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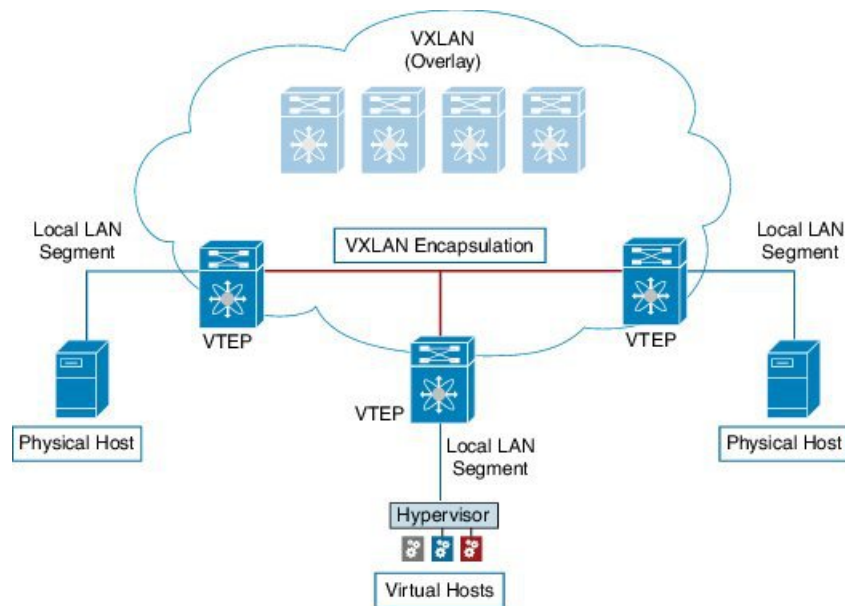
2. The VTEP encapsulates the traffic (frames) into VXLAN packets (overlay function – see Figure 1) and signals the underlay IP network.

3. Based on the underlay routing protocol, the packet is sent from the source VTEP to destination VTEP through the IP network (underlay function – see *Underlay Overview* figure).
4. The destination VTEP removes the VXLAN encapsulation (overlay function) and sends traffic to the intended server.

The VTEPs are a part of the underlay network as well since VTEPs need to be reachable to each other to send VXLAN encapsulated traffic across the IP underlay network.

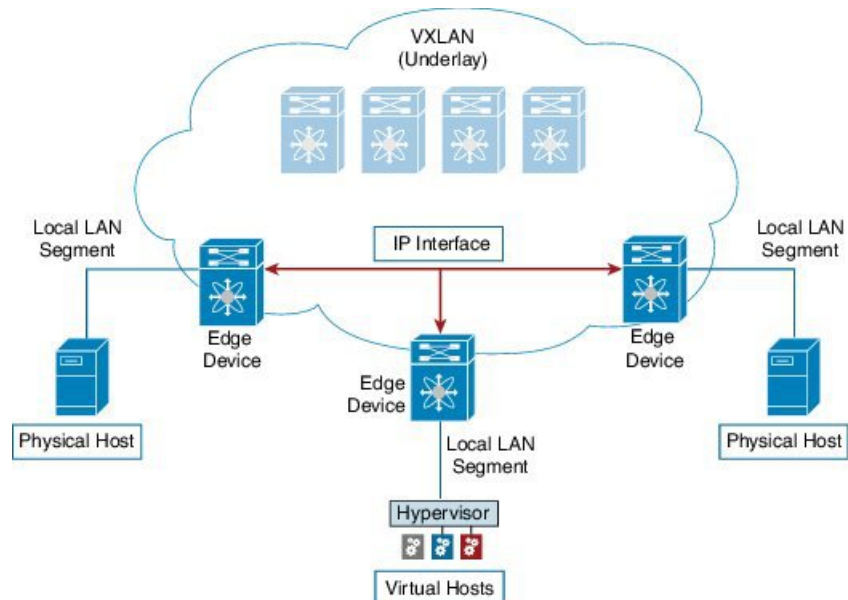
The *Overlay Overview* and *Underlay Overview* images (below) depict the broad difference between an overlay and underlay. Since the focus is on the VTEPs, the spine switches are only depicted in the background. Note that, in real time, the packet flow from VTEP to VTEP traverses through the spine switches.

**Figure 1: Overlay Overview**



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Figure 2: Underlay Overview



#### Deployment considerations for an underlay IP network in a VXLAN EVPN Programmable Fabric

The deployment considerations for an underlay IP network in a VXLAN EVPN Programmable Fabric are given below:

- Maximum transmission unit (MTU) – Due to VXLAN encapsulation, the MTU requirement is larger and we must avoid potential fragmentation.
  - An MTU of 9216 bytes on each interface on the path between the VTEPs accommodates maximum server MTU + VXLAN overhead. Most data center server NICs support up to 9000 bytes. So, no fragmentation is needed for VXLAN traffic.
  - The VXLAN IP fabric underlay supports the IPv4 address family.
- Unicast routing - Any unicast routing protocol can be used for the VXLAN IP underlay. You can implement OSPF, IS-IS, or eBGP to route between the VTEPs.



**Note** As a best practice, use a simple IGP (OSPF or IS-IS) for underlay reachability between VTEPs with iBGP for overlay information exchange.

- IP addressing – Point-to-point (P2P) or IP unnumbered links. For each point-to-point link, as example between the leaf switch nodes and spine switch nodes, typically a /30 IP mask should be assigned. Optionally a /31 mask or IP unnumbered links can be assigned. The IP unnumbered approach is leaner from an addressing perspective and consumes fewer IP addresses. The IP unnumbered option for the OSPF or IS-IS protocol underlay will minimize the use of IP addresses.

/31 network - An OSPF or IS-IS point-to-point numbered network is only between two switch (interfaces), and there is no need for a broadcast or network address. So, a /31 network suffices for this network. Neighbors on this network establish adjacency and there is no designated router (DR) for the network.




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**Note** IP Unnumbered for VXLAN underlay is supported starting with Cisco NX-OS Release 7.0(3)I7(2). Only a single unnumbered link between the same devices (for example, spine - leaf) is supported. If multiple physical links are connecting the same leaf and spine, you must use the single L3 port-channel with unnumbered link.

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- Multicast protocol for multi-destination (BUM) traffic – Though VXLAN has the BGP EVPN control plane, the VXLAN fabric still requires a technology for Broadcast/Unknown unicast/Multicast (BUM) traffic to be forwarded.
- PIM Bidir is supported on Cisco Nexus 9300-EX/FX/FX2 platform switches.
- vPC configuration — This is documented in **Configuring vPCs** of *Cisco Nexus 9000 Series NX-OS Interfaces Configuration Guide*.

## Unicast routing and IP addressing options

Each unicast routing protocol option (OSPF, IS-IS, and eBGP) and sample configurations are given below. Use an option to suit your setup's requirements.

- OSPF
- IS-IS
- eBGP

Sample configurations are from an IP underlay perspective and are not comprehensive.

- For complete configuration information including routing process, authentication, Bidirectional Forwarding Detection (BFD) information, and so on, see *Cisco Nexus 9000 Series NX-OS Unicast Routing Configuration Guide*.




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**Important** All routing configuration samples are from an IP underlay perspective and are not comprehensive. For complete configuration information including routing process, authentication, Bidirectional Forwarding Detection (BFD) information, and so on, see *Cisco Nexus 9000 Series NX-OS Unicast Routing Configuration Guide*.

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## OSPF Underlay IP Network

Some considerations are given below:

- For IP addressing, use P2P links. Since only two switches are directly connected, you can avoid a Designated Router/Backup Designated Router (DR/BDR) election.
- Use the *point-to-point* network type option. It is ideal for routed interfaces or ports, and is optimal from a Link State Advertisements (LSA) perspective.

- Do not use the broadcast type network. It is suboptimal from an LSA database perspective (LSA type 1 – Router LSA and LSA type 2 – Network LSA) and necessitates a DR/BDR election, thereby creating an additional election and database overhead.



**Note** You can divide OSPF networks into areas when the size of the routing domain contains a high number of routers and/or IP prefixes. The same general well known OSPF best practice rules in regards of scale and configuration are applicable for the VXLAN underlay too. For example, LSA type 1 and type 2 are never flooded outside of an area. With multiple areas, the size of the OSPF LSA databases can be reduced to optimize CPU and memory consumption.

For ease of use, the configuration mode from which you need to start configuring a task is mentioned at the beginning of each configuration.

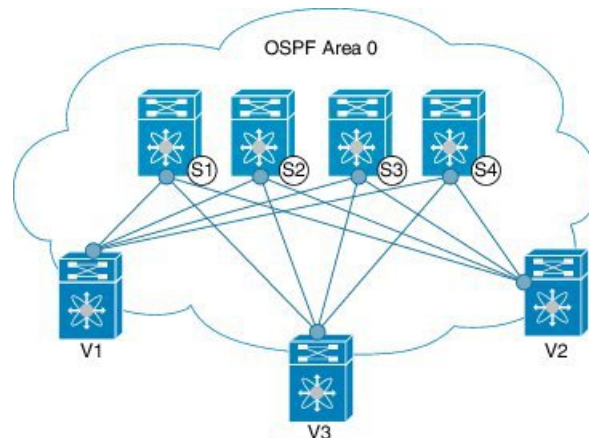
- Configuration tasks and corresponding show command output are displayed for a part of the topology in the image. For example, if the sample configuration is shown for a leaf switch and connected spine switch, the show command output for the configuration displays corresponding configuration.



**Note** MTU size of both ends of the link should be configured identically.

### OSPF configuration sample – P2P and IP unnumbered network scenarios

*Figure 3: OSPF as the underlay routing protocol*



#### OSPF – P2P link scenario with /31 mask

In the above image, the leaf switches (V1, V2, and V3) are at the bottom of the image. They are connected to the 4 spine switches (S1, S2, S3, and S4) that are depicted at the top of the image. For P2P connections between a leaf switch (also having VTEP function) and each spine, leaf switches V1, V2, and V3 should each be connected to each spine switch.

For V1, we should configure a P2P interface to connect to each spine switch.

A sample P2P configuration between a leaf switch (V1) interface and a spine switch (S1) interface is given below:

**OSPF global configuration on leaf switch V1**

```
(config) #
feature ospf
router ospf UNDERLAY
router-id 10.1.1.54
```

**OSPF leaf switch V1 P2P interface configuration**

```
(config) #
interface Ethernet 1/41
description Link to Spine S1
no switchport
ip address 198.51.100.1/31
mtu 9216
ip router ospf UNDERLAY area 0.0.0.0
ip ospf network point-to-point
```

The **ip ospf network point-to-point** command configures the OSPF network as a point-to-point network

The OSPF instance is tagged as UNDERLAY for better recall.

**OSPF loopback interface configuration (leaf switch V1)**

Configure a loopback interface so that it can be used as the OSPF router ID of leaf switch V1.

```
(config) #
interface loopback 0
ip address 10.1.1.54/32
ip router ospf UNDERLAY area 0.0.0.0
```

The interface will be associated with the OSPF instance UNDERLAY and OSPF area 0.0.0.0

**OSPF global configuration on spine switch S1**

```
(config) #
feature ospf
router ospf UNDERLAY
router-id 10.1.1.53
```

**(Corresponding) OSPF spine switch S1 P2P interface configuration**

```
(config) #
interface Ethernet 1/41
description Link to VTEP V1
ip address 198.51.100.2/31
mtu 9216
ip router ospf UNDERLAY area 0.0.0.0
ip ospf network point-to-point
no shutdown
```

**OSPF loopback Interface Configuration (spine switch S1)**

Configure a loopback interface so that it can be used as the OSPF router ID of spine switch S1.

```
(config) #
```

```
interface loopback 0
ip address 10.1.1.53/32
ip router ospf UNDERLAY area 0.0.0.0
```

The interface will be associated with the OSPF instance UNDERLAY and OSPF area 0.0.0.0

*To complete OSPF topology configuration for the 'OSPF as the underlay routing protocol' image, configure the following*

- 3 more V1 interfaces (or 3 more P2P links) to the remaining 3 spine switches.
- Repeat the procedure to connect P2P links between V2,V3 and V4 and the spine switches.

### OSPF - IP unnumbered scenario

A sample OSPF IP unnumbered configuration is given below:

#### OSPF leaf switch V1 configuration

##### OSPF global configuration on leaf switch V1

```
(config) #
feature ospf
router ospf UNDERLAY
router-id 10.1.1.54
```

The OSPF instance is tagged as UNDERLAY for better recall.

##### OSPF leaf switch V1 P2P interface configuration

```
(config) #
interface Ethernet1/41
description Link to Spine S1
mtu 9216
ip ospf network point-to-point
ip unnumbered loopback0
ip router ospf UNDERLAY area 0.0.0.0
```

The **ip ospf network point-to-point** command configures the OSPF network as a point-to-point network.

##### OSPF loopback interface configuration

Configure a loopback interface so that it can be used as the OSPF router ID of leaf switch V1.

```
(config) #
interface loopback0
ip address 10.1.1.54/32
ip router ospf UNDERLAY area 0.0.0.0
```

The interface will be associated with the OSPF instance UNDERLAY and OSPF area 0.0.0.0

#### OSPF spine switch S1 configuration:

##### OSPF global configuration on spine switch S1

```
(config) #
feature ospf
router ospf UNDERLAY
router-id 10.1.1.53
```

##### (Corresponding) OSPF spine switch S1 P2P interface configuration

```
(config) #
interface Ethernet1/41
description Link to VTEP V1
mtu 9216
```

```
ip ospf network point-to-point
ip unnumbered loopback0
ip router ospf UNDERLAY area 0.0.0.0
```

### OSPF loopback interface configuration (spine switch S1)

Configure a loopback interface so that it can be used as the OSPF router ID of spine switch S1.

```
(config) #
interface loopback0
ip address 10.1.1.53/32
ip router ospf UNDERLAY area 0.0.0.0
```

The interface will be associated with the OSPF instance UNDERLAY and OSPF area 0.0.0.0

To complete OSPF topology configuration for the ‘OSPF as the underlay routing protocol’ image, configure the following:

- *3 more VTEP V1 interfaces (or 3 more IP unnumbered links) to the remaining 3 spine switches.*
- *Repeat the procedure to connect IP unnumbered links between VTEPs V2,V3 and V4 and the spine switches.*

### OSPF Verification

Use the following commands for verifying OSPF configuration:

```
Leaf-Switch-V1# show ip ospf

Routing Process UNDERLAY with ID 10.1.1.54 VRF default
Routing Process Instance Number 1
Stateful High Availability enabled
Graceful-restart is configured
Grace period: 60 state: Inactive
Last graceful restart exit status: None
Supports only single TOS(TOS0) routes
Supports opaque LSA
Administrative distance 110
Reference Bandwidth is 40000 Mbps
SPF throttling delay time of 200.000 msec,
SPF throttling hold time of 1000.000 msec,
SPF throttling maximum wait time of 5000.000 msec
LSA throttling start time of 0.000 msec,
LSA throttling hold interval of 5000.000 msec,
LSA throttling maximum wait time of 5000.000 msec
Minimum LSA arrival 1000.000 msec
LSA group pacing timer 10 secs
Maximum paths to destination 8
Number of external LSAs 0, checksum sum 0
Number of opaque AS LSAs 0, checksum sum 0
Number of areas is 1, 1 normal, 0 stub, 0 nssa
Number of active areas is 1, 1 normal, 0 stub, 0 nssa
Install discard route for summarized external routes.
Install discard route for summarized internal routes.
Area BACKBONE(0.0.0.0)
Area has existed for 03:12:54
Interfaces in this area: 2 Active interfaces: 2
Passive interfaces: 0 Loopback interfaces: 1
No authentication available
SPF calculation has run 5 times
Last SPF ran for 0.000195s
Area ranges are
Number of LSAs: 3, checksum sum 0x196c2
```

```
Leaf-Switch-V1# show ip ospf interface

loopback0 is up, line protocol is up
IP address 10.1.1.54/32
Process ID UNDERLAY VRF default, area 0.0.0.0
Enabled by interface configuration
State LOOPBACK, Network type LOOPBACK, cost 1
Index 1
Ethernet1/41 is up, line protocol is up
Unnumbered interface using IP address of loopback0 (10.1.1.54)
Process ID UNDERLAY VRF default, area 0.0.0.0
Enabled by interface configuration
State P2P, Network type P2P, cost 4
Index 2, Transmit delay 1 sec
1 Neighbors, flooding to 1, adjacent with 1
Timer intervals: Hello 10, Dead 40, Wait 40, Retransmit 5
Hello timer due in 00:00:07
No authentication
Number of opaque link LSAs: 0, checksum sum 0

Leaf-Switch-V1# show ip ospf neighbors

OSPF Process ID UNDERLAY VRF default
Total number of neighbors: 1
Neighbor ID      Pri State           Up Time  Address        Interface
10.1.1.53        1 FULL/ -          06:18:32 10.1.1.53      Eth1/41
```

For a detailed list of commands, refer to the Configuration and Command Reference guides.

## IS-IS Underlay IP Network

Some considerations are given below:

- Because IS-IS uses Connectionless Network Service (CLNS) and is independent of the IP, full SPF calculation is avoided when a link changes.
- **Net ID** - Each IS-IS instance has an associated network entity title (NET) ID that uniquely identifies the IS-IS instance in the area. The NET ID is comprised of the IS-IS system ID, which uniquely identifies this IS-IS instance in the area, and the area ID. For example, if the NET ID is 49.0001.0010.0100.1074.00, the system ID is 0010.0100.1074 and the area ID is 49.0001.



### Important

**Level 1 IS-IS in the Fabric**—Cisco has validated the use of IS-IS Level 1 only and IS-IS Level 2 only configuration on all nodes in the programmable fabric. The fabric is considered a stub network where every node needs an optimal path to every other node in the fabric. Cisco NX-OS IS-IS implementation scales well to support a number of nodes in a fabric. Hence, there is no anticipation of having to break up the fabric into multiple IS-IS domains.

### IS-IS Underlay IP Network Reference Information

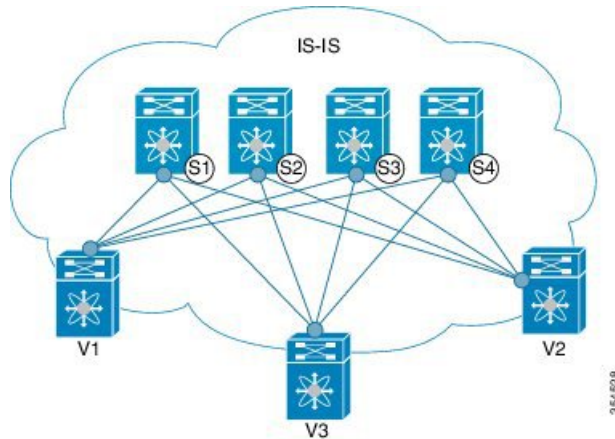
Configuration and operational notes for IS-IS underlay deployment:

- For ease of use, the configuration mode from which you need to start configuring a task is mentioned at the beginning of each configuration.

- Configuration tasks and corresponding show command output are displayed for a part of the topology in the image. For example, if the sample configuration is shown for a leaf switch and connected spine switch, the show command output for the configuration displays corresponding configuration.

### IS-IS configuration sample - P2P and IP unnumbered network scenarios

Figure 4: IS-IS as the underlay routing protocol



In the above image, the leaf switches (V1, V2, and V3, having the VTEP function) are at the bottom of the image. They are connected to the 4 spine switches (S1, S2, S3, and S4) that are depicted at the top of the image.

#### IS-IS – P2P link scenario with /31 mask

A sample P2P configuration between V1 and spine switch S1 is given below:

For P2P connections between a leaf switch and each spine switch, V1, V2, and V3 should each be connected to each spine switch.

For V1, we must configure a loopback interface and a P2P interface configuration to connect to S1. A sample P2P configuration between a leaf switch (V1) interface and a spine switch (S1) interface is given below:

#### IS-IS configuration on leaf switch V1

##### IS-IS global configuration

```
(config) #
feature isis
router isis UNDERLAY
net 49.0001.0010.0100.1074.00
is-type level-1
set-overload-bit on-startup 60
```

Setting the overload bit - You can configure a Cisco Nexus switch to signal other devices not to use the switch as an intermediate hop in their shortest path first (SPF) calculations. You can optionally configure the overload bit temporarily on startup. In the above example, the **set-overload-bit** command is used to set the overload bit on startup to 60 seconds.

##### IS-IS P2P interface configuration (leaf switch V1)

```
(config) #
interface Ethernet 1/41
description Link to Spine S1
```

```
mtu 9216
ip address 209.165.201.1/31
ip router isis UNDERLAY
```

### IS-IS loopback interface configuration (leaf switch V1)

Configure a loopback interface so that it can be used as the IS-IS router ID of leaf switch V1.

```
(config) #
interface loopback 0
ip address 10.1.1.74/32
ip router isis UNDERLAY
```

The IS-IS instance is tagged as UNDERLAY for better recall.

### (Corresponding) IS-IS spine switch S1 configuration

#### IS-IS global configuration

```
(config) #
feature isis
router isis UNDERLAY
net 49.0001.0010.0100.1053.00
is-type level-1
set-overload-bit on-startup 60
```

#### IS-IS P2P interface configuration (spine switch S1)

```
(config) #
interface Ethernet 1/1
description Link to VTEP V1
ip address 209.165.201.2/31
mtu 9216
ip router isis UNDERLAY
```

#### IS-IS loopback interface configuration (spine switch S1)

```
interface loopback 0
ip address 10.1.1.53/32
ip router isis UNDERLAY
.
```

To complete IS-IS topology configuration for the above image, configure the following:

- 3 more leaf switch V1's interfaces (or 3 more P2P links) to the remaining 3 spine switches.
- Repeat the procedure to connect P2P links between leaf switches V2, V3 and V4 and the spine switches.

### IS-IS - IP unnumbered scenario

#### IS-IS configuration on leaf switch V1

##### IS-IS global configuration

```
(config) #
feature isis
router isis UNDERLAY
net 49.0001.0010.0100.1074.00
is-type level-1
set-overload-bit on-startup 60
```

### IS-IS interface configuration (leaf switch V1)

```
(config) #
interface Ethernet1/41
description Link to Spine S1
mtu 9216
medium p2p
ip unnumbered loopback0
ip router isis UNDERLAY
```

### IS-IS loopback interface configuration (leaf switch V1)

```
(config) #
interface loopback0
ip address 10.1.1.74/32
ip router isis UNDERLAY
```

### IS-IS configuration on the spine switch S1

#### IS-IS global configuration

```
(config) #
feature isis
router isis UNDERLAY
net 49.0001.0010.0100.1053.00
is-type level-1
set-overload-bit on-startup 60
```

#### IS-IS interface configuration (spine switch S1)

```
(config) #
interface Ethernet1/41
description Link to V1
mtu 9216
medium p2p
ip unnumbered loopback0
ip router isis UNDERLAY
```

#### IS-IS loopback interface configuration (spine switch S1)

```
(config) #
interface loopback0
ip address 10.1.1.53/32
ip router isis UNDERLAY
```

### IS-IS Verification

Use the following commands for verifying IS-IS configuration on leaf switch V1:

```
Leaf-Switch-V1# show isis

ISIS process : UNDERLAY
Instance number : 1
UUID: 1090519320
Process ID 20258
VRF: default
System ID : 0010.0100.1074 IS-Type : L1
SAP : 412 Queue Handle : 15
Maximum LSP MTU: 9216
Stateful HA enabled
Graceful Restart enabled. State: Inactive
```

```

Last graceful restart status : none
Start-Mode Complete
BFD IPv4 is globally disabled for ISIS process: UNDERLAY
BFD IPv6 is globally disabled for ISIS process: UNDERLAY
Topology-mode is base
Metric-style : advertise(wide), accept(narrow, wide)
Area address(es) :
49.0001
Process is up and running
VRF ID: 1
Stale routes during non-graceful controlled restart
Interfaces supported by IS-IS :
loopback0
loopback1
Ethernet1/41
Topology : 0
Address family IPv4 unicast :
Number of interface : 2
Distance : 115
Address family IPv6 unicast :
Number of interface : 0
Distance : 115
Topology : 2
Address family IPv4 unicast :
Number of interface : 0
Distance : 115
Address family IPv6 unicast :
Number of interface : 0
Distance : 115
Level1
No auth type and keychain
Auth check set
Level2
No auth type and keychain
Auth check set
L1 Next SPF: Inactive
L2 Next SPF: Inactive

```

```
Leaf-Switch-V1# show isis interface
```

```

IS-IS process: UNDERLAY VRF: default
loopback0, Interface status: protocol-up/link-up/admin-up IP address: 10.1.1.74, IP subnet:
 10.1.1.74/32
IPv6 routing is disabled Level1
No auth type and keychain Auth check set
Level2
No auth type and keychain Auth check set
Index: 0x0001, Local Circuit ID: 0x01, Circuit Type: L1 BFD IPv4 is locally disabled for
Interface loopback0 BFD IPv6 is locally disabled for Interface loopback0 MTR is disabled
Level Metric 1 1
2 1
Topologies enabled:
L MT Metric MetricCfg Fwdng IPV4-MT IPV4Cfg IPV6-MT IPV6Cfg
1 0 1 no UP UP yes DN no
2 0 1 no DN DN no DN no

loopback1, Interface status: protocol-up/link-up/admin-up
IP address: 10.1.2.74, IP subnet: 10.1.2.74/32
IPv6 routing is disabled
Level1
No auth type and keychain
Auth check set
Level2
No auth type and keychain
Auth check set

```

```

Index: 0x0002, Local Circuit ID: 0x01, Circuit Type: L1
BFD IPv4 is locally disabled for Interface loopback1
BFD IPv6 is locally disabled for Interface loopback1
MTR is disabled
Passive level: level-2
Level      Metric
1          1
2          1
Topologies enabled:
L MT Metric MetricCfg Fwdng IPV4-MT IPV4Cfg IPV6-MT IPV6Cfg
1 0      1      no   UP   UP     yes   DN     no
2 0      1      no   DN   DN     no    DN     no

Ethernet1/41, Interface status: protocol-up/link-up/admin-up
IP unnumbered interface (loopback0)
IPv6 routing is disabled
No auth type and keychain
Auth check set
Index: 0x0002, Local Circuit ID: 0x01, Circuit Type: L1
BFD IPv4 is locally disabled for Interface Ethernet1/41
BFD IPv6 is locally disabled for Interface Ethernet1/41
MTR is disabled
Extended Local Circuit ID: 0x1A028000, P2P Circuit ID: 0000.0000.0000.00
Retx interval: 5, Retx throttle interval: 66 ms
LSP interval: 33 ms, MTU: 9216
P2P Adjs: 1, AdjsUp: 1, Priority 64
Hello Interval: 10, Multi: 3, Next IIH: 00:00:01
MT  Adjs  AdjsUp Metric  CSNP  Next CSNP  Last LSP ID
1   1     1       1       4     60  00:00:35  ffff.ffff.ffff.ff-ff
2   0     0       0       4     60  Inactive  ffff.ffff.ffff.ff-ff
Topologies enabled:
L MT Metric MetricCfg Fwdng IPV4-MT IPV4Cfg IPV6-MT IPV6Cfg
1 0      4      no   UP   UP     yes   DN     no
2 0      4      no   UP   DN     no    DN     no

Leaf-Switch-V1# show isis adjacency

IS-IS process: UNDERLAY VRF: default
IS-IS adjacency database:
Legend: '!': No AF level connectivity in given topology
System ID      SNPA    Level  State Hold Time  Interface
Spine-Switch-S1  N/A     1      UP    00:00:23  Ethernet1/41

```

For a detailed list of commands, refer to the Configuration and Command Reference guides.

## eBGP Underlay IP Network

Some customers prefer using the same protocol in both the underlay and overlay to minimize the number of protocols that need to be supported in their network.

- The eBGP-based underlay can be configured in multiple ways. The configurations presented here are validated for functionality and convergence.
- This design follows a multi-AS model.
- eBGP underlay requires numbered interfaces between leaf and spine nodes, as there is no other protocol to distribute peer reachability.
- Overlay sessions are configured on loopback addresses to enhance resiliency in case of link or node failures.

- BGP speakers on the spine layer configure all leaf node eBGP neighbors individually, unlike iBGP-based peering, which can use dynamic BGP.
- Guidelines for using multiple AS numbers in a fabric:
  - All spine nodes acting as BGP speakers reside in one AS.
  - Each leaf node uses a unique AS number, different from the spine BGP speakers.
  - A vPC leaf switch pair shares the same AS number.
  - If a globally unique AS number is required for the fabric, it can be configured on the border leaf or border PE switches. Other nodes can use private AS numbers.
  - BGP Confederation is not used.

### Configuration and Operation of eBGP Underlay

The eBGP-based underlay can be configured in multiple ways. The configurations presented here are validated for functionality and convergence.

The following list summarizes key configuration and operational aspects:

- This design follows a multi-AS model.
- eBGP underlay requires numbered interfaces between leaf and spine nodes to establish BGP sessions.
- Overlay sessions are configured on loopback addresses to improve resiliency.
- BGP speakers on the spine layer configure all leaf eBGP neighbors individually.
- Guidelines for multiple AS numbers:
  - All spine nodes configured as BGP speakers are in one AS.
  - Each leaf node uses a unique AS number different from the spine layer.
  - A vPC leaf switch pair uses the same AS number.
  - If a global AS is required, configure it on the border leaf or border PE switches. Others can use private AS numbers.
  - BGP Confederation is not used.

Sample configurations for a spine switch and leaf switch are provided below.

1. *Spine switch S1 configuration* — On spine switch S1, all leaf nodes are configured as eBGP neighbors.

```
(config) #
router bgp 65536
router-id 10.1.1.53
address-family ipv4 unicast
redistribute direct route-map DIRECT-ROUTES-MAP
```

The **redistribute direct** command advertises loopback addresses used for BGP and VTEP peering. The route map filters advertisements to include only eBGP peering and VTEP loopback addresses.

```
maximum-paths 2
address-family l2vpn evpn
retain route-target all
```

Since spine BGP speakers lack VRF configuration, the **retain route-target all** command retains and forwards routes to leaf VTEPs. The **maximum-paths** command enables ECMP in the underlay.

## 2. Underlay session towards leaf switch V1 (vPC setup)

```
(config) #
neighbor 10.0.1.2 remote-as 65551
address-family ipv4 unicast
disable-peer-as-check
send-community both
```

The **disable-peer-as-check** command allows route propagation between vPC switches sharing the same AS.

## 3. Overlay session on spine switch S1 towards leaf switch V1

```
(config) #
route-map UNCHANGED permit 10
set ip next-hop unchanged
```




---

**Note** The route map ensures that overlay routes preserve the originating leaf as the next hop.

---

```
(config) #
neighbor 10.0.51.1 remote-as 65551
update-source loopback0
ebgp-multihop 2
address-family l2vpn evpn
rewrite-evpn-rt-asn
disable-peer-as-check
send-community both
route-map UNCHANGED out
```

## 4. Route Target auto configuration

```
(config) #
vrf context coke
vni 50000
rd auto
address-family ipv4 unicast
route-target both auto
route-target both auto evpn
address-family ipv6 unicast
route-target both auto
route-target both auto evpn
```

The **rewrite-evpn-rt-asn** command is required when using the *Route Target auto* feature. Route targets are derived from the Local AS and VNID (Local AS:VNID).

## 5. Leaf switch VTEP V1 configuration

```
(config) #
router bgp 65551
router-id 10.1.1.54
address-family ipv4 unicast
maximum-paths 2
address-family l2vpn evpn
```

The **maximum-paths** command enables ECMP for underlay routes.

### 6. Underlay session on leaf switch VTEP V1 towards spine switch S1

```
(config) #
neighbor 10.0.1.1 remote-as 65536
address-family ipv4 unicast
allows-in
send-community both
```

The **allows-in** command is needed when vPC leaf nodes share the same AS number.

### 7. Overlay session towards spine switch S1

```
(config) #
neighbor 10.1.1.53 remote-as 65536
update-source loopback0
ebgp-multihop 2
address-family l2vpn evpn
rewrite-evpn-rt-asn
allows-in
send-community both
```

### 8. vPC backup session

```
(config) #
route-map SET-PEER-AS-NEXTHOP permit 10
set ip next-hop peer-address

neighbor 192.168.0.1 remote-as 65551
update-source Vlan3801
address-family ipv4 unicast
send-community both
route-map SET-PEER-AS-NEXTHOP out
```



#### Note

- This session is configured on the backup SVI between vPC leaf switches.
- For this deployment, the secondary IP must be pruned to enable its advertisement between vPC peers over iBGP.

To complete the configuration for the topology, perform the following:

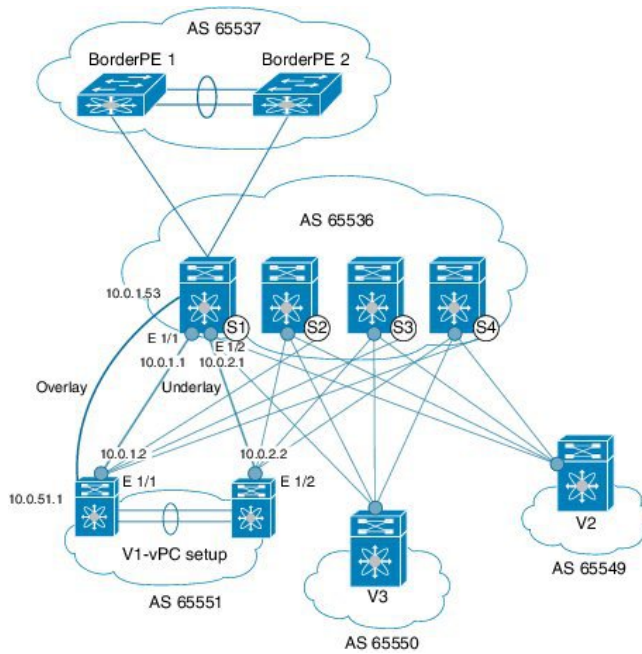
- Configure V1 as a BGP neighbor to other spine switches.
- Repeat the procedure for other leaf switches.

For BGP verification, use the following commands:

```
show bgp all
show bgp ipv4 unicast neighbors
show ip route bgp
```

For a detailed list of commands, refer to the Configuration and Command Reference guides.

Figure 5: eBGP as Underlay



## VXLAN EVPN Programmable Fabric Multicast Routing Support

Refer to the table below to know the multicast protocol(s) your Cisco Nexus switches support.

Table 1: Multicast Routing Options for Cisco Nexus Switches

Switch Combination	Multicast Routing Option
Cisco Nexus 7000/7700 Series switches with Cisco Nexus 9000 Series switches	PIM ASM (Sparse Mode)
Cisco Nexus 9000 Series	PIM ASM (Sparse Mode) or PIM BiDir



**Note** PIM BiDir is supported on Cisco Nexus 9300-FX/FX2 platform switches.

Beginning with Cisco NX-OS Release 10.4(3)F, PIM Bidir is also supported on Cisco Nexus 9300-FX3/GX/GX2/H2R/H1 switches, 9500 switches with 9700-GX line cards.

Beginning with Cisco NX-OS Release 10.3(5)M, PIM Bidir is also supported on Cisco Nexus 9300-FX3/GX/GX2/H2R/H1 switches, 9500 switches with 9700-GX line cards.

Beginning with Cisco NX-OS Release 10.5(2)F, PIM Bidir is also supported on Cisco Nexus 9500 Series switches with N9K-X9736C-FX3 line card.

You can transport BUM traffic without multicast, through ingress replication. Ingress replication is currently available on Cisco Nexus 9000 Series switches.

## PIM ASM and PIM Bidir Underlay IP Network

- PIM ASM is supported on Cisco Nexus 7000 and 9000 series switches as the underlay multicast protocol.
- Nexus 7000 also supports bidirectional PIM as the underlay multicast protocol.
- Anycast RP enables redundancy and load sharing between multiple Rendezvous-Points in the multicast topology.

### Multicast Topology Design Pointers and Configuration Notes

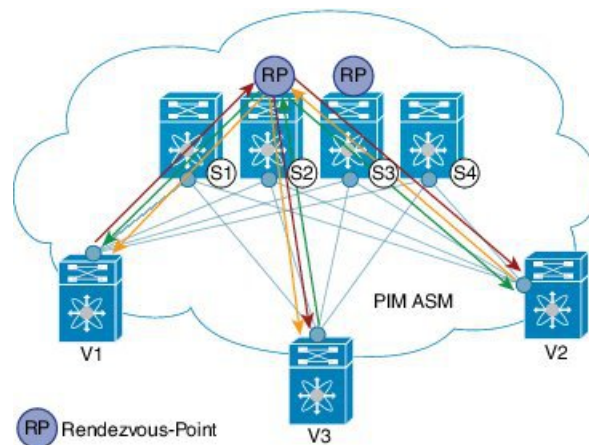
Some multicast topology design pointers are:

- Use spine/aggregation switches as Rendezvous-Point locations.
- Reserve a range of multicast groups (destination groups/DGroups) to service the overlay and optimize for diverse VNIs.
- In a spine-leaf topology with a lean spine, use multiple Rendezvous-Points across multiple spine switches.
- Use redundant Rendezvous-Points.
- Map different VNIs to different multicast groups, which are mapped to different Rendezvous-Points for load balancing.

The following configuration samples are from an IP underlay perspective and are not comprehensive. Functions such as PIM authentication, BFD for PIM, etc, are not shown here. Refer to the respective Cisco Nexus Series switch multicast configuration guide for complete information.

### PIM Sparse-Mode (Any-Source Multicast [ASM])

**Figure 6: PIM ASM as the IP multicast routing protocol**



- PIM ASM is the IP multicast routing protocol used in the underlay.
- Leaf switches (V1, V2, and V3 with VTEP configuration) connect to four spine switches (S1, S2, S3, and S4).
- Two multicast Rendezvous-Points (S2 and S3) are configured for load sharing and redundancy.
- Anycast RP ensures redundancy and load sharing between the two Rendezvous-Points by sharing the same IP address among multiple spines serving as RPs.

- Each RP has its unique IP address added in the RP set for RPs to sync information about sources between all spines acting as RPs.
- The shared multicast tree is unidirectional and uses the Rendezvous-Point for forwarding packets.
- PIM ASM at a glance: 1 source tree per multicast group per leaf switch.
- All VTEPs that serve a VNI join a shared multicast tree.
- VTEPs V1, V2, and V3 with hosts attached from a single tenant (e.g., tenant x) form a separate multicast (source, group) tree.
- A VTEP (e.g., V1) may have hosts belonging to other tenants; each tenant may have different multicast groups associated with it.
- A source tree is created for each tenant residing on the VTEP, if the tenants do not share a multicast group.

## Configure PIM ASM

This task describes how to configure PIM ASM, including Anycast Rendezvous-Point (RP), on Cisco Nexus 7000 and 9000 Series switches for both leaf and spine switches.

- Configure RP reachability and Anycast RP association on leaf switches.
- Configure PIM and loopback interfaces on spine switches acting as RPs and non-RPs.

The configuration mode required for each task is indicated at the beginning of each configuration block. Configuration tasks and corresponding show command outputs are displayed for a part of the topology, such as a leaf switch and connected spine switch. The show command output reflects only the relevant configuration.

- Repeat the configuration steps for all relevant switches and interfaces in your topology as indicated.

### Procedure

**Step 1** Configure RP reachability and interface parameters on the leaf switch (V1).

- Use the **feature pim** command to enable PIM and the **ip pim rp-address *rp-address* group-list *group-range*** command to define the Anycast RP.

**Example:**

```
switch(config)# feature pim
switch(config)# ip pim rp-address 198.51.100.220 group-list 224.1.1.1
```

198.51.100.220 is the Anycast Rendezvous-Point IP address.

- Use the **interface loopback *number*** command to configure the loopback interface for PIM.

**Example:**

```
switch(config)# interface loopback 0
switch(config-if)# ip address 209.165.201.20/32
switch(config-if)# ip pim sparse-mode
```

- Use the **interface ethernet *slot/port*** command to configure the Point-to-Point (P2P) interface for leaf switch V1 to spine switch S2 connectivity.

**Example:**

```
switch(config)# interface Ethernet 1/1
switch(config-if)# no switchport
switch(config-if)# ip address 209.165.201.14/31
switch(config-if)# mtu 9216
switch(config-if)# ip pim sparse-mode
```

- d) Repeat the above configuration for a P2P link between V1 and the spine switch (S3) acting as the redundant Anycast Rendezvous-Point.

**Step 2**

Configure connectivity to non-rendezvous point spine switches on leaf switch V1.

- a) Use the **interface ethernet slot/port** command to configure the P2P interface for leaf switch V1 to non-rendezvous point spine switch (S1) connectivity.

**Example:**

```
switch(config)# interface Ethernet 2/2
switch(config-if)# no switchport
switch(config-if)# ip address 209.165.201.10/31
switch(config-if)# mtu 9216
switch(config-if)# ip pim sparse-mode
```

- b) Repeat the above configuration for all P2P links between V1 and non-rendezvous point spine switches.

**Step 3**

Repeat the complete procedure above to configure all other leaf switches.

**Step 4**

Configure PIM and Anycast RP on spine switch S2 (Rendezvous Point).

- a) Use the **feature pim** command to enable PIM.

**Example:**

```
switch(config)# feature pim
```

- b) Use the **interface loopback number** command to configure the loopback interface for the RP.

**Example:**

```
switch(config)# interface loopback 0
switch(config-if)# ip address 10.10.100.100/32
switch(config-if)# ip pim sparse-mode
```

- c) Use the **interface loopback number** command to configure the loopback interface for Anycast RP.

**Example:**

```
switch(config)# interface loopback 1
switch(config-if)# ip address 198.51.100.220/32
switch(config-if)# ip pim sparse-mode
```

- d) Use the **ip pim anycast-rp anycast-rp-addr member-addr** command to associate Anycast RP with the loopback IP addresses of S2 and S3 for redundancy.

**Example:**

```
switch(config)# ip pim rp-address 198.51.100.220 group-list 224.1.1.1
switch(config)# ip pim anycast-rp 198.51.100.220 10.10.100.100
switch(config)# ip pim anycast-rp 198.51.100.220 10.10.20.100
```

Apply the above configurations to the other spine switch (S3) performing the role of RP.

**Step 5**

Configure PIM ASM on spine switches that are not designated as rendezvous points (S1 and S4).

- a) Use the **feature pim** and **ip pim rp-address** commands to configure PIM ASM globally on spine switch S1 (non-RP).

**Example:**

```
switch(config)# feature pim
switch(config)# ip pim rp-address 198.51.100.220 group-list 224.1.1.1
```

- b) Use the **interface loopback number** command to configure the loopback interface on spine switch S1.

**Example:**

```
switch(config)# interface loopback 0
switch(config-if)# ip address 10.10.100.103/32
switch(config-if)# ip pim sparse-mode
```

- c) Use the **interface ethernet slot/port** command to configure the P2P interface for spine switch S1 to leaf switch V1 connectivity.

**Example:**

```
switch(config)# interface Ethernet 2/2
switch(config-if)# no switchport
switch(config-if)# ip address 209.165.201.15/31
switch(config-if)# mtu 9216
switch(config-if)# ip pim sparse-mode
```

- d) Repeat the above configuration for all P2P links between the non-rendezvous point spine switches and other leaf switches (VTEPs).

## Verify PIM ASM Configuration

This task describes how to verify the PIM ASM configuration using various show commands on the device.

### Procedure

- Step 1** Enter the following command to display the multicast routing table for a specific group:

**Example:**

```
Leaf-Switch-V1# show ip mroute 224.1.1.1
IP Multicast Routing Table for VRF "default"
(*, 224.1.1.1/32), uptime: 02:21:20, nve ip pim
  Incoming interface: Ethernet1/1, RPF nbr: 10.10.100.100
  Outgoing interface list: (count: 1)
    nve1, uptime: 02:21:20, nve
(10.1.1.54/32, 224.1.1.1/32), uptime: 00:08:33, ip mrrib pim
  Incoming interface: Ethernet1/2, RPF nbr: 209.165.201.12
  Outgoing interface list: (count: 1)
    nve1, uptime: 00:08:33, mrrib
(10.1.1.74/32, 224.1.1.1/32), uptime: 02:21:20, nve mrrib ip pim
  Incoming interface: loopback0, RPF nbr: 10.1.1.74
  Outgoing interface list: (count: 1)
    Ethernet1/6, uptime: 00:29:19, pim
```

This command displays the multicast routing entries, including incoming and outgoing interfaces, RPF neighbors, and uptime for each entry.

- Step 2** Enter the following command to verify the PIM RP status information:

**Example:**

```
Leaf-Switch-V1# show ip pim rp
PIM RP Status Information for VRF "default"
BSR disabled
Auto-RP disabled
BSR RP Candidate policy: None
BSR RP policy: None
Auto-RP Announce policy: None
Auto-RP Discovery policy: None
RP: 198.51.100.220, (0), uptime: 03:17:43, expires: never,
  priority: 0, RP-source: (local), group ranges:
    224.0.0.0/9
```

This command displays the status of the Rendezvous Point (RP), including RP address, uptime, priority, and group ranges.

**Step 3** Enter the following command to display PIM interface status and statistics:

**Example:**

```
Leaf-Switch-V1# show ip pim interface
PIM Interface Status for VRF "default"
Ethernet1/1, Interface status: protocol-up/link-up/admin-up
IP address: 209.165.201.14, IP subnet: 209.165.201.14/31
PIM DR: 209.165.201.12, DR's priority: 1
PIM neighbor count: 1
PIM hello interval: 30 secs, next hello sent in: 00:00:11
PIM neighbor holdtime: 105 secs
PIM configured DR priority: 1
PIM configured DR delay: 3 secs
PIM border interface: no
PIM GenID sent in Hellos: 0x33d53dcl
PIM Hello MD5-AH Authentication: disabled
PIM Neighbor policy: none configured
PIM Join-Prune inbound policy: none configured
PIM Join-Prune outbound policy: none configured
PIM Join-Prune interval: 1 minutes
PIM Join-Prune next sending: 1 minutes
PIM BFD enabled: no
PIM passive interface: no
PIM VPC SVI: no
PIM Auto Enabled: no
PIM Interface Statistics, last reset: never
  General (sent/received):
    Hellos: 423/425 (early: 0), JPs: 37/32, Asserts: 0/0
    Grafts: 0/0, Graft-Acks: 0/0
    DF-Offers: 4/6, DF-Winners: 0/197, DF-Backoffs: 0/0, DF-Passes: 0/0
  Errors:
    Checksum errors: 0, Invalid packet types/DF subtypes: 0/0
    Authentication failed: 0
    Packet length errors: 0, Bad version packets: 0, Packets from self: 0
    Packets from non-neighbors: 0
    Packets received on passiveinterface: 0
    JPs received on RPF-interface: 0
    (*,G) Joins received with no/wrong RP: 0/0
    (*,G)/(S,G) JPs received for SSM/Bidir groups: 0/0
    JPs filtered by inbound policy: 0
    JPs filtered by outbound policy: 0
loopback0, Interface status: protocol-up/link-up/admin-up
IP address: 209.165.201.20, IP subnet: 209.165.201.20/32
PIM DR: 209.165.201.20, DR's priority: 1
PIM neighbor count: 0
PIM hello interval: 30 secs, next hello sent in: 00:00:07
PIM neighbor holdtime: 105 secs
PIM configured DR priority: 1
PIM configured DR delay: 3 secs
```

```

PIM border interface: no
PIM GenID sent in Hellos: 0x1be2bd41
PIM Hello MD5-AH Authentication: disabled
PIM Neighbor policy: none configured
PIM Join-Prune inbound policy: none configured
PIM Join-Prune outbound policy: none configured
PIM Join-Prune interval: 1 minutes
PIM Join-Prune next sending: 1 minutes
PIM BFD enabled: no
PIM passive interface: no
PIM VPC SVI: no
PIM Auto Enabled: no
PIM Interface Statistics, last reset: never
  General (sent/received):
    Hellos: 419/0 (early: 0), JPs: 2/0, Asserts: 0/0
    Grafts: 0/0, Graft-Acks: 0/0
    DF-Offers: 3/0, DF-Winners: 0/0, DF-Backoffs: 0/0, DF-Passes: 0/0
  Errors:
    Checksum errors: 0, Invalid packet types/DF subtypes: 0/0
    Authentication failed: 0
    Packet length errors: 0, Bad version packets: 0, Packets from self: 0
    Packets from non-neighbors: 0
      Packets received on passiveinterface: 0
    JPs received on RPF-interface: 0
    (*,G) Joins received with no/wrong RP: 0/0
    (*,G)/(S,G) JPs received for SSM/Bidir groups: 0/0
    JPs filtered by inbound policy: 0
    JPs filtered by outbound policy: 0

```

This command provides detailed information about PIM interfaces, including status, IP address, designated router, neighbor count, hello intervals, and interface statistics.

**Step 4** Enter the following command to display PIM neighbor information:

**Example:**

```

Leaf-Switch-V1# show ip pim neighbor
PIM Neighbor Status for VRF "default"
Neighbor      Interface      Uptime      Expires      DR      Bidir-      BFD
              Interface      Uptime      Expires      Priority Capable      State
10.10.100.100 Ethernet1/1    1w1d       00:01:33    1      yes        n/a

```

This command displays the PIM neighbors, their interfaces, uptime, DR priority, bidirectional capability, and BFD state.

**Step 5** For a detailed list of commands, refer to the Configuration and Command Reference guides.

## PIM Bidirectional (BiDir)

- Bidirectional PIM is supported on the Nexus 5600 and Nexus 7000 series as the underlay multicast protocol.
- VXLAN BiDir underlay is supported on Cisco Nexus 9300-EX and 9300-FX/FX2 /FX3 platform switches.
- With bidirectional PIM, one bidirectional, shared tree rooted at the RP is built for each multicast group, and source specific state is not maintained within the fabric, providing a more scalable solution.

### PIM BiDir as the IP multicast routing protocol

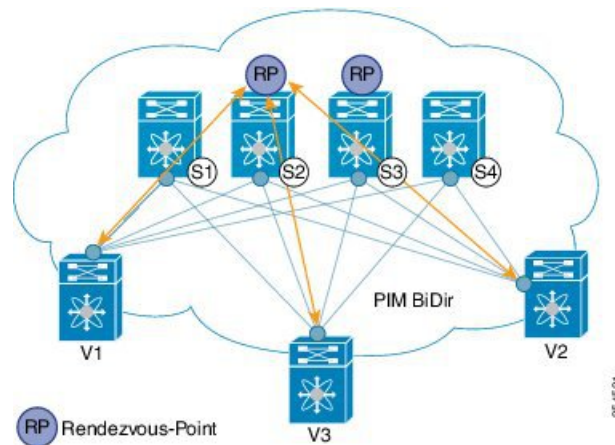
In the above image, the leaf switches (V1, V2, and V3) are at the bottom of the image. They are connected to the 4 spine switches (S1, S2, S3, and S4) that are depicted at the top of the image. The two PIM Rendezvous-Points using phantom RP mechanism are used for load sharing and redundancy purposes.

- The 3 VTEPs share the same VNI and multicast group mapping to form a single multicast group tree.



**Note** Load sharing happens only via different multicast groups, for the respective, different VNI.

*Figure 7: PIM BiDir as the IP multicast routing protocol*



#### PIM BiDir Configuration

The following is a configuration example of having two spine switches S2 and S3 serving as RPs using phantom RP for redundancy and loadsharing. Here S2 is the primary RP for group-list 227.2.2.0/26 and secondary for group-list 227.2.2.64/26. S3 is the primary RP for group-list 227.2.2.64/26 and secondary RP for group-list 227.2.2.0/26.



**Note** Phantom RP is used in a PIM BiDir environment where RP redundancy is designed using loopback networks with different mask lengths in the primary and secondary routers. These loopback interfaces are in the same subnet as the RP address, but with different IP addresses from the RP address. (Since the IP address advertised as RP address is not defined on any routers, the term phantom is used). The subnet of the loopback is advertised in the Interior Gateway Protocol (IGP). To maintain RP reachability, it is only necessary to ensure that a route to the RP exists.

Unicast routing longest match algorithms are used to pick the primary over the secondary router.

The primary router announces a longest match route (say, a /30 route for the RP address) and is preferred over the less specific route announced by the secondary router (a /29 route for the same RP address). The primary router advertises the /30 route of the RP, while the secondary router advertises the /29 route. The latter is only chosen when the primary router goes offline. We will be able to switch from the primary to the secondary RP at the speed of convergence of the routing protocol.

For ease of use, the configuration mode from which you need to start configuring a task is mentioned at the beginning of each configuration.

Configuration tasks and corresponding show command output are displayed for a part of the topology in the image. For example, if the sample configuration is shown for a leaf switch and connected spine switch, the show command output for the configuration only displays corresponding configuration.

## Configure PIM and Phantom RP on Leaf and Spine Switches

### Procedure

**Step 1** Configure PIM, phantom RP association, and interfaces on leaf switch V1.

- a) Use the **feature pim** and **ip pim rp-address *rp-address* group-list *group-range* bidir** commands to enable PIM and associate the phantom RP.

**Example:**

```
switch(config)# feature pim
switch(config)# ip pim rp-address 10.254.254.1 group-list 227.2.2.0/26 bidir
switch(config)# ip pim rp-address 10.254.254.65 group-list 227.2.2.64/26 bidir
```

- b) Use the **interface loopback *number*** command to configure the loopback interface for PIM.

**Example:**

```
switch(config)# interface loopback 0
switch(config-if)# ip address 10.1.1.54/32
switch(config-if)# ip pim sparse-mode
```

- c) Configure the Point-to-Point (P2P) interfaces and MTU settings for leaf switch connectivity.

**Example:**

```
switch(config)# interface Ethernet 1/1
switch(config-if)# no switchport
switch(config-if)# mtu 9216
switch(config-if)# medium p2p
switch(config-if)# ip unnumbered loopback 0
switch(config-if)# ip pim sparse-mode
switch(config)# interface Ethernet 2/2
```

```
switch(config-if) # no switchport
switch(config-if) # mtu 9216
switch(config-if) # medium p2p
switch(config-if) # ip unnumbered loopback 0
switch(config-if) # ip pim sparse-mode
```

Use an MTU of 9216 for Cisco Nexus 5600 series switches.

## Step 2 Configure phantom RP and PIM interfaces on spine switch S2 (RP1).

- a) Use the **feature pim** and **ip pim rp-address** commands to enable PIM and configure phantom RP association.

### Example:

```
switch(config) # feature pim
switch(config) # ip pim rp-address 10.254.254.1 group-list 227.2.2.0/26 bidir
switch(config) # ip pim rp-address 10.254.254.65 group-list 227.2.2.64/26 bidir
```

- b) Use the **interface loopback 0** command to configure the PIM loopback interface.

### Example:

```
switch(config) # interface loopback 0
switch(config-if) # ip address 10.1.1.53/32
switch(config-if) # ip pim sparse-mode
```

- c) Use the **interface ethernet slot/port** command to configure the P2P interface to leaf switch V1.

### Example:

```
switch(config) # interface Ethernet 1/1
switch(config-if) # no switchport
switch(config-if) # mtu 9216
switch(config-if) # medium p2p
switch(config-if) # ip unnumbered loopback 0
switch(config-if) # ip pim sparse-mode
```

- d) Use the **interface loopback number** command to configure loopback interfaces for phantom RP.

### Example:

```
switch(config) # interface loopback 1
switch(config-if) # ip address 10.254.254.2/30
switch(config-if) # ip pim sparse-mode
switch(config) # interface loopback 2
switch(config-if) # ip address 10.254.254.66/29
switch(config-if) # ip pim sparse-mode
```

## Step 3 Configure phantom RP and PIM interfaces on spine switch S3 (RP2).

- a) Use the **feature pim** and **ip pim rp-address** commands to enable PIM and configure phantom RP association.

### Example:

```
switch(config) # feature pim
switch(config) # ip pim rp-address 10.254.254.1 group-list 227.2.2.0/26 bidir
switch(config) # ip pim rp-address 10.254.254.65 group-list 227.2.2.64/26 bidir
```

- b) Use the **interface loopback 0** command to configure the PIM loopback interface.

### Example:

```
switch(config) # interface loopback 0
switch(config-if) # ip address 10.10.50.100/32
switch(config-if) # ip pim sparse-mode
```

- c) Use the **interface ethernet** *slot/port* command to configure the P2P interface to leaf switch V1.

**Example:**

```
switch(config)# interface Ethernet 2/2
switch(config-if)# no switchport
switch(config-if)# mtu 9216
switch(config-if)# medium p2p
switch(config-if)# ip unnumbered loopback 0
switch(config-if)# ip pim sparse-mode
```

- d) Use the **interface loopback** *number* command to configure loopback interfaces for phantom RP.

**Example:**

```
switch(config)# interface loopback 1
switch(config-if)# ip address 10.254.254.66/30
switch(config-if)# ip pim sparse-mode
switch(config)# interface loopback 2
switch(config-if)# ip address 10.254.254.2/29
switch(config-if)# ip pim sparse-mode
```

## Verify PIM BiDir Configuration

This task describes how to verify the PIM BiDir configuration using various show commands on the device.

### Procedure

- Step 1** Use the **show ip mroute** command to display the IP multicast routing table.

**Example:**

```
Leaf-Switch-V1# show ip mroute
IP Multicast Routing Table for VRF "default"
(*, 227.2.2.0/26), bidir, uptime: 4d08h, pim ip
  Incoming interface: Ethernet1/1, RPF nbr: 10.1.1.53
  Outgoing interface list: (count: 1)
    Ethernet1/1, uptime: 4d08h, pim, (RPF)
(*, 227.2.2.0/32), bidir, uptime: 4d08h, nve ip pim
  Incoming interface: Ethernet1/1, RPF nbr: 10.1.1.53
  Outgoing interface list: (count: 2)
    Ethernet1/1, uptime: 4d08h, pim, (RPF)
    nve1, uptime: 4d08h, nve
(*, 227.2.2.64/26), bidir, uptime: 4d08h, pim ip
  Incoming interface: Ethernet1/5, RPF nbr: 10.10.50.100/32
  Outgoing interface list: (count: 1)
    Ethernet1/5, uptime: 4d08h, pim, (RPF)
(*, 232.0.0.0/8), uptime: 4d08h, pim ip
  Incoming interface: Null, RPF nbr: 0.0.0.0
  Outgoing interface list: (count: 0)
```

Review the output to verify the multicast groups, incoming and outgoing interfaces, and RPF neighbors for PIM BiDir.

- Step 2** Use the **show ip pim rp** command to display PIM RP status information.

**Example:**

```
Leaf-Switch-V1# show ip pim rp
PIM RP Status Information for VRF "default"
BSR disabled
Auto-RP disabled
BSR RP Candidate policy: None
BSR RP policy: None
Auto-RP Announce policy: None
Auto-RP Discovery policy: None
RP: 10.254.254.1, (1),
  uptime: 4d08h  priority: 0,
  RP-source: (local),
  group ranges:
  227.2.2.0/26 (bidir)
RP: 10.254.254.65, (2),
  uptime: 4d08h  priority: 0,
  RP-source: (local),
  group ranges:
  227.2.2.64/26 (bidir)
```

Verify the RP addresses, group ranges, and bidirectional group assignments.

**Step 3** Use the **show ip pim interface** command to display the PIM interface status.

**Example:**

```
Leaf-Switch-V1# show ip pim interface
PIM Interface Status for VRF "default"
loopback0, Interface status: protocol-up/link-up/admin-up
  IP address: 10.1.1.54, IP subnet: 10.1.1.54/32
  PIM DR: 10.1.1.54, DR's priority: 1
  PIM neighbor count: 0
  PIM hello interval: 30 secs, next hello sent in: 00:00:23
  PIM neighbor holdtime: 105 secs
  PIM configured DR priority: 1
  PIM configured DR delay: 3 secs
  PIM border interface: no
  PIM GenID sent in Hellos: 0x12650908
  PIM Hello MD5-AH Authentication: disabled
  PIM Neighbor policy: none configured
  PIM Join-Prune inbound policy: none configured
  PIM Join-Prune outbound policy: none configured
  PIM Join-Prune interval: 1 minutes
  PIM Join-Prune next sending: 1 minutes
  PIM BFD enabled: no
  PIM passive interface: no
  PIM VPC SVI: no
  PIM Auto Enabled: no
  PIM Interface Statistics, last reset: never
  General (sent/received):
    Hellos: 13158/0 (early: 0), JPs: 0/0, Asserts: 0/0
    Grafts: 0/0, Graft-Acks: 0/0
    DF-Offers: 0/0, DF-Winners: 0/0, DF-Backoffs: 0/0, DF-Passes: 0/0
  Errors:
    Checksum errors: 0, Invalid packet types/DF subtypes: 0/0
    Authentication failed: 0
    Packet length errors: 0, Bad version packets: 0, Packets from self: 0
    Packets from non-neighbors: 0
      Packets received on passiveinterface: 0
    JPs received on RPF-interface: 0
    (*,G) Joins received with no/wrong RP: 0/0
    (*,G)/(S,G) JPs received for SSM/Bidir groups: 0/0
    JPs filtered by inbound policy: 0
    JPs filtered by outbound policy: 0
Ethernet1/1, Interface status: protocol-up/link-up/admin-up
  IP unnumbered interface (loopback0)
```

```

PIM DR: 10.1.1.54, DR's priority: 1
PIM neighbor count: 1
PIM hello interval: 30 secs, next hello sent in: 00:00:04
PIM neighbor holdtime: 105 secs
PIM configured DR priority: 1
PIM configured DR delay: 3 secs
PIM border interface: no
PIM GenID sent in Hellos: 0x2534269b
PIM Hello MD5-AH Authentication: disabled
PIM Neighbor policy: none configured
PIM Join-Prune inbound policy: none configured
PIM Join-Prune outbound policy: none configured
PIM Join-Prune interval: 1 minutes
PIM Join-Prune next sending: 1 minutes
PIM BFD enabled: no
PIM passive interface: no
PIM VPC SVI: no
PIM Auto Enabled: no
PIM Interface Statistics, last reset: never
  General (sent/received):
    Hellos: 13152/13162 (early: 0), JPs: 2/0, Asserts: 0/0
    Grafts: 0/0, Graft-Acks: 0/0
    DF-Offers: 9/5, DF-Winners: 6249/6254, DF-Backoffs: 0/1, DF-Passes: 0/1
  Errors:
    Checksum errors: 0, Invalid packet types/DF subtypes: 0/0
    Authentication failed: 0
    Packet length errors: 0, Bad version packets: 0, Packets from self: 0
    Packets from non-neighbors: 0
    Packets received on passiveinterface: 0
    JPs received on RPF-interface: 0
    (*,G) Joins received with no/wrong RP: 0/0
    (*,G)/(S,G) JPs received for SSM/Bidir groups: 0/0
    JPs filtered by inbound policy: 0
    JPs filtered by outbound policy: 0

```

Check the interface status, PIM DR, neighbor count, and interface statistics to ensure correct PIM BiDir operation.

**Step 4** Use the **show ip pim neighbor** command to display the PIM neighbor status.

**Example:**

```

Leaf-Switch-V1# show ip pim neighbor
PIM Neighbor Status for VRF "default"
Neighbor      Interface      Uptime      Expires      DR          Bidir-      BFD
              Interface      Uptime      Expires      Priority    Capable     State
10.1.1.53     Ethernet1/1    1w1d        00:01:33    1          yes         n/a
10.10.50.100 Ethernet2/2    1w1d        00:01:33    1          yes         n/a

```

Verify that the expected PIM neighbors are present and that the Bidir Capable field is set to "yes".

## Underlay Deployment Without Multicast (Ingress Replication)

Ingress replication is supported on Cisco Nexus 9000 Series switches.

- Beginning in NX-OS release 9.3(3), Ingress replication is supported on Cisco Nexus 9300-GX switches.