Contents

1 Configuring IPv6 Multicast Route Management

1.1 Introduction

Multicast route management covers how to create and modify multicast routes to control multicast packet forwarding and how to detect and maintain correctness of multicast forwarding paths. Multicast route management mainly includes the static multicast routing and reverse path forwarding (RPF) check features. Static multicast routing is used to modify or connect RPF routes, and RPF check is used to ensure that multicast data is forwarded on correct paths.

1.1.1 IPv6 Multicast Routing and Forwarding

An IPv6 multicast routing table includes MLD group entries, multicast protocol routing entries, multicast routing entries, and multicast hardware forwarding entries. These entries are maintained by different multicast routing protocols in the multicast network. The optimal IPv6 multicast routes are delivered to the hardware forwarding table and used to guide IPv6 multicast data forwarding. The RPF mechanism ensures that multicast data is forwarded on correct paths.

- MLD group entries: They are created when a host sends MLD join packets and used to maintain group member information and ask the multicast routing protocol to create (S, G) or (*, G) entries.

- Multicast protocol routing entries: They function as basis of multicast routing and forwarding and are maintained by different multicast routing protocols (the most widely applied protocol is PIM).

- Multicast routing entries: They are generated by the multicast routing management module and delivered to a multicast forwarding table. Different multicast routing protocols can be summarized based on the multicast routing entries to select an optimal route.

- Hardware forwarding entries: They are generated based on routing tables and used to guide multicast data forwarding.

1.1.2 RPF Check

1. **Basic Principles**

In unicast routing and forwarding, a device gets to know the outbound interface of packets based on the destination address. In multicast routing and forwarding, the destination address in multicast packets is a multicast address, based on which, a receiver address cannot be determined. However, the source address in multicast packets is determined and based on this source address, multicast packets can be forwarded on correct paths.

When receiving a multicast packet, a multicast device queries the unicast route of the multicast source based on the source address in the multicast packet and checks whether the outbound interface of this unicast route is consistent with the inbound interface of the multicast packet. If yes, it is considered that this multicast packet is forwarded on a correct path. The inbound interface of the multicast packet is referred to as an RPF interface.

2.   RPF Check Procedure

Unicast route, MBGP route, and static multicast route are the basis of RPF check. If these three types of routing entries exist on a multicast device, the multicast device performs the following checks in order after receiving a multicast packet:

(1) Select an optimal route from each of the three types of routing entries, respectively, based on the source address in the packet.

  ○   The outbound interface of a unicast route is an RPF interface and the next hop is an RPF neighbor.

  ○   The outbound interface of an MBGP route is an RPF interface and the next hop is an RPF neighbor.

  ○   The static multicast route is manually configured and an RPF interface and neighbor are specified.

(2) Select one route out of the three optimal routes as the RPF route. The selection rule is as follows:

  ○   If the longest match rule is not configured for selecting an RPF route, the one with the highest priority is selected as the RPF route. If the three routes have the same priority, the RPF route is selected in the order of static multicast route, MBGP route, and unicast route.

  ○   If the longest match rule is configured for selecting an RPF route, the one with the longest match is selected as the RPF route. If the three routes have the same mask, the one with the highest priority is selected as the RPF route. If they have the same priority, the RPF route is selected in the order of static multicast route, MBGP route, and unicast route.

(3) Compare the RPF interface of the RPF route with the inbound interface of the multicast packet.

  ○   If they are consistent, the route passes the RPF check and the multicast packet is forwarded to the downlink devices.

  ○   If they are inconsistent, the route fails the RPF check and the received multicast packet is discarded.

Table 1-1   Routing Table on a Multicast Device

IP Routing Table	
Network	**Interface**
1000::/64	Interface 0
2000::/64	Interface 1
3000::/64	Interface 2

As shown in Figure 1-2, the multicast device receives a multicast packet from the source 1000::1 through interface 0 and as listed in Table 1-1, the outbound interface of the route to the source 1000::1 is also interface 0. The outbound interface of the route is consistent with the inbound interface of the multicast packet. The route passes the RPF check and the multicast packet is forwarded on the correct path.

Figure 1-2   Topology of RPF Check Success

Multicast stream from source 1000:1

Interface 0

Interface 1   Interface 2
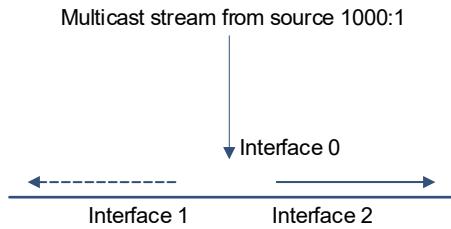
As shown in [Figure 1-3](#), the multicast device receives a multicast packet from the source 1000::1 through interface 1 and the outbound interface of the route to the source 1000::1 is Interface 0. The outbound interface of the route is inconsistent with the inbound interface of the multicast packet. The route fails the RPF check and the multicast packet is discarded.

Figure 1-3   Topology of RPF Check Failure

Multicast stream from source 1000:1

Interface 1

Interface 0   Interface 2
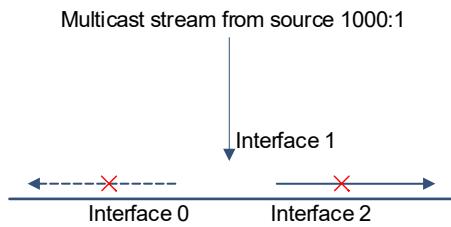
3.   **Application Scenarios of RPF Check in Multicast Forwarding**

A multicast device ensures that multicast packets are forwarded on correct paths and avoids loops on the forwarding paths based on the RPF check mechanism. In actual applications, if the multicast device performs RPF check each time it receives a multicast packet, the multicast device is overloaded. Therefore, upon receiving a multicast packet, the multicast device checks for corresponding (S, G) hardware forwarding entry, rather than performs RPF check. The checking process is as follows:

● If no (S, G) hardware forwarding entry exists, the multicast device performs RPF check, uses the RPF interface as an inbound interface, creates a multicast routing entry, and delivers the entry to the multicast forwarding table.

   ○ If the route passes the RPF check, the inbound interface of the multicast packet is consistent with the RPF interface. The multicast packet is forwarded to all the outbound interfaces in the forwarding table.

   ○ If the route fails the RPF check, the inbound interface of the multicast packet is inconsistent with the RPF interface. The multicast packet is discarded.

● If (S, G) hardware forwarding entries exist, the multicast device checks whether the inbound interface in the forwarding entry is consistent with the inbound interface of the multicast packet.

   ○ If they are consistent, the multicast packet is forwarded to all the outbound interfaces.

   ○ If they are inconsistent, the multicast device performs RPF check. If the RPF interface is consistent with the inbound interface in the hardware forwarding entry, the source path of the packet is incorrect but the (S, G) entry is correct. The multicast packet is discarded. If the RPF interface is inconsistent with the inbound interface in the hardware forwarding entry, the (S, G) entry expired. The inbound interface in the

entry is updated as an RPF interface. Then, the multicast device checks whether the RPF interface is consistent with the inbound interface of the packet. If they are consistent, this multicast packet is forwarded to all outbound interfaces in the forwarding table. Otherwise, this multicast packet is discarded.

1.1.3 Protocols and Standards

- RFC2710: Multicast Listener Discovery (MLDv1) for IPv6
- RFC3810: Multicast Listener Discovery Version 2 (MLDv2) for IPv6
- RFC4601: Protocol Independent Multicast-Sparse Mode (PIM-SM)
- RFC5059: Bootstrap Router (BSR) Mechanism for Protocol Independent Multicast (PIM)
- RFC4607: Source-Specific Multicast for IP

1.2 Configuration Task Summary

The IPv6 multicast route management configuration includes the following tasks:

(1) Configuring Basic Functions of IPv6 Multicast

(2) (Optional) Configuring the Maximum Number of Entries in an IPv6 Multicast Routing Table

(3) (Optional) Configuring an IPv6 Multicast Border

(4) (Optional) Configuring an IPv6 Static Multicast Route

(5) (Optional) Enabling Forced Forwarding of Multicast Packets by Software

(6) (Optional) Enabling L2 Direction Control for Multicast Streams

(7) (Optional) Configuring RPF Route Selection Based on the Longest Match Rule

1.3 Prerequisites

- In the multicast network, all nodes are reachable via IPv6 unicast routes.
- Configuring Basic Functions of IPv6 Multicast.

1.4 Configuring Basic Functions of IPv6 Multicast

1.4.1 Overview

The multicast routing function is enabled in the local network and a PIM network is created to provide data sources and user hosts in the network with the IPv6 multicast service.

A device maintains the routing table used for multicast packet forwarding over an IPv6 multicast routing protocol (for example, PIM-SMv6), and learns information about the status of group members in the directly-connected network segments over the MLDv1/v2 protocol. A host joins a specific IPv6 multicast group by sending an MLD REPORT message.

1.4.2 Restrictions and Guidelines

- The IPv6 multicast routing function should be enabled on each multicast device.
- The IPv6 multicast routing function is enabled prior to different IPv6 multicast protocols.
- The IPv6 multicast routing function and the MLD Snooping function are mutually exclusive.

- The IPv6 multicast protocol function must be enabled on each interface in the multicast network.

- After L3 multicast is enabled in the private VLAN and super VLAN and a multicast source exists in a sub VLAN, an extra entry whose ingress is the sub VLAN into which the multicast stream enters must be copied due to the validity check during multicast forwarding. This increases a multicast hardware entry and decreases the multicast capacity by one.

1.4.3 Prerequisites

In the multicast network, all nodes are reachable via IPv6 unicast routes.

1.4.4 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Enable the IPv6 multicast routing function.

ipv6 multicast-routing

The IPv6 multicast routing function is disabled by default.

(4) Enter the interface configuration mode.

interface *interface-type interface-number*

(5) Configure an IPv6 multicast protocol.

ipv6 pim sparse-mode

No IPv6 multicast protocol is enabled by default.

1.5 Configuring the Maximum Number of Entries in an IPv6 Multicast Routing Table

1.5.1 Overview

Every multicast data packet received by a device is used to maintain relevant IPv6 multicast routing entries. However, excessive multicast routing entries may exhaust device memory and cause device performance to decrease. Users can restrict the number of entries in the IPv6 multicast routing table based on the actual networking conditions and service performance requirements.

1.5.2 Restrictions and Guidelines

Due to limitations by hardware resources, routing entries that exceed the range permitted by hardware can be forwarded only by software, which causes performance to decrease.

1.5.3 Prerequisites

Configuring Basic Functions of IPv6 Multicast.

1.5.4 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Configure the maximum number of entries in an IPv6 multicast routing table.

ipv6 multicast route-limit *limit* [*threshold*]

By default, a maximum of 4000 entries can be added to an IPv6 multicast routing table.

The configured value of *threshold* must be smaller than or equal to the configured value of *limit*.

1.6   Configuring an IPv6 Multicast Border

1.6.1 Overview

An IPv6 multicast border is configured to define the transmission range of multicast packets. When a multicast border is configured on an interface, this interface cannot forward or receive multicast packets, including those sent from the local host.

1.6.2 Restrictions and Guidelines

- The ACL referenced in this command can be a standard ACL or an extended ACL. If an extended ACL is used, only destination addresses need to be matched.

- This command can be used to filter MLD and PIM-SMv6 protocol packets relevant to the IPv6 multicast group range. Multicast data streams are not sent or received by this multicast border interface.

1.6.3 Prerequisites

- [Configuring Basic Functions of IPv6 Multicast.](#)

- Before an IPv6 multicast border is configured, ensure that the corresponding ACL is created and a multicast group range is specified. For details about ACL configuration, see *Configuring ACL*.

1.6.4 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Enter the interface configuration mode.

interface *interface-type interface-number*

(4) Enable the IPv6 multicast routing function.

ipv6 multicast boundary *acl-name* [**in** | **out**]

No IPv6 multicast border is configured by default.

1.7 Configuring an IPv6 Static Multicast Route

1.7.1 Overview

An IPv6 static multicast route is configured to specify an RPF interface or RPF neighbor for multicast packets from a specific multicast source. This function is used to modify and connect RPF routes.

- Modify an RPF route. A device expects to receive multicast packets from a source through a specified interface. However, the RPF check result indicates that the RPF interface is not this specified interface. In this case, you need to configure an IPv6 static multicast route to specify this interface as an RPF interface. Upon receiving multicast packets from the source, the device performs RPF check. If the RPF check result indicates that the RPF interface is not this specified interface, the route fails the RPF check.

- Connect an RPF route. If the unicast route is interrupted, the RPF routing fails. In this case, you can configure a static multicast route to specify the RPF interface to complete the RPF check and implement multicast packet forwarding.

1.7.2 Restrictions and Guidelines

To specify an outbound interface rather than a next-hop IP address for the IPv6 static multicast route, ensure that the outbound interface is of the point-to-point type.

1.7.3 Prerequisites

[Configuring Basic Functions of IPv6 Multicast.](#)

1.7.4 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Configure an IPv6 static multicast route.

ipv6 mroute *ipv6-address/prefix-length* [*protocol*] { *ipv6-rpf-addrress* | *interface-type interface-number* } [*distance*]

No IPv6 static multicast route is configured by default.

1.8 Enabling Forced Forwarding of Multicast Packets by Software

1.8.1 Overview

After this function is enabled, all IPv6 multicast data packets destined for the CPU are forcedly forwarded by software.

1.8.2 Restrictions and Guidelines

The cache mechanism and forwarding performance problem may cause packet disorder if the multicast streams are heavy. You are not advised to run this command generally.

1.8.3 Prerequisites

[Configuring Basic Functions of IPv6 Multicast.](#)

1.8.4 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Enable the function of forced forwarding of multicast packets by software.

msf6 force-forwarding

The function of forced forwarding of IPv6 multicast packets (destined for the CPU) by software is disabled by default.

1.9 Enabling L2 Direction Control for Multicast Streams

1.9.1 Overview

L2 direction control is enabled for multicast streams to control the forwarding of multicast streams on an interface. Multiple commands can be configured for a specified multicast stream so that the stream can be forwarded by multiple interfaces. After direction control is enabled for a multicast stream, the stream can be forwarded only by these configured interfaces. Other interfaces are not permitted to forward the stream.

1.9.2 Restrictions and Guidelines

This function controls only the forwarding of multicast streams on interfaces, but does not directly affect the processing of multicast protocols on the protocol packets. Some features (for example, establishment of L3 hardware forwarding entry) of multicast protocols (such as PIM-SMv6) are driven by multicast data streams, and therefore, the behavior of the multicast routing protocols may still be affected.

1.9.3 Prerequisites

[Configuring Basic Functions of IPv6 Multicast.](#)

1.9.4 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Enable L2 direction control for multicast streams.

ipv6 multicast static *ipv6-source-address ipv6-group-address interface-type interface-number*

L2 direction control is disabled for multicast streams by default.

1.10 Configuring RPF Route Selection Based on the Longest Match Rule

1.10.1 Overview

In multicast routing, various routing entries, such as static multicast routing entry, MBGP routing entry and unicast routing entry, may exist. If RPF route selection based on the longest match rule is configured, the route with the longest match mask is selected from the optimal routes of multiple routing entries as the RPF route. If the routes have the same mask length, the route with the highest priority is selected from the optimal routes. If they have the same priority, the RPF route is selected in the order of static multicast route, MBGP route, and unicast route.

1.10.2 Restrictions and Guidelines

It is recommended that RPF route selection based on the longest match rule be configured on each device unless otherwise specified.

1.10.3 Prerequisites

Configuring Basic Functions of IPv6 Multicast.

1.10.4 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Configure RPF route selection based on the longest match rule.

ipv6 multicast rpf longest-match

By default, the route with the highest priority is selected as the RPF route. If the routes have the same priority, the RPF route is selected in the order of IPv6 static multicast route, IPv6 MBGP route and IPv6 unicast route.

1.11 Monitoring

Run the **show** command to check the running status of a configured function to verify the configuration effect.

Run the **debug** command to output debugging information.

⚠ **Caution**

The output debugging information occupies system resources. Therefore, disable the debugging function immediately after use.

Run the **clear** commands to clear information.

⚠ **Caution**

Running the **clear** commands may lose vital information and thus interrupt services.

Table 1-1   Monitoring

Command	Purpose
clear ipv6 mroute { *	*ipv6-group-address* [*ipv6-source –address*] }	Clears the IPv4 hardware forwarding entry.
clear ipv6 mroute statistics { *	*ipv6-group-address* [*ipv6-source-address*] }	Clears the statistics about the IPv6 hardware forwarding entry.
show ipv6 mroute [*ipv6-group-or-source-address* [*ipv6-group-or-source-address*]] [**sparse**] [**summary**	**count**]	Displays the IPv6 hardware forwarding entry.
show ipv6 rpf *ipv6-source-address*	Displays the RPF information of a specified IPv6 source address.
show ipv6 mroute static	Displays the IPv6 static multicast route information.
show ipv6 mvif [*interface-type interface-number*]	Displays information about the configured IPv6 multicast interface that takes effect.
show ipv6 mrf6 mfc	Displays the IPv6 L3 hardware forwarding entry.
show msf6 msc	Displays the IPv6 L2 and L3 hardware forwarding entry.
debug nsm mcast6 all	Displays the running procedure of the multicast core.
debug nsm mcast6 fib-msg	Displays the communication procedure between the IPv6 multicast core and protocol module.
debug nsm mcast6 mif	Displays the interface running procedure of the IPv6 multicast core.
debug nsm mcast6 stats	Displays the procedure for processing interfaces and behavior statistics of the IPv6 multicast core.
debug ipv6 mrf forwarding	Displays the procedure for IPv6 L3 multicast forwarding.
debug ipv6 mrf mfc	Displays the procedure for operating IPv6 L3 hardware forwarding entries.
debug ipv6 mrf event	Displays the procedure for processing IPv6 L3 multicast forwarding events.
debug msf6 forwarding	Displays the procedure for IPv6 L2 and L3 multicast packet forwarding.
debug msf6 mfc	Displays the procedure for operating IPv6 L2 and L3

Command	Purpose
	hardware forwarding entries.
debug msf6 ssp	Displays the bottom-layer hardware processing procedure of IPv6 L2 and L3 multicast forwarding.
debug msf6 api	Displays the procedure for invoking API interfaces for IPv6 L2 and L3 multicast forwarding.
debug msf6 event	Displays the procedure for processing IPv6 L2 and L3 multicast forwarding events.

1.12 Configuration Examples

1.12.1 Configuring an IPv6 Static Multicast Route to Modify the RPF Route

1.   Requirements

As shown in Figure 1-1, Device A, Device B, and Device C run the OSPF protocol and the PIM-SMv6 function is enabled on each interface. Originally, multicast data sent by the multicast source to Host A is forwarded through the path Device A > Device B. To reduce the load of the link from Device A to Device B, multicast data stream is separated from the unicast data stream. Therefore, the multicast data from the multicast source is sent through the path Device A > Device C > Device B.

2.   Topology

Figure 1-1   Topology of IPv6 Static Multicast Route Configuration for Modifying the RPF Route
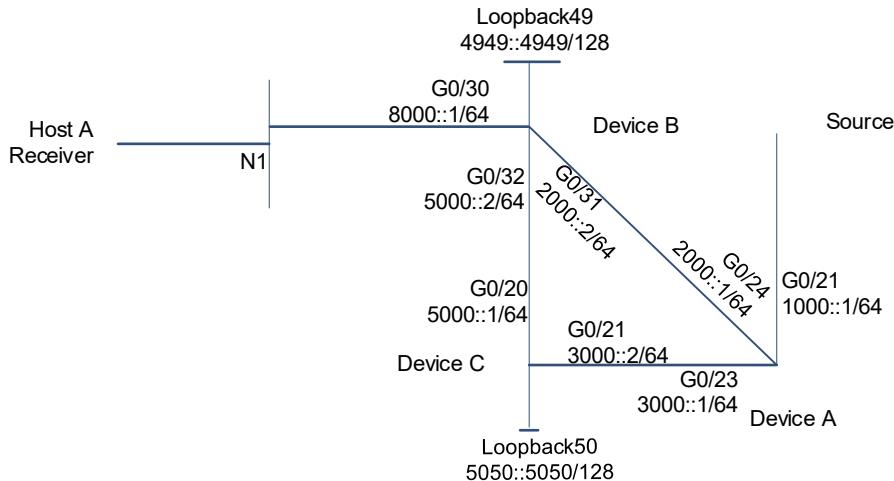
3.   Notes

As shown in Figure 1-1, separate multicast data from unicast data by configuring a static multicast route on Device B to modify the RPF interface of the multicast data. Unicast data is forwarded through the path Device A > Device B, and multicast data is forwarded through the path Device A > Device C > Device B. The specific configuration method is as follows:

- Configure an IPv6 address and a unicast routing protocol on the multicast devices. A reachable unicast route is a basis of multicast protocol running.

- Enable the IPv6 multicast routing function on all multicast devices. Enable the PIM-SMv6 function on the interfaces connecting multicast devices, the interfaces connecting user hosts, and the multicast source interfaces. Configure C-BSR and C-RP on Device C.

- Configure an RPF static multicast route on Device B, specify Device C as an RPF neighbor, and modify the forwarding path of the multicast data packets.

4. Procedure

(1) Configure an IPv6 address and a unicast routing protocol on the multicast devices.

Configure an IPv6 address and a unicast routing protocol on Device A.

```
DeviceA> enable
DeviceA# config terminal
DeviceA(config)# interface GigabitEthernet 0/21
DeviceA(config-if-GigabitEthernet 0/21)# no switchport
DeviceA(config-if-GigabitEthernet 0/21)# ipv6 address 1000::1/64
DeviceA(config-if-GigabitEthernet 0/21)# ipv6 ospf 4949 area 0
DeviceA(config-if-GigabitEthernet 0/21)# exit
DeviceA(config)# interface GigabitEthernet 0/23
DeviceA(config-if-GigabitEthernet 0/23)# no switchport
DeviceA(config-if-GigabitEthernet 0/23)# ipv6 address 3000::1/64
DeviceA(config-if-GigabitEthernet 0/23)# ipv6 ospf 4949 area 0
DeviceA(config-if-GigabitEthernet 0/23)# exit
DeviceA(config)# interface GigabitEthernet 0/24
DeviceA(config-if-GigabitEthernet 0/24)# no switchport
DeviceA(config-if-GigabitEthernet 0/24)# ipv6 address 2000::1/64
DeviceA(config-if-GigabitEthernet 0/24)# ipv6 ospf 4949 area 0
DeviceA(config-if-GigabitEthernet 0/24)# ipv6 pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/24)# exit
DeviceA(config)# ipv6 router ospf 4949
```

Configure an IPv6 address and a unicast routing protocol on Device B.

```
DeviceB> enable
DeviceB# config terminal
DeviceB(config)# interface GigabitEthernet 0/30
DeviceB(config-if-GigabitEthernet 0/30)# no switchport
DeviceB(config-if-GigabitEthernet 0/30)# ipv6 address 8000::1/64
DeviceB(config-if-GigabitEthernet 0/30)# ipv6 ospf 4949 area 0
DeviceB(config-if-GigabitEthernet 0/30)# exit
DeviceB(config)# interface GigabitEthernet 0/31
DeviceB(config-if-GigabitEthernet 0/31)# no switchport
DeviceB(config-if-GigabitEthernet 0/31)# ipv6 address 2000::2/64
DeviceB(config-if-GigabitEthernet 0/31)# ipv6 ospf 4949 area 0
DeviceB(config-if-GigabitEthernet 0/31)# exit
DeviceB(config)# interface GigabitEthernet 0/32
```

```
DeviceB(config-if-GigabitEthernet 0/32)# no switchport
DeviceB(config-if-GigabitEthernet 0/32)# ipv6 address 5000::2/64
DeviceB(config-if-GigabitEthernet 0/32)# exit
DeviceB(config)# interface Loopback 49
DeviceB(config-if-Loopback 49)# ipv6 address 4949::4949/128
DeviceB(config-if-Loopback 49)# ipv6 ospf 4949 area 0
DeviceB(config-if-Loopback 49)# exit
DeviceB(config)# ipv6 router ospf 4949
```

Configure an IPv6 address and a unicast routing protocol on Device C.

```
DeviceC> enable
DeviceC# config terminal
DeviceC(config)# interface GigabitEthernet 0/20
DeviceC(config-if-GigabitEthernet 0/20)# no switchport
DeviceC(config-if-GigabitEthernet 0/20)# ipv6 address 5000::1/64
DeviceC(config-if-GigabitEthernet 0/20)# ipv6 ospf 4949 area 0
DeviceC(config-if-GigabitEthernet 0/20)# exit
DeviceC(config)# interface GigabitEthernet 0/21
DeviceC(config-if-GigabitEthernet 0/21)# no switchport
DeviceC(config-if-GigabitEthernet 0/21)# ipv6 address 3000::2/64
DeviceC(config-if-GigabitEthernet 0/21)# ipv6 ospf 4949 area 0
DeviceC(config-if-GigabitEthernet 0/21)# exit
DeviceC(config)# interface Loopback 50
DeviceC(config-if-Loopback 50)# ipv6 address 5050::5050/128
DeviceC(config-if-Loopback 50)# ipv6 ospf 4949 area 0
DeviceC(config-if-Loopback 50)# exit
DeviceC(config)# ipv6 router ospf 4949
```

(2) Enable the IPv6 multicast routing function on all multicast devices. Enable the PIM-SMv6 function on the interfaces connecting multicast devices, the interfaces connecting user hosts, and the multicast source interfaces. Configure C-BSR and C-RP on Device C.

Enable the multicast routing and PIM-SMv6 related functions on Device A.

```
DeviceA> enable
DeviceA# config terminal
DeviceA(config)# ipv6 multicast-routing
DeviceA(config)# interface GigabitEthernet 0/21
DeviceA(config-if-GigabitEthernet 0/21)# ipv6 pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/21)# exit
DeviceA(config)# interface GigabitEthernet 0/23
DeviceA(config-if-GigabitEthernet 0/23)# ipv6 pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/23)# exit
DeviceA(config)# interface GigabitEthernet 0/24
DeviceA(config-if-GigabitEthernet 0/24)# ipv6 pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/24)# exit
```

Enable the multicast routing and PIM-SMv6 related functions on Device B.

```
DeviceB> enable
```

```
DeviceB# config terminal
DeviceB(config)# ipv6 multicast-routing
DeviceB(config)# interface GigabitEthernet 0/30
DeviceB(config-if-GigabitEthernet 0/30)# ipv6 pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/30)# exit
DeviceB(config)# interface GigabitEthernet 0/31
DeviceB(config-if-GigabitEthernet 0/31)# ipv6 pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/31)# exit
DeviceB(config)# interface GigabitEthernet 0/32
DeviceB(config-if-GigabitEthernet 0/32)# ipv6 pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/32)# exit
DeviceB(config)# interface Loopback 49
DeviceB(config-if-Loopback 49)# ipv6 pim sparse-mode
DeviceB(config-if-Loopback 49)# exit
```

Enable the multicast routing and PIM-SMv6 related functions on Device C.

```
DeviceC> enable
DeviceC# config terminal
DeviceC(config)# ipv6 multicast-routing
DeviceC(config)# ipv6 multicast-routing
DeviceC(config)# interface GigabitEthernet 0/20
DeviceC(config-if-GigabitEthernet 0/20)# ipv6 pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/20)# exit
DeviceC(config)# interface GigabitEthernet 0/21
DeviceC(config-if-GigabitEthernet 0/21)# ipv6 pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/21)# exit
DeviceC(config)# interface Loopback 50
DeviceC(config-if-Loopback 50)# ipv6 pim sparse-mode
DeviceC(config-if-Loopback 50)# exit
```

Configure C-BSR and C-RP on Device A.

```
DeviceA> enable
DeviceA# config terminal
DeviceA(config)# ipv6 pim bsr-candidate GigabitEthernet 0/21
DeviceA(config)# ipv6 pim rp-candidate GigabitEthernet 0/21
```

(3) Configure an RPF static multicast route on Device B, specify Device C as an RPF neighbor, and modify the forwarding path of the multicast data packets.

```
DeviceB> enable
DeviceB# config terminal
DeviceB(config)# ipv6  mroute 1000::/64 5000::1
```

5.   Verification

(1) Run the **show ipv6 mld groups** command on Device B to check whether Host A joins the group FF15::11 and the multicast source 1000::2 sends packets to the group FF15::11.

```
DeviceB> enable
DeviceB# show ipv6 mld groups
```

```
MLD Connected Group Membership
Group Address                            Interface
Uptime     Expires   Last Reporter
ff15::11                                 GigabitEthernet 0/30
00:12:17  00:03:00  fe80::8205:88ff:fe22:b468
DeviceB#
```

(2) Run the **show ipv6 mroute** command on Device A to display the hardware forwarding entry and check whether the next hop is Device C and the outbound interface is GigabitEthernet 0/23.

```
DeviceA> enable
DeviceA# show ipv6 mroute

IPv6 Multicast Routing Table
Flags: I - Immediate Stat, T - Timed Stat, F - Forwarder installed,
       R - RPT, S - SPT, s - SSM Group
Timers: Uptime/Stat Expiry
Interface State: Interface

(1000::2, ff15::11), uptime 00:08:53, stat expires 00:03:12
Owner PIMSMV6, Flags: TFS
  Incoming interface: GigabitEthernet 0/21
  Outgoing interface list:
    GigabitEthernet 0/23

DeviceA#
```

(3) Run the **show ipv6 rpf** command on Device B to check whether the next hop of the multicast source is Device C and the RPF interface is GigabitEthernet 0/32.

```
DeviceB# show ipv6 rpf 1000::
RPF information for 1000::
RPF interface: GigabitEthernet 0/32
  RPF neighbor: 5000::1
  RPF route: 1000::/64
  RPF type: static
  RPF recursion count: 0
  Doing distance-preferred lookups across tables
Distance: 0
  Metric: 0
DeviceB#
```

6.   Configuration Files

● Device A configuration file

```
hostname DeviceA
!
ipv6 multicast-routing
!
interface GigabitEthernet 0/21
```

```
 no switchport
 ipv6 address 1000::1/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/23
 no switchport
 ipv6 address 3000::1/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/24
 no switchport
 ipv6 address 2000::1/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
ipv6 router ospf 4949
 graceful-restart
!
ipv6 pim bsr-candidate GigabitEthernet 0/21
ipv6 pim rp-candidate GigabitEthernet 0/21
!
```

● Device B configuration file

```
hostname DeviceB
!
ipv6 multicast-routing
!
ipv6 mroute 1000::/64 5000::1
!
interface GigabitEthernet 0/30
 no switchport
 ipv6 address 8000::1/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/31
 no switchport
 ipv6 address 2000::2/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/32
 no switchport
 ipv6 address 5000::2/64
 ipv6 pim sparse-mode
```

```
!
interface Loopback 49
 ipv6 address 4949::4949/128
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
ipv6 router ospf 4949
 graceful-restart
!
```

● Device C configuration file

```
hostname DeviceC
!
ipv6 multicast-routing
!
interface GigabitEthernet 0/20
 no switchport
 ipv6 address 5000::1/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/21
 no switchport
 ipv6 address 3000::2/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface Loopback 50
 ipv6 address 5050::5050/128
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
ipv6 router ospf 4949
 graceful-restart
!
```

7.   Common Errors

- ● IPv6 unicast routing is incorrectly configured.
- ● The IPv6 multicast routing function is not enabled on a multicast device.
- ● No IPv6 multicast protocol is enabled on an interface.

1.12.2 Configuring a Static Multicast Route to Connect the RPF Route

1.   Requirements

As shown in , Device B and Device C run the OSPF protocol, and the unicast route to Device A is isolated. The PIM-SMv6 function is enabled on the interfaces of Device A, Device B and Device C. Host A can

normally receive multicast data packets from Source 2, and it is required to receive multicast data packets from Source 1 as well.

2.   Topology

Figure 1-1   Topology of IPv6 Static Multicast Route Configuration for Connecting the RPF Route
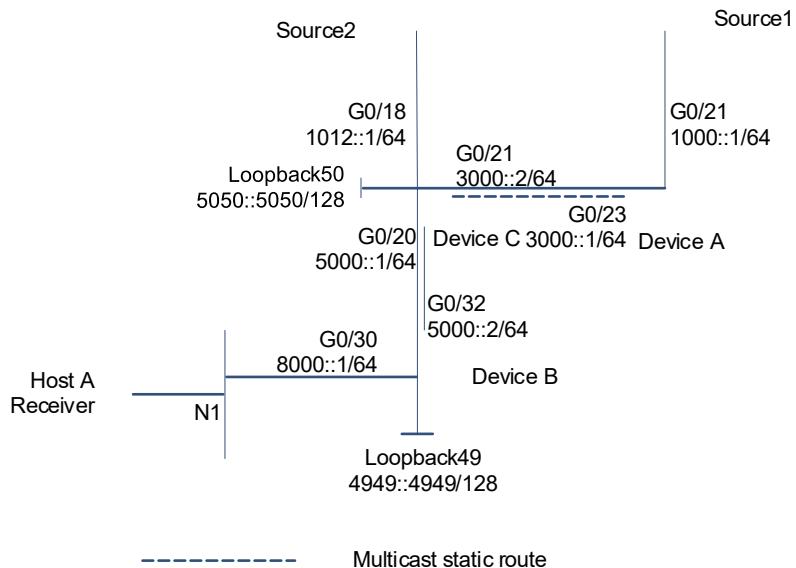
3.   Notes

Configure a static multicast route to establish an RPF route that is destined to source 1 based on the path Device B > Device C > Device A. The specific configuration method is as follows:

- Configure an IPv6 address for each interface of the devices, and configure the OSPF protocol on Device B and Device C to separate multicast routes from unicast routes on Device A.

- Enable the IPv6 multicast routing function, configure the PIM-SMv6 protocol on each L3 interface of the devices and configure the C-BSR and C-RP in the global configuration, and enable the MLD function on the interface connected to hosts.

- Configure static multicast routes to source 1 on Device B and Device C.

4.   Procedure

(1) Configure an IPv6 address for each interface of the devices, and configure the OSPF protocol on Device B and Device C to separate multicast routes from unicast routes on Device A.

Configure an IPv6 address for the interface on Device A.

```
DeviceA> enable
DeviceA# configure terminal
DeviceA(config)# interface GigabitEthernet 0/21
DeviceA(config-if-GigabitEthernet 0/21)# no switchport
DeviceA(config-if-GigabitEthernet 0/21)# ipv6 address 1000::1/64
DeviceA(config-if-GigabitEthernet 0/21)# exit
DeviceA(config)# interface GigabitEthernet 0/23
```

```
DeviceA(config-if-GigabitEthernet 0/23)# no switchport
DeviceA(config-if-GigabitEthernet 0/23)# ipv6 address 3000::1/64
DeviceA(config-if-GigabitEthernet 0/23)# exit
DeviceA(config)# ipv6 route 5050::5050/128 3000::2
```

Configure an IPv6 address and the OSPF protocol for the interface on Device B.

```
DeviceB> enable
DeviceB# configure terminal
DeviceB(config)# interface GigabitEthernet 0/30
DeviceB(config-if-GigabitEthernet 0/30)# no switchport
DeviceB(config-if-GigabitEthernet 0/30)# ipv6 address 8000::1/64
DeviceB(config-if-GigabitEthernet 0/30)# ipv6 ospf 4949 area 0
DeviceB(config-if-GigabitEthernet 0/30)# exit
DeviceB(config)# interface GigabitEthernet 0/32
DeviceB(config-if-GigabitEthernet 0/32)# no switchport
DeviceB(config-if-GigabitEthernet 0/32)# ipv6 address 5000::2/64
DeviceB(config-if-GigabitEthernet 0/32)# ipv6 ospf 4949 area 0
DeviceB(config-if-GigabitEthernet 0/32)# exit
DeviceB(config)# interface Loopback 49
DeviceB(config-if-Loopback 49)# ipv6 address 4949::4949/128
DeviceB(config-if-Loopback 49)# ipv6 ospf 4949 area 0
DeviceB(config-if-Loopback 49)# exit
DeviceB(config)# ipv6 router ospf 4949
DeviceB(config-router)# exit
```

Configure an IPv6 address and the OSPF protocol for the interface on Device C.

```
DeviceC> enable
DeviceC# configure terminal
DeviceC(config)# interface GigabitEthernet 0/18
DeviceC(config-if-GigabitEthernet 0/18)# no switchport
DeviceC(config-if-GigabitEthernet 0/18)# ipv6 address 1012::1/64
DeviceC(config-if-GigabitEthernet 0/18)# ipv6 ospf 4949 area 0
DeviceC(config-if-GigabitEthernet 0/18)# exit
DeviceC(config)# interface GigabitEthernet 0/20
DeviceC(config-if-GigabitEthernet 0/20)# no switchport
DeviceC(config-if-GigabitEthernet 0/20)# ipv6 address 5000::1/64
DeviceC(config-if-GigabitEthernet 0/20)# ipv6 ospf 4949 area 0
DeviceC(config-if-GigabitEthernet 0/20)# exit
DeviceC(config)# interface GigabitEthernet 0/21
DeviceC(config-if-GigabitEthernet 0/21)# no switchport
DeviceC(config-if-GigabitEthernet 0/21)# ipv6 address 3000::2/64
DeviceC(config-if-GigabitEthernet 0/21)# ipv6 ospf 4949 area 0
DeviceC(config-if-GigabitEthernet 0/21)# exit
DeviceC(config)# interface Loopback 50
DeviceC(config-if-Loopback 50)# ipv6 address 5050::5050/128
DeviceC(config-if-Loopback 50)# ipv6 ospf 4949 area 0
DeviceC(config-if-Loopback 50)# exit
```

```
DeviceC(config)# ipv6 router ospf 4949
DeviceC(config-router)# exit
```

(2) Enable the IPv6 multicast routing function, configure the PIM-SMv6 protocol on each L3 interface of the devices and configure the C-BSR and C-RP in the global configuration, and enable the MLD function on the interface connected to hosts.

Enable the IPv6 multicast routing function and configure the PIM-SMv6 protocol on Device A.

```
DeviceA> enable
DeviceA# configure terminal
DeviceA(config)# ipv6 multicast-routing
DeviceA(config)# interface GigabitEthernet 0/21
DeviceA(config-if-GigabitEthernet 0/21)# ipv6 pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/21)# exit
DeviceA(config)# interface GigabitEthernet 0/23
DeviceA(config-if-GigabitEthernet 0/23)# ipv6 pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/23)# exit
```

Enable the IPv6 multicast routing function and configure the PIM-SMv6 protocol on Device B.

```
DeviceB> enable
DeviceB# configure terminal
DeviceB(config)# ipv6 multicast-routing
DeviceB(config)# interface GigabitEthernet 0/30
DeviceB(config-if-GigabitEthernet 0/30)# ipv6 pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/30)# exit
DeviceB(config)# interface GigabitEthernet 0/32
DeviceB(config-if-GigabitEthernet 0/32)# ipv6 pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/32)# exit
DeviceB(config)# interface Loopback 49
DeviceB(config-if-Loopback 49)# ipv6 pim sparse-mode
DeviceB(config-if-Loopback 49)# exit
```

Enable the IPv6 multicast routing function and functions related to the PIM-SMv6 protocol on Device C.

```
DeviceC> enable
DeviceC# configure terminal
DeviceC(config)# ipv6 multicast-routing
DeviceC(config)# interface GigabitEthernet 0/18
DeviceC(config-if-GigabitEthernet 0/18)# ipv6 pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/18)# exit
DeviceC(config)# interface GigabitEthernet 0/20
DeviceC(config-if-GigabitEthernet 0/20)# ipv6 pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/20)# exit
DeviceC(config)# interface GigabitEthernet 0/21
DeviceC(config-if-GigabitEthernet 0/21)# ipv6 pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/21)# exit
DeviceC(config)# interface Loopback 50
DeviceC(config-if-Loopback 50)# ipv6 pim sparse-mode
DeviceC(config-if-Loopback 50)# exit
```

```
DeviceC(config)# ipv6 pim bsr-candidate Loopback 50
DeviceC(config)# ipv6 pim rp-candidate Loopback 50
```

Enable Source 1 (1000::2/64) and Source 2 (1012::2/64) to send multicast data packets to the multicast group (FF14::10). Add Host A to the multicast group (FF14::10) so that Host A can receive multicast data packets from Source 2 but cannot receive multicast data packets from Source 1.

Run the **show ipv6 rpf** 1000::2 command on Device C. No route exists. No RPF route to Source 1 exists on Device C.

(3) Configure static multicast routes to source 1 on Device B and Device C.

On Device B, configure an RPF static multicast route and configure Device C as an RPF neighbor to Source 1.

```
DeviceB> enable
DeviceB# configure terminal
DeviceB(config)# ipv6 mroute 1000::/64 5000::1
```

On Device C, configure an RPF static multicast route and configure Device A as an RPF neighbor to Source 1.

```
DeviceC> enable
DeviceC# configure terminal
DeviceC(config)# ipv6 mroute 1000::/64 3000::1
```

5.   Verification

Run the **show ipv6 rpf** 1000::2 command on Device B to display the RPF information of Source 1. The RPF information is displayed as follows:

```
DeviceB> enable
DeviceB# show ipv6 rpf 1000::2
RPF information for 1000::2
RPF interface: GigabitEthernet 0/32
  RPF neighbor: 5000::1
  RPF route: 1000::/64
  RPF type: static
  RPF recursion count: 0
  Doing distance-preferred lookups across tables
Distance: 0
  Metric: 0
DeviceB#
```

Run the **show ipv6 rpf** 1000::2 command on Device C to display the RPF information of Source 1. The RPF information is displayed as follows:

```
DeviceC> enable
DeviceC# show ipv6 rpf 1000::2
RPF information for 1000::2
RPF interface: GigabitEthernet 0/21
  RPF neighbor: 3000::1
  RPF route: 1000::/64
  RPF type: static
```

```
  RPF recursion count: 0
  Doing distance-preferred lookups across tables
Distance: 0
  Metric: 0
DeviceC#
```

Enable Source 1 and Source 2 to send multicast data packets to the multicast group (FF14::10), and add Host A to the multicast group.

Run the **show ipv6 pim sparse-mode mroute** command on Device B and Device C to display routing entry information. The multicast entries of Source 1 exist on Device B and Device C. Host A normally receives multicast data packets from Source 1.

```
DeviceC> enable
DeviceC# show ipv6 pim sparse-mode mroute
IPv6 Multicast Routing Table
(*,*,RP) Entries: 0
(*,G) Entries: 1
(S,G) Entries: 2
(S,G,rpt) Entries: 2
FCR Entries: 0
REG Entries: 0


(*, ff14::10)
RP: 5050::5050
RPF nbr: ::
RPF idx: None
Upstream State: JOINED
  00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31
Local
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FCR:

(1000::2, ff14::10)
RPF nbr: fe80::2d0:f8ff:fe22:358d
RPF idx: GigabitEthernet 0/21
SPT bit: 1
Upstream State: JOINED
jt_timer expires in 11 seconds
kat expires in 209 seconds
  00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31
Local
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(1000::2, ff14::10, rpt)
RP: 5050::5050
RPF nbr: ::
RPF idx: None
Upstream State: PRUNED
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25 26 27 28 29 30 31
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(1012::2, ff14::10)

RPF nbr: fe80::2d0:f8ff:fe22:363d

RPF idx: GigabitEthernet 0/18

SPT bit: 1

Upstream State: JOINED

jt_timer expires in 19 seconds

kat expires in 147 seconds
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25 26 27 28 29 30 31
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RP: 5050::5050
RPF nbr: ::
RPF idx: None
Upstream State: PRUNED
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25 26 27 28 29 30 31
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DeviceC#


DeviceB> enable
DeviceB# show ipv6 pim sparse-mode mroute
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IPv6 Multicast Routing Table
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(*,G) Entries: 1
(S,G) Entries: 0
(S,G,rpt) Entries: 0
FCR Entries: 2
REG Entries: 0


(*, ff14::10)
RP: 5050::5050
RPF nbr: fe80::274:9cff:feee:f49f
RPF idx: GigabitEthernet 0/32
Upstream State: JOINED
jt_timer expires in 58 seconds
   00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31
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FCR:
Source: 1000::2
  00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31
Outgoing
0   .
0   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .   .
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 KAT timer running, 120 seconds remaining
```

```
 Packet count 1
Source: 1012::2
  00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31
Outgoing
0  .
0  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .  .
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 KAT timer running, 99 seconds remaining
 Packet count 1

DeviceB#
```

6. Configuration Files

● Device A configuration file

```
hostname DeviceA
!
ipv6 multicast-routing
!
interface GigabitEthernet 0/21
 no switchport
 ipv6 address 1000::1/64
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/23
 no switchport
 ipv6 address 3000::1/64
 ipv6 pim sparse-mode
!
ipv6 route 5050::5050/128 3000::2
!
```

● Device B configuration file

```
hostname DeviceB
!
ipv6 multicast-routing
!
ipv6 mroute 1000::/64 5000::1
!
interface GigabitEthernet 0/30
 no switchport
 ipv6 address 8000::1/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/32
 no switchport
 ipv6 address 5000::2/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
ipv6 router ospf 4949
 graceful-restart
!
```

● Device C configuration file

```
hostname DeviceC
!
ipv6 multicast-routing
!
ipv6 mroute 1000::/64 3000::1
!
interface GigabitEthernet 0/18
 no switchport
 ipv6 address 1012::1/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/20
 no switchport
 ipv6 address 5000::1/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
interface GigabitEthernet 0/21
 no switchport
 ipv6 address 3000::2/64
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
```

```
interface Loopback 50
 ipv6 address 5050::5050/128
 ipv6 ospf 4949 area 0
 ipv6 pim sparse-mode
!
ipv6 router ospf 4949
 graceful-restart
!
ipv6 pim bsr-candidate Loopback 50
ipv6 pim rp-candidate Loopback 50
!
```

7.   Common Errors

● IPv6 unicast routing is incorrectly configured.