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1 Configuring PIM-SM

1.1 Introduction

The Protocol Independent Multicast (PIM) is an intra-domain multicast routing protocol that is independent from unicast routing protocols. Any unicast routing protocol, for example, static route, Routing Information Protocol (RIP), and Open Shortest Path First (OSPF), can provide routing information for IP multicast. Multicast routing is independent from unicast routing, and simply uses unicast routing tables to generate multicast routing information. The Protocol Independent Multicast-Sparse Mode (PIM-SM) is used most widely, and applies to networks of any form, especially large networks where group members are scattered in a wide area. Compared with other intra-domain multicast routing protocols, PIM-SM has irreplaceable advantages.

1.2 Principles

PIM-SM considers that not all hosts need to receive multicast data, and sends multicast data to hosts that require the multicast data.

A PIM multicast device provides multicast service in any-source multicast (ASM) and source-specific multicast (SSM) models. For groups in the SSM address range, the SSM model is used. For other groups, the ASM model is used. In the ASM model, a host joins a specified multicast group G without the multicast source S specified. In the SSM model, a host can join a specified multicast group G to receive multicast data from a specified source S.

1.2.1 ASM Model

1. Basic Principles

PIM-SM in the ASM model is implemented as follows:

- A rendezvous point (RP) is used as a root of a rendezvous point tree (RPT) for transition. The designated router (DR) connected to a host sends a join message to the RP of a multicast group, and the multicast devices on the route create (*, G) entries hop by hop. Based on the entries, an RPT is created with the RP as the root.
- To send data to a multicast group, the source DR sends a register message to the RP to create an (S, G) entry on the RP. After the registration succeeds, the multicast source sends multicast data to the RP. After the multicast data arrives at the RP, it is copied and sent to the host via the RPT.

In the ASM model, the key mechanisms of PIM-SM include PIM neighbor creation, DR election, RP, bootstrap router (BSR), multicast source registration, shortest path tree (SPT) switchover, and assertion.

2. PIM Neighbor Creation

Neighbor relationship must be created between PIM multicast devices to form a PIM network, so that PIM control messages and multicast packets can be transmitted on the network. A Hello message is sent from a PIM interface. In the multicast packet with the Hello message encapsulated, the destination address is

224.0.0.13 (indicating all PIM multicast devices in the same network segment), the source address is the IP address of the PIM interface, and the time to live (TTL) value is 1. The Hello message is used to:

- Discover PIM neighbors.

PIM multicast devices in the same network segment receive the multicast packet with the destination address as 224.0.0.13, obtain neighbor information, and create neighbor relationship. After the neighbor relationship is created, the PIM interfaces can receive and process other PIM packets and create multicast routing entries.

When a PIM interface is enabled or detects a new neighbor, a Triggered-Hello-Delay message is used to generate a random time. Within the time, the interface sends Hello messages.

- Negotiate protocol parameters. The Hello message contains the following key parameters:
 - **DR Priority:** The priority of a multicast device for DR election. The device with a higher priority is selected.
 - **Holdtime:** The neighbor is considered reachable before timeout.
 - **Propagation Delay:** Duration between the time when a PIM device receives a prune packet and the time when the PIM device sends the prune packet to the uplink devices.
 - **Override-Interval:** The interval to override the prune.
- Maintain neighbor relationship.

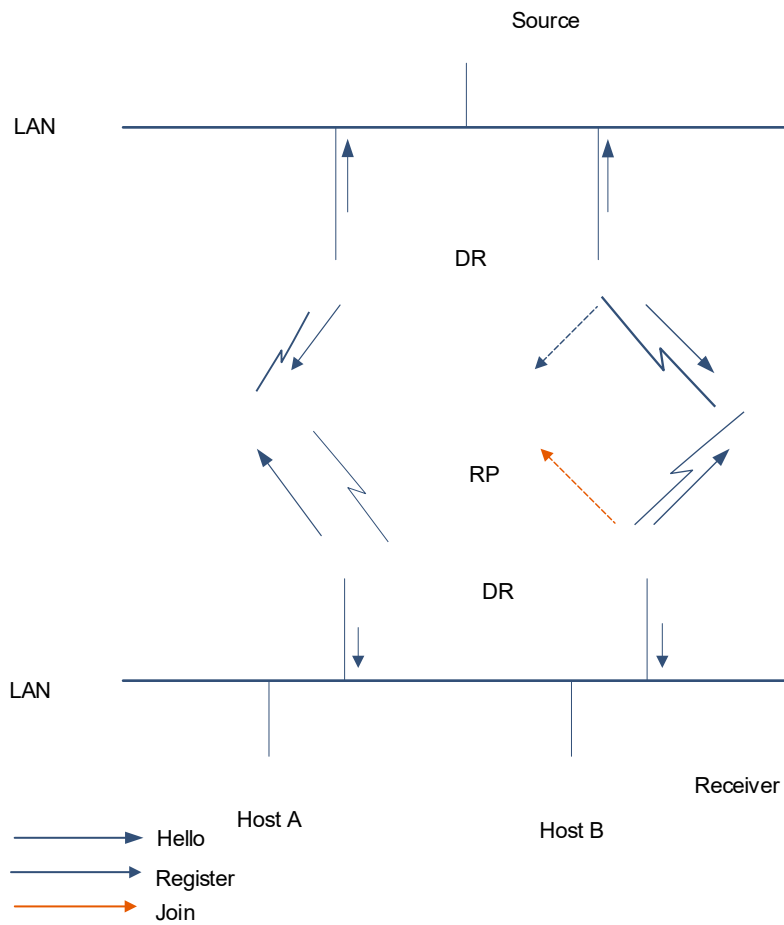
A Hello message is sent periodically between PIM multicast devices. If no new Hello message is received from a PIM neighbor within the hold time, this neighbor is considered unreachable and then removed from the neighbor list. Any change of PIM neighbors will cause change of the multicast topology in the network. If an uplink or a downlink neighbor in a multicast distribution tree (MDT) is unreachable, multicast routes converge again and the MDT is reshaped.

3. DR Election

As shown in [Figure 1-1](#), the source DR sends a register message to the RP. Member DRs send join messages to the RP and forward multicast data to members in a multicast group. In the network segment to which members and multicast source are connected, multiple PIM devices obtain IP addresses and DR priorities of neighbors based on the Hello messages sent between the PIM devices during PIM neighbor creation. The PIM device that is elected becomes a member DR or source DR. The election rules are as follows:

- (1) The DR priorities are compared. The device with a higher priority is selected.
- (2) If the DR priorities are the same or there is any neighbor in the shared network segment that does not support DR priority, the IP addresses of the devices are compared. The device with a larger IP address is selected.

Figure 1-1 Schematic Diagram of DR Election



4. BSR Election

In the PIM network, the BSR periodically generates bootstrap messages (BSMs) that include a series of candidate-RPs (C-RPs) and corresponding group addresses. The BSMs are sent in the entire domain hop by hop. All PIM multicast devices in the network receive the BSMs and record the C-RPs and corresponding group addresses.

In the PIM-SM domain, one or multiple candidate-BSRs (C-BSRs) are configured and the BSR is elected based on rules.

5. RP Election

In the PIM network, the RP processes register messages of the source DR and join packets of group members. The process from the multicast source to members of the multicast group is divided into two sections: The SPT that uses the source DR as the root and the RP as the leaf, and the RPT that uses the RP as the root and member DRs as leaves. In the PIM-SM network with the ASM model, the RP must act as a transition to create or forward data.

In the PIM network, an RP can serve one or more groups, and a group can be served by only one RP. In the PIM network, the RP can be configured as static or dynamic.

- Static RP

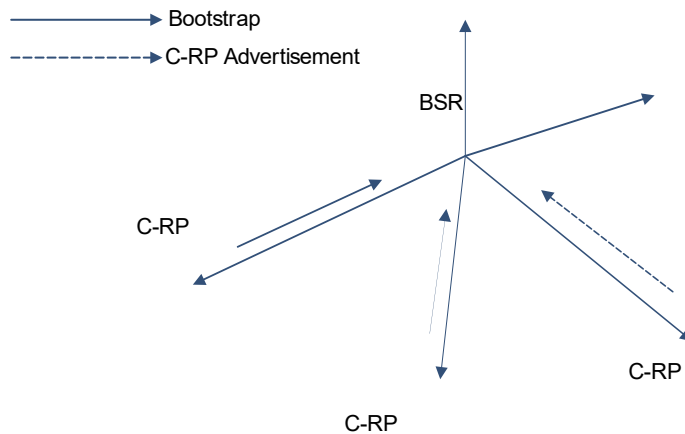
A static RP sets the RP address on each PIM multicast device to enable the entire PIM network to know the RP address.

- Dynamic RP

As shown in [Figure 1-1](#), multiple C-RPs can be configured in a PIM-SM domain to elect an RP dynamically. These C-RPs add their own addresses and served multicast groups to advertisement packets and sent the packets to the BSR periodically in unicast mode. The BSR is elected from the configured C-BSRs based on rules. The BSR periodically generates BSMs that include a series of C-RPs and corresponding group addresses. The BSMs are sent in the entire domain. Each PIM device in the domain receives and saves these BSMs, and applies the same hash algorithms to compute and elect an RP for each group. The BSR and RP election process is as follows:

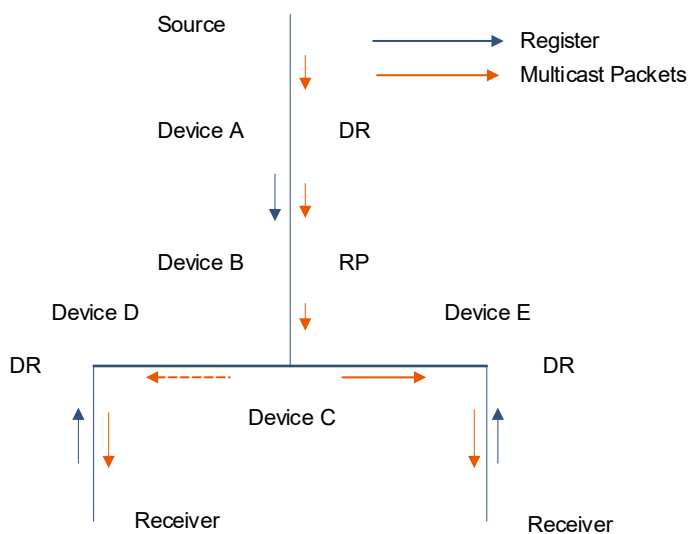
- BSR election process: Initially, each C-BSR considers itself a BSR and sends a BSM throughout the network. The BSMs carry the C-BSR addresses and priorities. Upon receiving the BSMs, each PIM device compares the C-BSR addresses and priorities to elect the BSR.
- RP election process: The C-RPs periodically send advertisement packets to the BSR in unicast mode to advertise the C-RP addresses, priorities, and addresses of the served groups. The BSR collects the information as RP-Set, encapsulates the information in a BSM, and sends the messages to each PIM device in the network. Upon receiving the RP-Set, the PIM devices in the network use the same algorithms for computation to obtain the RP that serves each group. Each PIM device obtains the RP position of each group.

Figure 1-1 Schematic Diagram of Dynamic RP Election



6. Multicast Source Registration

Figure 1-1 Schematic Diagram of Multicast Source Registration



As shown in [Figure 1-1](#), when a multicast source sends data to a group, the source DR sends a register message to the RP so that the RP obtains the source information and a multicast packet and forwards the multicast packet to the members in the group. The forwarding process is as follows:

- (1) The multicast source sends a multicast packet to the source DR.
- (2) The source DR encapsulates the multicast packet in a register message and sends the message to the RP in unicast mode.
- (3) Upon receiving the register message, the RP decapsulates the message and forwards the multicast packet to the members in a group via the RPT. Meanwhile, the RP sends an (S, G) join packet to the source. The PIM devices on the route create (S, G) entries, and finally create an SPT from the source to the RP.
- (4) The source DR S forwards multicast packets based on this SPT. The multicast data is sent to the RP in the form of multicast packets.
- (5) Upon receiving multicast packets from the source, the RP discards the register message and sends a register-stop message to the source.
- (6) Upon receiving the register-stop message, the source DR stops encapsulating the register message, forwards multicast packets via the SPT, and periodically sends a register-probe message to the RP.
- (7) Upon receiving the register-probe message, the RP sends a register-stop message to the source DR and updates the (S, G) entries.
- (8) Upon receiving the register-stop message, the source DR continues forwarding multicast packets via the SPT without encapsulating the register message.

7. RPT Construction

When a group member joins the network, the DR connecting to the group member sends a join packet to the RP. If a multicast source has sent a multicast packet to the RP, the multicast packet will be sent to the group member via the RPT.

The RPT construction procedure is as follows:

- When a member DR receives an IGMP (*, G) INCLUDE Report packet, if the member DR is not an RP of the group G, the member DR sends a (*, G) join packet to the RP and the multicast devices on the route create the (*, G) entries hop by hop to generate an RPT that uses the RP as the root.
- During RPT construction, each PIM device checks the reverse path forwarding (RPF) when sending a join packet to the RP to find the unicast route to the RP. The outbound interface of the unicast route is an uplink interface, and the next hop of the unicast route is the RPF neighbor. The join packet is sent from the member DR to the RP.

8. SPT Switchover

In the PIM-SM network of the ASM model, one or multiple multicast groups correspond to one RP. Before SPT switchover, all packets of multicast groups sent to the RP service must be transitioned by the RP. When the sending rate of multicast packets grows, the RP load is increased. To solve this problem, the PIM-SM switches over the SPT to relieve the RP load. SPT switchover can be triggered by the RP or a member DR.

- SPT switchover triggered by the RP

After receiving a register message from the source DR, the RP decapsulates the register message, forwards the multicast packets in the message to the group members via the RPT, and sends an (S, G) join packet to the source DR. The PIM multicast devices on the route create (S, G) entries hop by hop to create an SPT from the RP to the source.
- SPT switchover triggered by a member DR
 - a When receiving the first multicast packet from the RP, the member DR obtains the source address.
 - b The member DR sends an (S, G) join packet to the source. The PIM devices on the route create (S, G) entries and create an SPT from the member DR to the source DR.
 - c After the SPT is created, the member DR sends a prune packet to the RP hop by hop and removes the downlink interface from the (*, G) entries. After the pruning, the RP does not forward multicast packets to the member DR via the RPT.
 - d The SPT from the member DR to the source DR does not pass the RP. The RP sends a prune packet to the source DR to remove the downlink interface from the (S, G) entries. After the pruning, the source DR does not forward packets to the RP via the original "RP-source DR" SPT.

1.2.2 SSM Model

1. Basic Principles

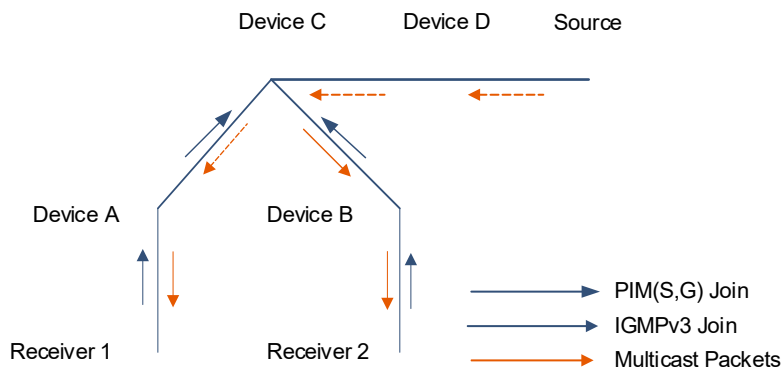
In the SSM model, members in a multicast group can specify to receive or reject data from a multicast source. The group members get to know the (S, G) entries of sources through access to the server or receiving advertisements. After understanding requirement of group members, the member DR sends a join packet to the source DR. This join packet is transmitted to the multicast source hop by hop to create an SPT from the source to the group members.

Note

- To implement the SSM model on IPv4, complete multicast interconnection through the PIM-SM and configure IGMPv3 to manage relationship between the hosts and devices.
 - SSM model requirements: The hosts must know the addresses of multicast sources in advance using other network services so that the hosts can select multicast sources.
-

- On the devices that reside on the route from the hosts to the multicast source, the PIM-SM and SSM functions must be enabled.

Figure 1-1 SSM Model



Note

After the SSM function is enabled, the default group range of the SSM is **232/8**. You can modify the group range of the SSM using commands.

In the SSM model, the key mechanisms of PIM-SM include neighbor creation, DR election, and SPT creation.

2. PIM Neighbor Creation

For more information about the PIM neighbor creation mechanism in the SSM model, see the PIM neighbor creation mechanism in the ASM model in [2. PIM Neighbor Creation](#).

3. DR Election

For more information about the DR election mechanism in the SSM model, see the DR election mechanism in the ASM model in [3. DR Election](#).

4. SPT Construction

The SPT construction mechanism is as follows:

- (1) The source DR learns through IGMPv3 that a group member wants to receive data of a multicast source and sends an (S, G) join packet to the source hop by hop.
- (2) The PIM multicast devices on the route receive the (S, G) join packet and create the (S, G) entries, creating an SPT from the group member to the source.
- (3) After the SPT is created, the multicast source distributes the multicast packets to the group member via the SPT.

1.2.3 Protocols and Standards

- RFC4601: Protocol Independent Multicast-Sparse Mode (PIM-SM)
- RFC5059: Bootstrap Router (BSR) Mechanism for Protocol Independent Multicast (PIM)
- RFC3962: Protocol Independent Multicast-Dense Mode protocol
- RFC4607: Source-Specific Multicast for IP

1.3 Restrictions and Guidelines

- Before PIM-SM is enabled, enable the multicast routing and forwarding function in global configuration mode. Otherwise, multicast packets cannot be sent even if PIM-SM is enabled.
- In the IPv4 multicast network, the PIM (IPv4) protocol must be run on all L3 devices. Otherwise, a forwarding route cannot be created.

1.4 Configuration Task Summary

The PIM-SM configuration includes the following tasks:

- (1) [Enabling the PIM-SM Function](#)
- (2) Configuring a model for PIM-SM. Select at least one of the configuration tasks to complete.
 - [Configuring PIM-SM in the ASM Model](#)
 - [Configuring PIM-SM in the SSM Model](#)
- (3) [Configuring PIM Neighbor Parameters](#). All the configuration tasks below are optional. Select the configuration tasks as required.
 - [Configuring the Neighbor Message Time Parameters](#)
 - [Configuring Neighbor Tracking](#)
 - [Configuring Neighbor Filtering](#)
- (4) (Optional) [Configuring DR Priority](#)
- (5) [Configuring Parameters of the Join/Prune Packets](#). All the configuration tasks below are optional. Select the configuration tasks as required.
 - [Configuring Join/Prune Packet Sending Interval](#)
 - [Configuring the Prune Delay](#)
- (6) (Optional) [Enabling PIM-SM on the Super VLAN Interface](#)
- (7) (Optional) [Enabling PIM BFD Correlation](#)

1.5 Enabling the PIM-SM Function

1.5.1 Overview

Neighbor relationship must be created between PIM multicast devices to form a PIM-SM network, so that PIM control messages and multicast packets can be transmitted on the network. The PIM-SM function must be configured on all interfaces so that PIM neighbor creation, multicast entry creation, and multicast packet forwarding can be successful.

In a PIM network, if you want an interface, for example, a stub network device interface connecting to hosts, to receive multicast packets without involving the PIM network topology construction, you can set the interface to the PIM-SM passive mode. After the PIM-SM passive mode is configured, the interface does not process PIM packets. This improves device performance.

1.5.2 Restrictions and Guidelines

- The IPv4 multicast routing function must be enabled on each multicast device.

- The PIM-SM function should be enabled on the following interfaces: interfaces interconnecting multicast devices, interfaces connecting the static RP, C-RP and C-BSRs, and interfaces connecting multicast sources and hosts.
- PIM interfaces must be L3 interfaces, including: routing, L3AP, switch virtual interface (SVI), and loopback interfaces.

1.5.3 Prerequisites

All PIM interfaces can be reached via IPv4 unicast routes.

1.5.4 Procedure

- (1) Enter the privileged EXEC mode.

enable

- (2) Enter the global configuration mode.

configure terminal

- (3) Enable IPv4 multicast routing.

ip multicast-routing

The IPv4 multicast routing function is disabled by default.

- (4) Enter the interface configuration mode.

interface *interface-type interface-number*

- (5) Enable the PIM-SM function.

ip pim sparse-mode

The PIM-SM function is disabled by default.

- (6) (Optional) Enable the PIM-SM passive mode.

ip pim sparse-mode passive

The PIM-SM passive mode is disabled by default.

1.6 Configuring PIM-SM in the ASM Model

1.6.1 Overview

The PIM-SM network supports the multicast service in the ASM and SSM models. Either one model or two models can be configured.

PIM-SM in the ASM model can provide hosts with multicast services of any source. A host joining a multicast group can receive multicast packets destined to this multicast group from any source.

If you require a PIM network to support the multicast service in the ASM model, an RP must be configured.

There are three methods to configure an RP:

- Configure a static RP.
- Configure a dynamic RP.
- Configure static and dynamic RPs. If static and dynamic RPs are available at the same time, dynamic RPs are preferred.

1.6.2 Configuration Tasks

The PIM-SM ASM model configuration includes the following tasks. Select the tasks to configure a static RP or a dynamic RP, or configure both.

- [Configuring a Static RP](#)
- Configuring a Dynamic RP
 - [Configuring C-BSRs and Related Parameters](#)
 - [Configuring C-RPs and Related Parameters](#)
 - (Optional) [Configuring Registration Parameters](#)
- (Optional) [Configuring the Last Hop Device to Switch over from the RPT to SPT](#)

1.6.3 Prerequisites

In the PIM-SM multicast network, all nodes are reachable via IPv4 unicast routes.

1.6.4 Configuring a Static RP

1. Overview

You can manually configure a static RP to prevent frequent packet interaction between the BSR and C-RPs or between the BSR and PIM multicast devices and avoid bandwidth occupation. If the multicast network is simple or small, you can configure a static RP.

2. Restrictions and Guidelines

- Static RPs must be configured on every multicast device.
- The multicast device selected as a static RP must boast high performance.
- You are advised to use the loopback interface as a static RP address.
- Static RPs configured on multicast devices should be consistent, including RP address and address range of the served groups.
- If multiple static RPs are configured to correspond to different addresses of groups, the RPs can implement load balancing.
- If multiple static RPs serve the same group, the static RP with a larger IP address is selected first.
- You can use the control list to configure an RP to serve multiple (referencing an ACL) or all (not referencing an ACL) multicast groups. However, an RP can adopt only one configuration. The last configuration overrides the preceding configurations.

3. Prerequisites

Before an address range of a group is configured for an RP, ensure that the corresponding ACL is created and specify a multicast group range for the static RP to serve. For more information about ACL configuration, see *Configuring ACL*.

4. Procedure

- (1) Enter the privileged EXEC mode.
enable
- (2) Enter the global configuration mode.

configure terminal

- (3) Configure a static RP.

```
ip pim rp-address rp-address [ { acl-name | acl-number } ]
```

No static RP is configured by default.

1.6.5 Configuring C-BSRs and Related Parameters

1. Overview

In the PIM-SM domain of the ASM model, a unique BSR must be available. The BSR collects and releases RP information.

- The BSR is elected from C-BSRs based on rules. The election rules are as follows:
 - a The priorities of the C-BSRs are compared. The device with a higher priority is selected.
 - b If the priorities are the same, the IP addresses are compared. The device with a larger IP address is selected.
 - c The winner is elected as the BSR in the domain and periodically sends BSMs in the domain. A BSM contains the BSR IP address, RP-Set and hash mask information. The hash mask is used for hash calculation during C-RP election. In the hold time of a BSM, if other C-BSRs do not receive the BSM from the BSR, the BSR is considered unreachable and a new round of BSR election is initiated.
- To avoid fraud by an illegitimate BSR, a BSR range can be specified on all PIM devices in the domain so that the PIM devices ignore a BSM that is sent from an illegitimate BSR.
- To limit BSM flooding, you can configure a BSR border on an interface. Upon receiving BSMs, this interface discards the BSMs without forwarding them. This limits the BSM flooding.

2. Restrictions and Guidelines

- C-BSRs must be configured on one or multiple multicast devices.
- The multicast devices selected as C-BSRs must boast high performance. The C-RPs and C-BSRs can reside on the same or different multicast devices.
- You are advised to use the loopback interface as a C-BSR address.
- If multiple C-BSRs are configured, they can implement redundancy backup.
- You are advised to configure a valid BSR address range on all PIM devices in the domain.
- A BSR border must be configured on the interface between domains.

3. Prerequisites

- [Enabling the PIM-SM Function.](#)
- Before a valid BSR address range is configured on PIM devices, ensure that the corresponding ACL is created and specify a valid BSR range. For more information about ACL configuration, see *Configuring ACL*.

4. Procedure

- (1) Configure C-BSRs and related parameters.

- a Enter the privileged EXEC mode.

```
enable
```

- b Enter the global configuration mode.

- configure terminal**
- c Configure C-BSRs.

ip pim bsr-candidate *interface-type interface-number* [*hash-mask-length* [*priority-value*]]

No C-BSR is configured by default.
- (2) (Optional) Configure a valid BSR address range on all PIM devices.
- a Enter the privileged EXEC mode.

enable
 - b Enter the global configuration mode.

configure terminal
 - c Configure a BSM limit on the PIM multicast devices.

ip pim accept-bsr list { *acl-name* | *acl-number* }

All BSMs are received by default.
- (3) (Optional) Configure a BSR border on the interface between PIM-SM domains.
- a Enter the privileged EXEC mode.

enable
 - b Enter the global configuration mode.

configure terminal
 - c Enter the interface configuration mode.

interface *interface-type interface-number*
 - d Configure a BSR border.

ip pim bsr-border

No BSR border is configured by default.

If multiple domains exist, the BSR border must be configured on the interface between two domains.

1.6.6 Configuring C-RPs and Related Parameters

1. Overview

- After a multicast device is configured as a C-RP, the C-RP periodically sends an advertisement packet to the BSR in unicast mode. The packet includes the RP priority, advertisement packet hold time (greater than the interval of sending the advertisement packet), RP address, address of the served group, and prefix of the multicast address. Upon receiving the advertisement packet, the BSR collects the information in the packet as RP-Set in the advertisement packet hold time, encapsulates the information in a BSM, and sends the message to all PIM devices. Upon receiving the BSM from the BSR, the PIM devices in the domain apply the same algorithms for hash calculation to calculate the C-RP serving each multicast group. After the advertisement packet hold timer times out, if the BSR does not receive a next advertisement packet from the C-RP, this C-RP is considered unreachable.
- To prevent fraud by an illegitimate C-RP, a C-RP range can be specified on the BSR. If an advertisement packet comes from an illegitimate C-RP, the packet is ignored.
- The BSR can determine whether to receive an advertisement packet with the prefix of the multicast address being 0 from a C-RP. When the prefix of the multicast address is 0, this C-RP serves all multicast groups.

- When receiving the BSM from the BSR, each PIM multicast device in the domain applies rules to select the RP. The RP election rules are as follows:
 - a The address of the multicast group that a host joins is compared with the mask length of the group address range that the C-RP serves. The device with the longest mask is selected.
 - b If the addresses are consistent with the mask length, the priorities of the C-RPs are compared. The device with the smallest priority value is selected.
 - c If the priorities are consistent, hash values are calculated and compared. The device with the largest hash value is selected.
 - d If the hash values are the same, the IP addresses of the C-RPs are compared. The device with the largest IP address is selected.

2. Restrictions and Guidelines

- C-RPs must be configured on one or multiple multicast devices.
- The multicast devices selected as C-RPs must boast high performance. The C-RPs and C-BSRs can reside on the same or different multicast devices.
- You are advised to use the loopback interface as a C-RP address.
- If multiple C-RPs are configured to serve the same group, they can implement redundancy backup.
- If multiple C-RPs are configured to serve different groups, they can implement load balancing.
- A valid C-RP range can be configured on the BSR.
- To specify a group range for C-RPs to serve, you can add the ACL option to the **ip pim rp-candidate** command. The group range is calculated based on the permit access control entry (ACE), rather than the deny ACE.

3. Prerequisites

- [Enabling the PIM-SM Function](#).
- If the **group-list** parameter is used to limit the range of groups served by the RP, ensure that the corresponding ACL is created and specify a multicast group range for the RP to serve. For more information about ACL configuration, see *Configuring ACL*.

4. Procedure

- Configure C-RPs and related parameters.
 - a Enter the privileged EXEC mode.
enable
 - b Enter the global configuration mode.
configure terminal
 - c Configure C-RPs.
ip pim rp-candidate interface-type interface-number [priority priority-value] [interval interval] [group-list { acl-name | acl-number }]
No C-RP is configured by default.
- (Optional) Configure the BSR to receive C-RP advertisement packets with the prefix of the multicast address being 0. This C-RP serves all the multicast groups.

- a Enter the privileged EXEC mode.
enable
- d Enter the global configuration mode.
configure terminal
- e Configure the BSR to receive advertisement packets from the C-RP that serves all multicast groups.
ip pim accept-crp-with-null-group
The function for the BSR to receive advertisement packets from the C-RP that serves all multicast groups is disabled by default.
You are advised to enable this function on all C-BSRs.
- (Optional) Configure a valid C-RP range on the BSR.
 - a Enter the privileged EXEC mode.
enable
 - f Enter the global configuration mode.
configure terminal
 - g Configure a valid C-RP range.
ip pim accept-crp list { acl-name | acl-number }
The C-BSRs receive all external C-RP advertisement packets by default.
You are advised to enable this function on all C-BSRs.
- (Optional) Configure to ignore RP priority on all PIM multicast devices and reselect an RP.
 - a Enter the privileged EXEC mode.
enable
 - h Enter the global configuration mode.
configure terminal
 - i Configure to ignore the RP priority for RP election.
ip pim ignore-rp-set-priority
If the address of the multicast group that a host joins is consistent with the mask length of the group address range that the C-RPs serve, the RP with the highest priority is selected by default.
You can configure to ignore C-RP priority on each multicast device.

1.6.7 Configuring Registration Parameters

1. Overview

When a multicast source sends multicast data, the data arrives at the source DR first. Upon receiving the multicast data, the source DR encapsulates the multicast data as a register message and sends the message to the RP. Related parameters of the register message are configured on the source DR and RP.

- You can configure the following parameters on the source DR:
 - RP reachability checking: Before sending a register message, the source DR determines whether the RP is reachable. If the RP is reachable, the message is sent. Otherwise, the message is not sent.
 - Limit on the rate of sending the register message: The rate of sending each register message in (S, G)

status is limited. If multiple register messages in (S, G) status are sent from the same source, the rate of the register messages is limited to the product of $N \times$ Limit value.

- Source address in the register message: The source address in the register message is the address of the DR interface connected to the multicast source by default. If a security policy is configured on the RP to filter out this address, the RP does not receive register messages from this source DR. In this case, you can specify a reachable source address as the source address of the register message.
- Register suppression time: When the RP receives multicast packets sent by the multicast source via the SPT, the RP sends a register-stop message to the source DR. Within the register-suppression time, the source DR stops encapsulating the register message and sends multicast packets to the RP via the SPT. After the register suppression timer times out, if the source DR does not receive another register-stop message from the RP, the source DR continues to encapsulate the register message and send the message to the RP.
- Null message detection time: Before the register suppression timer times out, the RP receives a null message from the source DR, refreshes the local (S, G) entries, and sends a register-stop message to the source DR so that the source DR refreshes the register suppression timer. Otherwise, the source DR continues to encapsulate the register message and send multicast packets to the RP in the form of the register message.
- You can configure the following parameters on the RP:
 - (S, G) address range of source: Provide multicast services for hosts in the permitted multicast group in the ASM model. After this parameter is configured, the RP replies a register-stop message upon receiving data from an unauthorized source.
 - Length of register message checksum: Adjust the calculation method of the register message checksum and calculate the checksum of the entire PIM protocol packets (including encapsulated multicast packets) or the checksum of PIM headers of separate register messages.
 - Register message decapsulation and delivery to downlink interface: Configure this parameter on the RP to decapsulate the received register message and forward the multicast packets in the register message.
 - Register message (S, G) entry timeout period: Configure this parameter to configure the timeout period of (S, G) entries. The (S, G) entries age if no packet is received within the register message timeout period.

2. Restrictions and Guidelines

- The source address in the specified register message must be reachable in unicast mode. You are advised to use the loopback interface of the source DR as the source address of the register message.
- If the **ip pim rp-register-kat** command is not configured, modifying the register suppression time on the RP changes the (S, G) entry timeout period.
- Configuring a limit to the register message rate reduces the load of the source DR and RP. Only register messages under the limit are sent.
- The register-probe time cannot be greater than a half of the register suppression time. Otherwise, the configuration failed and an alarm is generated.
- The sum of the three times of register suppression time and the register-probe time does not exceed 65,535. Otherwise, the configuration failed and an alarm is generated.

3. Prerequisites

- [Enabling the PIM-SM Function.](#)
- Before an (S, G) address range is configured for the source, if the **list** parameter is specified, ensure that the corresponding ACL is created and specify an (S, G) address range for the source. For more information about ACL configuration, see *Configuring ACL*.
- Before an (S, G) address range is configured for the source, if the **route-map** parameter is specified, ensure that the corresponding route map is created and specify an (S, G) address range for the source. For more information about route map configuration, see *Configuring Route Policies*.
- Before the register message checksum calculation is applied to entire packets, if the **group-list** parameter is specified, ensure that the corresponding ACL is created and specify the register message checksum calculation to apply to the entire packets in a multicast group address range. For more information about ACL configuration, see "Configuring ACL" in *ACL and QoS Configuration Guide*.

4. Procedure

All the configuration tasks below are optional. Select the configuration tasks as required.

- Configure registration parameters on the source DR.
 - a Enter the privileged EXEC mode.
enable
 - b Enter the global configuration mode.
configure terminal
 - c Enable RP reachability checking on the source DR.
ip pim register-rp-reachability
The RP reachability checking function is disabled by default.
 - d Limit the rate of sending register messages on the source DR.
ip pim register-rate-limit rate
The sending rate of register messages is not limited by default.
 - e Configure a source address in the register messages on the source DR.
ip pim register-source { local-address | interface-type interface-number }
The source IP address in the register messages is the address of the DR interface connected to the source by default.
 - f Configure the register suppression time on the source DR.
ip pim register-suppression suppression-time
The default register suppression time is **60** seconds.
 - g Configure the null message detection time on the source DR.
ip pim probe-interval interval
The default register-probe time is **5** seconds.
- Configure registration parameters on the RP.
 - a Enter the privileged EXEC mode.
enable

- h Enter the global configuration mode.

configure terminal

- i Configure the (S, G) address range for the source on the RP.

ip pim accept-register { **list** { *acl-name* | *acl-number* } | **route-map** *route-map-name* } *

The (S, G) address range of register messages is not limited by default. The RP receives register messages of all (S, G) addresses.

- j Enable register message checksum calculation to be applied to the entire packets on the RP.

ip pim register-checksum-wholepkt [**group-list** { *acl-name* | *acl-number* }]

By default, the register message checksum of headers of only PIM packets and register messages, rather than the entire packets, is calculated.

If the **group-list** parameter is not specified, this configuration applies to all group addresses.

- k Enable the RP to decapsulate the received register messages and forward the multicast packets in the received register messages on the RP.

ip pim register-decapsulate-forward

The function for the RP to decapsulate the register messages and forward the multicast packets is disabled by default.

The register message decapsulation and multicast packet forwarding function is implemented by the corresponding software. If there are too many register messages to be decapsulated and forwarded, the CPU is overloaded. Therefore, you are not advised to enable this function.

- l Configure the timeout period for the (S, G) entries created upon receiving the register message on the RP.

ip pim rp-register-kat *interval*

By default, the timeout period for the (S, G) entries is the sum of three times of the register suppression time and the register-probe time.

1.6.8 Configuring the Last Hop Device to Switch over from the RPT to SPT

1. Overview

If the multicast traffic in a network is heavy, the RP easily gets overloaded and then faulty. To relieve the RP load, you can initiate SPT switchover through the member DR. You can specify multicast groups to perform SPT switchover.

2. Prerequisites

- [Enabling the PIM-SM Function](#).
- Before an address range of a group is configured for SPT switchover, ensure that the corresponding ACL is created and specify a multicast group range for SPT switchover. For more information about ACL configuration, see "Configuring ACL" in *ACL and QoS Configuration Guide*.

3. Procedure

- (1) Enter the privileged EXEC mode.

enable

- (2) Enter the global configuration mode.

configure terminal

- (3) Enable the SPT switchover function.

ip pim spt-threshold [group-list { *acl-name* | *acl-number* }]

The SPT switchover function is disabled by default.

If the **group-list** parameter is not specified, all groups support SPT switchover.

1.7 Configuring PIM-SM in the SSM Model

1.7.1 Overview

The PIM-SM function in the SSM model can provide specified source services for hosts so that the hosts can determine to receive or reject multicast data of specified sources based on needs.

1.7.2 Restrictions and Guidelines

- If you require a PIM network to support the multicast service in the SSM model, the SSM function must be enabled.
- The SSM function must be enabled on each multicast device.
- The address range of SSM groups configured on all multicast devices must be consistent.
- IGMPv3 or SSM mapping must be enabled.

1.7.3 Prerequisites

- In the multicast network, all nodes are reachable via IPv4 unicast routes.
- [Enabling the PIM-SM Function](#).
- Before an SSM group range is configured using an ACL, ensure that the corresponding ACL is created and specify an SSM multicast group range. For more information about ACL configuration, see "Configuring ACL" in *ACL and QoS Configuration Guide*.

1.7.4 Procedure

- (1) Enter the privileged EXEC mode.

enable

- (2) Enter the global configuration mode.

configure terminal

- (3) Enable the SSM function.

ip pim ssm { default | range { *acl-name* | *acl-number* } }

The SSM function is disabled by default.

1.8 Configuring PIM Neighbor Parameters

1.8.1 Overview

PIM multicast devices transmit hello messages to discover neighbors, coordinate protocol parameters and maintain neighbor relationships.

1.8.2 Configuration Tasks

All the configuration tasks below are optional. Select the configuration tasks as required.

- [Configuring the Neighbor Message Time Parameters](#)
- [Configuring Neighbor Tracking](#)
- [Configuring Neighbor Filtering](#)

1.8.3 Prerequisites

- In the multicast network, all nodes are reachable via IPv4 unicast routes.
- [Enabling the PIM-SM Function](#).

1.8.4 Configuring the Neighbor Message Time Parameters

1. Overview

The neighbor message time parameters include hello message sending interval and hello message sending delay.

- The hello message sending interval can be configured, and the hello message hold time is 3.5 times the hello message sending interval. If no new hello message is received within the hello message hold time, the neighbor is considered unreachable.
- When the PIM interface is enabled or detects a new neighbor, random time is generated and it is referred to as hello message sending delay. Within the delay time, the interface sends hello messages out.

2. Restrictions and Guidelines

If the hello message hold time is greater than 65,535 seconds, the hello message sending interval is automatically set to 18,725 seconds.

3. 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) Configure the neighbor message time parameters. Select at least one of them to configure.
 - Configure the hello message sending interval.
ip pim query-interval *interval*

The hello message is sent at an interval of **30** seconds by default.

- o Configure the hello message sending delay.

ip pim triggered-hello-delay *delay*

The hello message sending delay is **5** seconds by default.

1.8.5 Configuring Neighbor Tracking

1. Overview

After the suppression capability of an interface is enabled, when a multicast device plans to send a join packet to an uplink multicast device but it receives a join packet sent from the neighbor to the uplink multicast device, this local multicast device suppresses its own join packet. If the suppression capability of the interface is disabled, the join packet can be sent. When the suppression capability of downlink hosts is disabled, an uplink device can determine the number of the downlink hosts based on the quantity of received join packets. This is neighbor tracking.

2. 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 neighbor tracking function.

ip pim neighbor-tracking

The neighbor tracking function is disabled by default.

1.8.6 Configuring Neighbor Filtering

1. Overview

The neighbor filtering function can protect neighborhood. Controlling neighbors can strengthen PIM network security and limit the valid address range of neighbors. If a neighbor is filtered out based on an access filtering list, PIM-SM does not create peer relationship with the neighbor or stops the peer relationship with this neighbor.

2. Prerequisites

Before an access filtering list is configured, ensure that the corresponding ACL is created and specify a valid neighbor address range. For more information about ACL configuration, see "Configuring ACL" in *ACL and QoS Configuration Guide*.

3. 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 neighbor filtering function.

```
ip pim neighbor-filter { acl-name | acl-number }
```

The neighbor filtering function is disabled by default.

1.9 Configuring DR Priority

1.9.1 Overview

In a network segment shared by multicast sources and group members, multiple PIM multicast devices exist. The PIM multicast devices elect a DR based on neighbor messages. A device with the highest priority is selected. If the priorities are the same or some PIM devices do not support the DR priority function, the IP addresses are compared and the PIM multicast device with the largest IP address is selected. The selected PIM device functions as a DR, transmits protocol packets between the sources and members, and forwards multicast packets.

1.9.2 Prerequisites

- In the multicast network, all nodes are reachable via IPv4 unicast routes.
- [Enabling the PIM-SM Function.](#)

1.9.3 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) Configure a DR priority in hello messages.

```
ip pim dr-priority priority-value
```

The default DR priority in hello messages is 1.

1.10 Configuring Parameters of the Join/Prune Packets

1.10.1 Overview

A device sends a join packet to request an uplink device to forward multicast packets and sends a prune packet to request the uplink device to stop forwarding multicast packets. The request route is referred to as an RPT or SPT.

1.10.2 Restrictions and Guidelines

- The network administrator must ensure that the prune override interval is smaller than the join-prune packet

hold time. Otherwise, a short interrupt may occur.

- When the PIM multicast device receives a prune message from an uplink interface, there are other downlink devices existent in the shared network segment. If this PIM multicast device still needs to receive multicast data, the PIM multicast device must send a prune override message to the uplink device within the override interval.

1.10.3 Configuration Tasks

All the configuration tasks below are optional. Select the configuration tasks as required.

- [Configuring Join/Prune Packet Sending Interval](#)
- [Configuring the Prune Delay](#)

1.10.4 Prerequisites

[Enabling the PIM-SM Function.](#)

1.10.5 Configuring Join/Prune Packet Sending Interval

1. Overview

A PIM device periodically sends the join/prune packet to an uplink device to update the forwarding status. The join packet is used to request data forwarding and the prune packet is used to stop data forwarding. Upon receiving the join/prune packet, the uplink device starts the join/prune packet hold time timer.

- If a join packet hold time timer times out, the PIM device is suppressed to forward multicast packets of the corresponding multicast group through the downlink interface.
- If a prune packet hold time timer times, the PIM device is restored to forward the multicast packets of the corresponding multicast group through the downlink interface.

2. Restrictions and Guidelines

The join/prune packet sending interval must be smaller than the join/prune packet hold time. Generally, the join/prune packet hold time is 3.5 times the join/prune packet sending interval.

3. Procedure

(1) Enter the privileged EXEC mode.

```
enable
```

(2) Enter the global configuration mode.

```
configure terminal
```

(3) Configure the join/prune packet sending interval.

```
ip pim jp-timer interval
```

The join/prune packet is sent at an interval of **60** seconds by default.

1.10.6 Configuring the Prune Delay

1. Overview

Upon receiving a prune packet from a downlink device, the multicast device does not perform prune immediately and it waits for a period of time. This period of time is divided into two parts: The part from the

time when the multicast device receives a prune message to the time when the multicast device sends the prune message to the uplink device is referred to as the prune propagation delay; the part from the time when the PIM device receives a prune packet to the time when the device continues to forward the multicast packets to a downlink device is referred to as the override interval. The period from the time when the multicast device receives a prune message to the time when the prune action is performed is the sum of the propagation delay and the override interval.

2. Restrictions and Guidelines

In the period from the time when the multicast device receives a prune message to the time when the prune action is performed, if the PIM device receives a prune override message from the downlink interface, the PIM device cancels pruning.

3. 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) Configure the prune message propagation delay.

ip pim propagation-delay *propagation-delay*

The default propagation delay of an interface is **500** ms.

- (5) Configure the prune override interval.

ip pim override-interval *override-interval*

The default override interval is **2500** ms.

1.11 Enabling PIM-SM on the Super VLAN Interface

1. Overview

In most scenarios of a PIM network, the PIM-SM protocol does not need to be enabled on a super VLAN interface. A super VLAN interface is connected to many sub VLANs. If the PIM-SM protocol is enabled on the super VLAN interface, the device replicates and sends a multicast protocol packet to all the sub VLANs, which easily surpasses the processing capability of the device and causes packet loss even protocol flapping. In some scenarios, the PIM-SM protocol must be enabled on the super VLAN interface. You can configure the command to enable the protocol packets to be sent to the specified sub VLANs or all sub VLANs. If the packets are sent to all VLANs, protocol flapping may occur.

2. Restrictions and Guidelines

- This function must be enabled on the super VLAN interface.
- If you enable protocol packets to be sent to all sub VLANs, the packets may surpass the processing capability of the device, causing protocol flapping.

3. 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 PIM-SM protocol packets to be sent to specified sub VLANs.

ip pim sparse-mode subvlan [**all** | *vlan-id*]

The PIM-SM function is disabled on a super VLAN interface by default.

1.12 Enabling PIM BFD Correlation

1. Overview

In some shared multicast networks, PIM neighbor status change triggers re-initiation of some mechanisms, for example, DR election mechanism. Generally, a PIM neighbor triggers a new round of election after the neighborhood times out, causing multicast data interruption. PIM bidirectional forwarding detection (BFD) correlation can quickly detect link status and neighbor faults in a shared network segment and trigger a new round of DR election. This reduces multicast data transmission interrupt time and ensures reliability of the multicast network.

2. Restrictions and Guidelines

- If DR election or assertion election is required in a multicast network, you are advised to enable PIM-SM BFD correlation.
- The PIM BFD function must be enabled on the interconnection interface of the multicast devices.
- PIM interfaces must be L3 interfaces, including: routing, L3AP, switch virtual interface (SVI), and loopback interfaces.

3. Prerequisites

- In the network, all nodes are reachable via IPv4 unicast routes.
- [Enabling the PIM-SM Function.](#)

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 PIM BFD correlation.

ip pim bfd

PIM BFD correlation is disabled by default.

1.13 Monitoring

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

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 ip mroute { * <i>group-address</i> [<i>source-address</i>] }	Clears multicast routing entries.
clear ip mroute statistics { * <i>group-address</i> [<i>source-address</i>] }	Clears statistical information about multicast routing.
clear ip pim sparse-mode bsr rp-set *	Clears dynamic RP information.
clear ip pim sparse-mode track	Clears statistical information about PIM-SM protocol packets.
show ip pim sparse-mode bsr-router	Displays details about the BSR.
show ip pim sparse-mode interface [<i>interface-type</i> <i>interface-number</i>] [detail]	Displays PIM-SM information of an interface.
show ip pim sparse-mode local-members [<i>interface-type</i> <i>interface-number</i>]	Displays local IGMP information about a PIM-SM interface.
show ip pim sparse-mode mroute [<i>group-or-source-address</i> [<i>group-or-source-address</i>]]	Displays information about the PIM-SM multicast routing table.
show ip pim sparse-mode neighbor [detail]	Displays PIM-SM neighbor information.
show ip pim sparse-mode nexthop	Displays the PIM-SM next hop information in an NSM.
show ip pim sparse-mode rp-hash <i>group-address</i>	Displays RP information corresponding to a group address.
show ip pim sparse-mode rp mapping	Displays all RPs and the groups served by the RPs.
show ip pim sparse-mode track	Displays the number of PIM packets sent and received since the statistic start time.

1.14 Configuration Examples

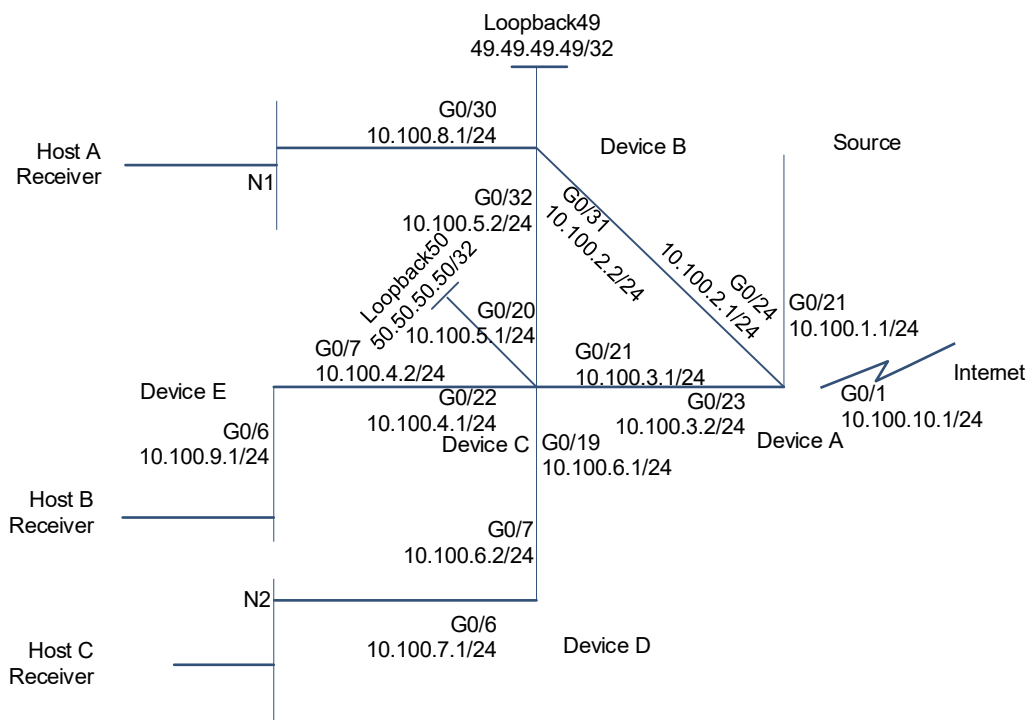
1.14.1 Configuring Basic Functions of PIM-SM in the ASM Model

1. Requirements

As shown in [Figure 1-1](#), the internal network is connected to the Internet. The PIM-SM protocol is configured on each multicast device to provide ASM multicast services for hosts in networks N1 and N2 so that hosts joining a multicast group can receive multicast data destined to this multicast group from any multicast source, including video-on-demand information.

2. Topology

Figure 1-1 PIM-SM Multicast Network Topology in the ASM Model



3. Notes

- Configure IP addresses and unicast routing protocols for multicast devices. The PIM routing protocol in a multicast domain depends on unicast routing protocols. Normal communication of unicast routing lays a foundation of multicast routing. Ensure that each PIM node is reachable via unicast routes.
- Enable the multicast function on all multicast devices. Enabling the multicast function is a prerequisite of PIM-SM configuration.
- Enable the basic functions of PIM-SM on all interfaces of the multicast devices. The other functions of PIM-SM can be enabled only after the basic functions of PIM-SM are enabled.
- Enable the IGMP function on the interface connected to hosts so that the hosts can join or leave a multicast group by sending IGMP messages. The multicast devices acting as leaf nodes maintain group membership based on the IGMP protocol.

- Configure RPs. In the PIM-SM network in the ASM model, the RP is a transitional station for forwarding multicast data. It is recommended that the multicast device with many traffic flows be configured as an RP, for example, device C in [Figure 1-1](#).
- Configure a BSR border on the interface connected to the Internet. BSMs must be transmitted in the PIM-SM domain within the border to improve the multicast controllability.

4. Procedure

- (1) Configure IP addresses and enable unicast routing protocols on interfaces of different devices.

Configure IPv4 addresses on interfaces of device A, and configure the OSPF protocol to implement internetworking.

```
DeviceA> enable
DeviceA# config terminal
DeviceA(config)# interface gigabitEthernet 0/1
DeviceA(config-if-GigabitEthernet 0/1)# no switchport
DeviceA(config-if-GigabitEthernet 0/1)# ip address 10.100.10.1 255.255.255.0
DeviceA(config-if-GigabitEthernet 0/1)# exit
DeviceA(config)# interface gigabitEthernet 0/21
DeviceA(config-if-GigabitEthernet 0/21)# no switchport
DeviceA(config-if-GigabitEthernet 0/21)# ip address 10.100.1.1 255.255.255.0
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)# ip address 10.100.3.2 255.255.255.0
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)# ip address 10.100.2.1 255.255.255.0
DeviceA(config-if-GigabitEthernet 0/24)# exit
DeviceA(config)# router ospf 49
DeviceA(config-router)# network 10.100.1.0 0.0.0.255 area 0
DeviceA(config-router)# network 10.100.10.0 0.0.0.255 area 0
DeviceA(config-router)# network 10.100.2.0 0.0.0.255 area 0
DeviceA(config-router)# network 10.100.3.0 0.0.0.255 area 0
DeviceA(config-router)# exit
```

Configure IPv4 addresses on interfaces of device B, and configure the OSPF protocol to implement internetworking.

```
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)# ip address 10.100.8.1 255.255.255.0
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)# ip address 10.100.2.2 255.255.255.0
```

```
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)# ip address 10.100.5.2 255.255.255.0
DeviceB(config-if-GigabitEthernet 0/32)# exit
DeviceB(config)# interface loopback 49
DeviceB(config-if-Loopback 49)# ip address 49.49.49.49 255.255.255.255
DeviceB(config-if-Loopback 49)# exit
DeviceB(config)# router ospf 49
DeviceB(config-router)# network 10.100.8.0 0.0.0.255 area 0
DeviceB(config-router)# network 10.100.2.0 0.0.0.255 area 0
DeviceB(config-router)# network 10.100.5.0 0.0.0.255 area 0
DeviceB(config-router)# network 49.49.49.49 0.0.0.0 area 0
DeviceB(config-router)# exit
```

Configure IPv4 addresses on interfaces of device C, and configure the OSPF protocol to implement internetworking.

```
DeviceC> enable
DeviceC# config terminal
DeviceC(config)# interface GigabitEthernet 0/19
DeviceC(config-if-GigabitEthernet 0/19)# no switchport
DeviceC(config-if-GigabitEthernet 0/19)# ip address 10.100.6.1 255.255.255.0
DeviceC(config-if-GigabitEthernet 0/19)# exit
DeviceC(config)# interface GigabitEthernet 0/20
DeviceC(config-if-GigabitEthernet 0/20)# no switchport
DeviceC(config-if-GigabitEthernet 0/20)# ip address 10.100.5.1 255.255.255.0
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)# ip address 10.100.3.1 255.255.255.0
DeviceC(config-if-GigabitEthernet 0/21)# exit
DeviceC(config)# interface GigabitEthernet 0/22
DeviceC(config-if-GigabitEthernet 0/22)# no switchport
DeviceC(config-if-GigabitEthernet 0/22)# ip address 10.100.4.1 255.255.255.0
DeviceC(config-if-GigabitEthernet 0/22)# exit
DeviceC(config)# interface loopback 50
DeviceC(config-if-Loopback 50)# ip address 50.50.50.50 255.255.255.255
DeviceC(config-if-Loopback 50)# exit
DeviceC(config)# router ospf 49
DeviceC(config-router)# network 10.100.6.0 0.0.0.255 area 0
DeviceC(config-router)# network 10.100.5.0 0.0.0.255 area 0
DeviceC(config-router)# network 10.100.3.0 0.0.0.255 area 0
DeviceC(config-router)# network 10.100.4.0 0.0.0.255 area 0
DeviceC(config-router)# network 50.50.50.50 0.0.0.0 area 0
DeviceC(config-router)# exit
```

Configure IPv4 addresses on interfaces of device D, and configure the OSPF protocol to implement internetworking.

```
DeviceD> enable
DeviceD# config terminal
DeviceD(config)# interface GigabitEthernet 0/6
DeviceD(config-if-GigabitEthernet 0/6)# no switchport
DeviceD(config-if-GigabitEthernet 0/6)# ip address 10.100.7.1 255.255.255.0
DeviceD(config-if-GigabitEthernet 0/6)# exit
DeviceD(config)# interface GigabitEthernet 0/7
DeviceD(config-if-GigabitEthernet 0/7)# no switchport
DeviceD(config-if-GigabitEthernet 0/7)# ip address 10.100.6.2 255.255.255.0
DeviceD(config-if-GigabitEthernet 0/7)# exit
DeviceD(config)# router ospf 49
DeviceD(config-router)# network 10.100.6.0 0.0.0.255 area 0
DeviceD(config-router)# network 10.100.7.0 0.0.0.255 area 0
DeviceD(config-router)# exit
```

Configure IPv4 addresses on interfaces of device E, and configure the OSPF protocol to implement internetworking.

```
DeviceE> enable
DeviceE# config terminal
DeviceE(config)# interface GigabitEthernet 0/6
DeviceE(config-if-GigabitEthernet 0/6)# no switchport
DeviceE(config-if-GigabitEthernet 0/6)# ip address 10.100.9.1 255.255.255.0
DeviceE(config-if-GigabitEthernet 0/6)# interface GigabitEthernet 0/7
DeviceE(config-if-GigabitEthernet 0/7)# no switchport
DeviceE(config-if-GigabitEthernet 0/7)# ip address 10.100.4.2 255.255.255.0
DeviceE(config-if-GigabitEthernet 0/7)# exit
DeviceE(config)# router ospf 49
DeviceE(config-router)# network 10.100.9.0 0.0.0.255 area 0
DeviceE(config-router)# network 10.100.4.0 0.0.0.255 area 0
DeviceE(config-router)# exit
```

- (2) Enable the multicast and PIM-SM functions on all multicast devices, and enable the IGMP function on all multicast devices connected to hosts.

Enable the multicast and PIM-SM functions on device A.

```
DeviceA(config)# ip multicast-routing
DeviceA(config)# interface gigabitEthernet 0/21
DeviceA(config-if-GigabitEthernet 0/21)# ip pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/21)# exit
DeviceA(config)# interface gigabitEthernet 0/23
DeviceA(config-if-GigabitEthernet 0/23)# ip pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/23)# exit
DeviceA(config)# interface gigabitEthernet 0/24
DeviceA(config-if-GigabitEthernet 0/24)# ip pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/24)# exit
```

Enable the multicast, PIM-SM, and IGMP functions on device B.

```
DeviceB(config)# ip multicast-routing
```



```
DeviceB(config)# interface gigabitEthernet 0/30
DeviceB(config-if-GigabitEthernet 0/30)# ip pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/30)# exit
DeviceB(config)# interface gigabitEthernet 0/31
DeviceB(config-if-GigabitEthernet 0/31)# ip pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/31)# exit
DeviceB(config)# interface gigabitEthernet 0/32
DeviceB(config-if-GigabitEthernet 0/32)# ip pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/32)# exit
DeviceB(config)# interface loopback 49
DeviceB(config-if-Loopback 49)# ip pim sparse-mode
DeviceB(config-if-Loopback 49)# exit
```

Enable the multicast and PIM-SM functions on device C.

```
DeviceC(config)# ip multicast-routing
DeviceC(config)# interface gigabitEthernet 0/19
DeviceC(config-if-GigabitEthernet 0/19)# ip pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/19)# exit
DeviceC(config)# interface gigabitEthernet 0/20
DeviceC(config-if-GigabitEthernet 0/20)# ip pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/20)# exit
DeviceC(config)# interface gigabitEthernet 0/21
DeviceC(config-if-GigabitEthernet 0/21)# ip pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/21)# exit
DeviceC(config)# interface gigabitEthernet 0/22
DeviceC(config-if-GigabitEthernet 0/22)# ip pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/22)# exit
DeviceC(config)# interface loopback 50
DeviceC(config-if-Loopback 50)# ip pim sparse-mode
DeviceC(config-if-Loopback 50)# exit
```

Enable the multicast, PIM-SM, and IGMP functions on device D.

```
DeviceD(config)# ip multicast-routing
DeviceD(config)# interface gigabitEthernet 0/6
DeviceD(config-if-GigabitEthernet 0/6)# ip pim sparse-mode
DeviceD(config-if-GigabitEthernet 0/6)# exit
DeviceD(config)# interface gigabitEthernet 0/7
DeviceD(config-if-GigabitEthernet 0/7)# ip pim sparse-mode
DeviceD(config-if-GigabitEthernet 0/7)# exit
```

Enable the multicast, PIM-SM, and IGMP functions on device E.

```
DeviceE(config)# ip multicast-routing
DeviceE(config)# interface gigabitEthernet 0/6
DeviceE(config-if-GigabitEthernet 0/6)# ip pim sparse-mode
DeviceE(config-if-GigabitEthernet 0/6)# exit
DeviceE(config)# interface gigabitEthernet 0/7
DeviceE(config-if-GigabitEthernet 0/7)# ip pim sparse-mode
DeviceE(config-if-GigabitEthernet 0/7)# exit
```

(3) Configure RPs.

Note

There are two methods to configure RPs: dynamic RPs and static RPs. You can configure either or both types of RPs. If static and dynamic RPs are available at the same time, the dynamic RPs are preferred by default.

Configure dynamic RPs. One or multiple multicast devices in the PIM-SM domain must be configured as C-RPs and C-BSRs. In this example, device B and device C are configured as C-RP and C-BSR. The address range of the served groups of the RP, as well as the interfaces of the C-RP and C-BSR are configured on device B and device C. The loopback interface is configured as the interface of the C-RP and C-BSR.

Configure C-RP and C-BSR and address range of the served groups of the RP on device B.

```
DeviceB(config)# ip pim bsr-candidate loopback 49
DeviceB(config)# ip access-list standard 49
DeviceB(config-std-nacl)# permit 224.0.0.0 0.255.255.255
DeviceB(config)# ip pim rp-candidate loopback 49 group-list 49
```

Configure C-RP and C-BSR and address range of the served groups of the RP on device C.

```
DeviceC(config)# ip pim bsr-candidate loopback 50
DeviceC(config)# ip access-list standard 50
DeviceC(config-std-nacl)# permit 225.0.0.0 0.255.255.255
DeviceC(config-std-nacl)# exit
DeviceC(config)# ip pim rp-candidate loopback 50 group-list 50
```

Configure static RPs. The addresses of static RPs must be specified on all multicast devices.

Configure a static RP on device A.

```
DeviceA(config)# ip pim rp-address 50.50.50.50
```

Configure a static RP on device B.

```
DeviceB(config)# ip pim rp-address 50.50.50.50
```

Configure a static RP on device C.

```
DeviceC(config)# ip pim rp-address 50.50.50.50
```

Configure a static RP on device D.

```
DeviceD(config)# ip pim rp-address 50.50.50.50
```

Configure a static RP on device E.

```
DeviceE(config)# ip pim rp-address 50.50.50.50
```

(4) Configure a BSR border on the device A interface connected to the Internet.

```
DeviceA(config-if-GigabitEthernet 0/1)# ip pim bsr-border
```

5. Verification

- (1) Run the **show ip pim sparse-mode interface** command to display the PIM-SM running information on the interfaces.

The PIM-SM running information on the interface of device A is as follows:

```
DeviceA> enable
```

```

DeviceA#show ip pim sparse-mode interface
Address          Interface          VIFindex Ver/Mode
Nbr-Count DR-Prior DR
10.100.1.1      GigabitEthernet 0/21           1          v2/S      0
1              10.100.1.1
10.100.3.2      GigabitEthernet 0/23           2          v2/S      1
1              10.100.3.2
10.100.2.1      GigabitEthernet 0/24           3          v2/S      0
1              10.100.2.1
DeviceA#

```

The PIM-SM running information on the interface of device B is as follows:

```

DeviceB> enable
DeviceB# show ip pim sparse-mode interface
Address          Interface          VIFindex Ver/Mode
Nbr-Count DR-Prior DR
10.100.8.1      GigabitEthernet 0/30           1          v2/S      0
1              10.100.8.1
10.100.2.2      GigabitEthernet 0/31           4          v2/S      1
1              10.100.2.2
10.100.5.2      GigabitEthernet 0/32           2          v2/S      1
1              10.100.5.2
49.49.49.49     Loopback 49       3          v2/S      0
1              49.49.49.49
DeviceB#

```

The PIM-SM running information on the interface of device C is as follows:

```

DeviceC> enable
DeviceC# show ip pim sparse-mode interface
Address          Interface          VIFindex Ver/Mode
Nbr-Count DR-Prior DR
10.100.6.1      GigabitEthernet 0/19           1          v2/S      1
1              10.100.6.2
10.100.5.1      GigabitEthernet 0/20           2          v2/S      1
1              10.100.5.2
10.100.3.1      GigabitEthernet 0/21           3          v2/S      1
1              10.100.3.2
10.100.4.1      GigabitEthernet 0/22           4          v2/S      1
1              10.100.4.2
50.50.50.50     Loopback 50       5          v2/S      0
1              50.50.50.50
DeviceC#

```

The PIM-SM running information on the interface of device D is as follows:

```

DeviceD> enable
DeviceD# show ip pim sparse-mode interface
Address          Interface          VIFindex Ver/Mode
Nbr-Count DR-Prior DR

```

```

10.100.7.1      GigabitEthernet 0/6          1      v2/S    0
1      10.100.7.1
10.100.6.2      GigabitEthernet 0/7          2      v2/S    1
1      10.100.6.2
DeviceD#

```

The PIM-SM running information on the interface of device E is as follows:

```

DeviceE> enable
DeviceE# show ip pim sparse-mode interface
Address          Interface          VIFindex Ver/Mode
Nbr-Count DR-Prior DR
10.100.9.1      GigabitEthernet 0/6          1      v2/S    0
1      10.100.9.1
10.100.4.2      GigabitEthernet 0/7          2      v2/S    1
1      10.100.4.2
DeviceE#

```

- (2) Run the **show ip pim sparse-mode bsr-router** command to display the election information of the BSRs.

The election information on device A is as follows:

```

DeviceA> enable
DeviceA# show ip pim sparse-mode bsr-router
PIMv2 Bootstrap information
  BSR address: 50.50.50.50
  Uptime:      00:48:33, BSR Priority: 64, Hash mask length: 10
  Expires:     00:01:32
  Role: Non-candidate BSR   Priority: 0, Hash mask length: 10
  State: Accept Preferred
DeviceA#

```

The election information on device B is as follows:

```

DeviceB> enable
DeviceB# show ip pim sparse-mode bsr-router
PIMv2 Bootstrap information
  BSR address: 50.50.50.50
  Uptime:      00:49:26, BSR Priority: 64, Hash mask length: 10
  Expires:     00:01:39
  Role: Candidate BSR      Priority: 64, Hash mask length: 10
  State: Candidate BSR

Candidate RP: 49.49.49.49(Loopback 49)
  Advertisement interval 60 seconds
  Next Cand_RP_advertisement in 00:00:19
DeviceB#

```

The election information on device C is as follows:

```

DeviceC> enable
DeviceC# show ip pim sparse-mode bsr-router
PIMv2 Bootstrap information

```

```

This system is the Bootstrap Router (BSR)
  BSR address: 50.50.50.50
  Uptime:      00:51:04, BSR Priority: 64, Hash mask length: 10
  Next bootstrap message in 00:00:56
  Role: Candidate BSR   Priority: 64, Hash mask length: 10
  State: Elected BSR
DeviceC#

```

The election information on device D is as follows:

```

DeviceD> enable
DeviceD# show ip pim sparse-mode bsr-router
PIMv2 Bootstrap information
  BSR address: 50.50.50.50
  Uptime:      00:51:38, BSR Priority: 64, Hash mask length: 10
  Expires:     00:01:28
  Role: Non-candidate BSR   Priority: 0, Hash mask length: 10
  State: Accept Preferred
DeviceD#

```

The election information on device E is as follows:

```

DeviceE> enable
DeviceE# show ip pim sparse-mode bsr-router
PIMv2 Bootstrap information
  BSR address: 50.50.50.50
  Uptime:      00:52:24, BSR Priority: 64, Hash mask length: 10
  Expires:     00:01:42
  Role: Non-candidate BSR   Priority: 0, Hash mask length: 10
  State: Accept Preferred
DeviceE#

```

- (3) Run the **show ip pim sparse-mode rp mapping** command to display the RP information on the multicast devices.

The RP information on device A is as follows:

```

DeviceA> enable
DeviceA# show ip pim sparse-mode rp mapping
PIM Group-to-RP Mappings
Group(s): 224.0.0.0/8
  RP: 49.49.49.49(Not self)
    Info source: 50.50.50.50, via bootstrap, priority 192
    Uptime: 00:55:25, expires: 00:01:52
Group(s): 225.0.0.0/8
  RP: 50.50.50.50(Not self)
    Info source: 50.50.50.50, via bootstrap, priority 192
    Uptime: 00:00:48, expires: 00:01:52
Group(s): 224.0.0.0/4, Static
  RP: 50.50.50.50(Not self) , Static
    Uptime: 00:50:13

```

```
DeviceA#
```

The RP information on device B is as follows:

```
DeviceB> enable
DeviceB# show ip pim sparse-mode rp mapping
PIM Group-to-RP Mappings
Group(s): 224.0.0.0/8
  RP: 49.49.49.49(Self)
    Info source: 50.50.50.50, via bootstrap, priority 192
    Uptime: 00:56:12, expires: 00:02:05
Group(s): 225.0.0.0/8
  RP: 50.50.50.50(Not self)
    Info source: 50.50.50.50, via bootstrap, priority 192
    Uptime: 00:01:35, expires: 00:02:05
Group(s): 224.0.0.0/4, Static
  RP: 50.50.50.50(Not self) , Static
    Uptime: 00:49:36
DeviceB#
```

The RP information on device C is as follows:

```
DeviceC> enable
DeviceC# show ip pim sparse-mode rp mapping
PIM Group-to-RP Mappings
This system is the Bootstrap Router (v2)
Group(s): 224.0.0.0/8
  RP: 49.49.49.49(Not self)
    Info source: 49.49.49.49, via bootstrap, priority 192
    Uptime: 00:56:17, expires: 00:02:13
Group(s): 225.0.0.0/8
  RP: 50.50.50.50(Self)
    Info source: 50.50.50.50, via bootstrap, priority 192
    Uptime: 00:01:40, expires: 00:01:50
Group(s): 224.0.0.0/4, Static
  RP: 50.50.50.50(Self) , Static
    Uptime: 00:49:39
DeviceC#
```

The RP information on device D is as follows:

```
DeviceD> enable
DeviceD# show ip pim sparse-mode rp mapping
PIM Group-to-RP Mappings
Group(s): 224.0.0.0/8
  RP: 49.49.49.49(Not self)
    Info source: 50.50.50.50, via bootstrap, priority 192
    Uptime: 00:56:22, expires: 00:01:55
Group(s): 225.0.0.0/8
  RP: 50.50.50.50(Not self)
    Info source: 50.50.50.50, via bootstrap, priority 192
```

```

        Uptime: 00:01:45, expires: 00:01:55
Group(s): 224.0.0.0/4, Static
        RP: 50.50.50.50(Not self) , Static
        Uptime: 00:49:40
DeviceD#

```

The RP information on device E is as follows:

```

DeviceE> enable
DeviceE# show ip pim sparse-mode rp mapping
PIM Group-to-RP Mappings
Group(s): 224.0.0.0/8
    RP: 49.49.49.49(Not self)
        Info source: 50.50.50.50, via bootstrap, priority 192
        Uptime: 00:56:27, expires: 00:01:50
Group(s): 225.0.0.0/8
    RP: 50.50.50.50(Not self)
        Info source: 50.50.50.50, via bootstrap, priority 192
        Uptime: 00:01:50, expires: 00:01:50
Group(s): 224.0.0.0/4, Static
    RP: 50.50.50.50(Not self) , Static
        Uptime: 00:49:43
DeviceE#

```

- (4) Run the **show ip pim sparse-mode mroute** command to display the multicast routing tables of PIM-SM. The multicast source (10.100.1.2/24) sends traffic to the multicast groups (225.0.0.1/24) and (224.0.1.1/24). Host A joins the multicast group (225.0.0.1), and host B joins the multicast group (224.0.1.1).

The routing table information on device A is as follows:

```

DeviceA> enable
DeviceA# show ip pim sparse-mode mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 0
(S,G) Entries: 2
(S,G,rpt) Entries: 2
FCR Entries: 0
REG Entries: 2

(10.100.1.2, 224.0.1.1)
RPF nbr: 0.0.0.0
RPF idx: None
SPT bit: 1
Upstream State: JOINED
kat expires in 53 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

```



```
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Outgoing
0 . .
o . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

(10.100.1.2, 224.0.1.1, rpt)
RP: 50.50.50.50
RPF nbr: 10.100.3.1
RPF idx: GigabitEthernet 0/23
Upstream State: RPT NOT 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
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
```

```
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Pruned
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Outgoing
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

(10.100.1.2, 225.0.0.1)
RPF nbr: 0.0.0.0
RPF idx: None
SPT bit: 1
Upstream State: JOINED
kat expires in 100 seconds
```



```
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Outgoing
0 . . .
o . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

(10.100.1.2, 225.0.0.1, rpt)
RP: 50.50.50.50
RPF nbr: 10.100.3.1
RPF idx: GigabitEthernet 0/23
Upstream State: RPT NOT 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
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
```

```
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Pruned
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Outgoing
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
DeviceA#
```

The routing table information on device B is as follows (only key information is displayed):

```
DeviceB> enable
DeviceB# show ip pim sparse-mode mroute
IP Multicast Routing Table
```

```
(* ,*,RP) Entries: 0
(*,G) Entries: 1
(S,G) Entries: 0
(S,G,rpt) Entries: 0
FCR Entries: 1
REG Entries: 0

(* , 225.0.0.1)
RP: 50.50.50.50
RPF nbr: 10.100.5.1
RPF idx: GigabitEthernet 0/32
Upstream State: JOINED
jt_timer expires in 52 seconds
FCR:
Source: 10.100.1.2
KAT timer running, 166 seconds remaining
  Packet count 1

DeviceB#
```

The routing table information on device C is as follows (only key information is displayed):

```
DeviceC> enable
DeviceC# show ip pim sparse-mode mroute
IP Multicast Routing Table

(* ,*,RP) Entries: 0
(*,G) Entries: 2
(S,G) Entries: 2
(S,G,rpt) Entries: 2
FCR Entries: 0
REG Entries: 0

(* , 224.0.1.1)
RP: 50.50.50.50
RPF nbr: 0.0.0.0
RPF idx: None
Upstream State: JOINED
FCR:

(10.100.1.2, 224.0.1.1)
RPF nbr: 10.100.3.2
RPF idx: GigabitEthernet 0/21
SPT bit: 1
Upstream State: JOINED
jt_timer expires in 15 seconds
kat expires in 203 seconds
```

```

(10.100.1.2, 224.0.1.1, rpt)
RP: 50.50.50.50
RPF nbr: 0.0.0.0
RPF idx: None
Upstream State: PRUNED

(*, 225.0.0.1)
RP: 50.50.50.50
RPF nbr: 0.0.0.0
RPF idx: None
Upstream State: JOINED
FCR:

(10.100.1.2, 225.0.0.1)
RPF nbr: 10.100.3.2
RPF idx: GigabitEthernet 0/21
SPT bit: 1
Upstream State: JOINED
jt_timer expires in 23 seconds
kat expires in 176 seconds

(10.100.1.2, 225.0.0.1, rpt)
RP: 50.50.50.50
RPF nbr: 0.0.0.0
RPF idx: None
Upstream State: PRUNED

DeviceC#

```

The routing table information on device E is as follows (only key information is displayed):

```

DeviceE> enable
DeviceE# show ip pim sparse-mode mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 1
(S,G) Entries: 0
(S,G,rpt) Entries: 0
FCR Entries: 1
REG Entries: 0

(*, 224.0.1.1)
RP: 50.50.50.50
RPF nbr: 10.100.4.1
RPF idx: GigabitEthernet 0/7
Upstream State: JOINED

```

```
jt_timer expires in 34 seconds
FCR:
Source: 10.100.1.2
KAT timer running, 156 seconds remaining
  Packet count 1

DeviceE#
```

6. Configuration Files

- Device A configuration file

```
hostname DeviceA
!
ip multicast-routing
!
interface GigabitEthernet 0/1
  no switchport
  ip address 10.100.1.1 255.255.255.0
  ip pim sparse-mode
  ip pim bsr-border
!
interface GigabitEthernet 0/21
  no switchport
  ip address 10.100.1.1 255.255.255.0
  ip pim sparse-mode
!
interface GigabitEthernet 0/23
  no switchport
  ip address 10.100.3.2 255.255.255.0
  ip pim sparse-mode
!
interface GigabitEthernet 0/24
  no switchport
  ip address 10.100.2.1 255.255.255.0
  ip pim sparse-mode
!
router ospf 49
  graceful-restart
  network 10.100.1.0 0.0.0.255 area 0
  network 10.100.2.0 0.0.0.255 area 0
  network 10.100.3.0 0.0.0.255 area 0
  network 10.100.10.0 0.0.0.255 area 0
!
ip pim rp-address 50.50.50.50
!
```

- Device B configuration file


```
hostname DeviceB
!
ip access-list standard 49
 20 permit 224.0.0.0 0.255.255.255
!
ip multicast-routing
!
interface GigabitEthernet 0/30
 no switchport
 ip address 10.100.8.1 255.255.255.0
 ip pim sparse-mode
!
interface GigabitEthernet 0/31
 no switchport
 ip address 10.100.2.2 255.255.255.0
 ip pim sparse-mode
!
interface GigabitEthernet 0/32
 no switchport
 ip address 10.100.5.2 255.255.255.0
 ip pim sparse-mode
!
interface Loopback 49
 ip address 49.49.49.49 255.255.255.255
 ip pim sparse-mode
!
router ospf 49
 graceful-restart
 network 10.100.2.0 0.0.0.255 area 0
 network 10.100.5.0 0.0.0.255 area 0
 network 10.100.8.0 0.0.0.255 area 0
 network 49.49.49.49 0.0.0.0 area 0
!
ip pim rp-address 50.50.50.50
ip pim bsr-candidate Loopback 49
ip pim rp-candidate Loopback 49 group-list 49
!
```

- Device C configuration file

```
hostname DeviceC
!
ip access-list standard 50
 10 permit 225.0.0.0 0.255.255.255
!
ip multicast-routing
!
interface GigabitEthernet 0/19
```

```
no switchport
ip address 10.100.6.1 255.255.255.0
ip pim sparse-mode
!
interface GigabitEthernet 0/20
no switchport
ip address 10.100.5.1 255.255.255.0
ip pim sparse-mode
!
interface GigabitEthernet 0/21
no switchport
ip address 10.100.3.1 255.255.255.0
ip pim sparse-mode
!
interface GigabitEthernet 0/22
no switchport
ip address 10.100.4.1 255.255.255.0
ip pim sparse-mode
!
interface Loopback 50
ip address 50.50.50.50 255.255.255.255
ip pim sparse-mode
!
router ospf 49
 graceful-restart
 network 10.100.3.0 0.0.0.255 area 0
 network 10.100.4.0 0.0.0.255 area 0
 network 10.100.5.0 0.0.0.255 area 0
 network 10.100.6.0 0.0.0.255 area 0
 network 50.50.50.50 0.0.0.0 area 0
!
ip pim rp-address 50.50.50.50
ip pim bsr-candidate Loopback 50
ip pim rp-candidate Loopback 50 group-list 50
!
```

- Device D configuration file

```
hostname DeviceD
!
ip multicast-routing
!
interface GigabitEthernet 0/6
no switchport
ip address 10.100.7.1 255.255.255.0
ip pim sparse-mode
!
interface GigabitEthernet 0/7
```

```
no switchport
ip address 10.100.6.2 255.255.255.0
ip pim sparse-mode
!
router ospf 49
 graceful-restart
 network 10.100.6.0 0.0.0.255 area 0
 network 10.100.7.0 0.0.0.255 area 0
!
ip pim rp-address 50.50.50.50
!
```

- Device E configuration file

```
hostname DeviceE
!
ip multicast-routing
!
interface GigabitEthernet 0/6
 no switchport
 ip address 10.100.9.1 255.255.255.0
 ip pim sparse-mode
!
interface GigabitEthernet 0/7
 no switchport
 ip address 10.100.4.2 255.255.255.0
 ip pim sparse-mode
!
router ospf 49
 graceful-restart
 network 10.100.4.0 0.0.0.255 area 0
 network 10.100.9.0 0.0.0.255 area 0
!
ip pim rp-address 50.50.50.50
!
```

7. Common Errors

- The multicast routing function is not enabled on multicast devices.
- The multicast function is not enabled on any interface.
- No BSR border is configured between PIM-SM domains.
- No RP is configured.
- No static RP is configured on a multicast device, or the configured static RP on this multicast device is not consistent with the configuration on other multicast devices.
- C-RPs are configured, but no C-BSR is configured.
- Static RP, C-RP or C-BSR is unreachable via unicast routes.

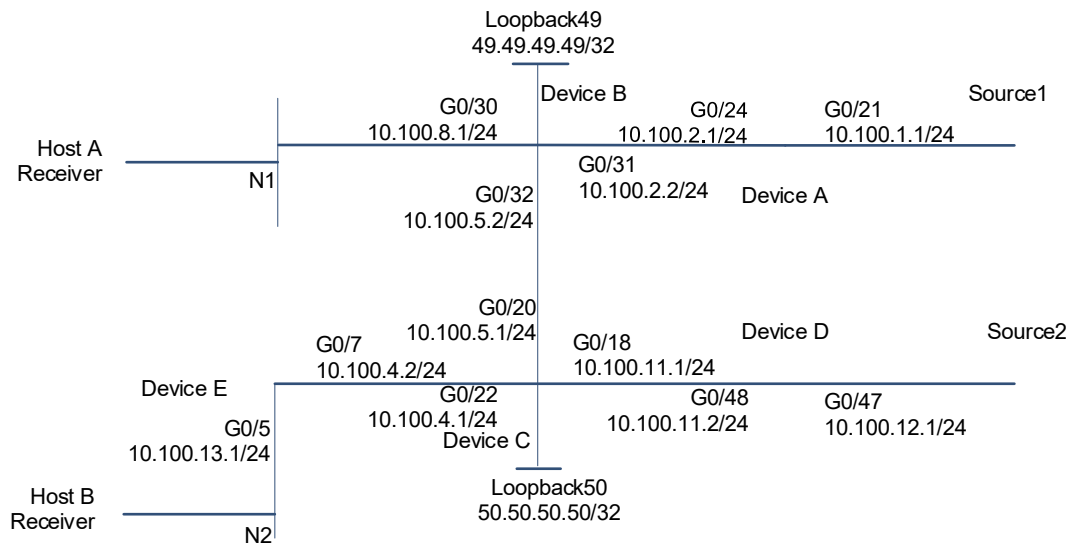
1.14.2 Configuring Basic Functions of PIM-SM in the SSM Model

1. Requirements

As shown in [Figure 1-1](#), the PIM-SM protocol is enabled on multicast devices to provide SSM services for hosts in N1 and N2 so that the hosts can receive multicast data from specified multicast sources to the multicast group that the hosts join, for example, video-on-demand.

2. Topology

Figure 1-1 PIM-SM Multicast Network Topology in the SSM Model



3. Notes

- Configure IP addresses and unicast routing protocols for multicast devices. The PIM routing protocol in a multicast domain depends on unicast routing protocols. Normal communication of unicast routing lays a foundation of multicast routing. Ensure that each PIM node is reachable via unicast routes.
- Enable the multicast function on all multicast devices. Enabling the multicast function is a prerequisite of PIM-SM configuration.
- Enable the basic functions of PIM-SM on all interfaces of the multicast devices. The other functions of PIM-SM can be enabled only after the basic functions of PIM-SM are enabled.
- Enable the IGMP function on the interface connected to hosts and set the IGMP version to v3 so that the hosts can join or leave a multicast group by sending IGMP messages based on the specified source. The multicast devices acting as leaf nodes maintain group membership based on the IGMP protocol.
- Configure the same address range of SSM on all multicast devices. The SSM services provided by the multicast devices in the PIM-SM domain are dedicated to specified groups, which realizes multicast controllability.

4. Procedure

- (1) Configure IP addresses and enable unicast routing protocols on interfaces of different devices.
Configure IP addresses and enable unicast routing protocols on interfaces of 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)# ip address 10.100.1.1 255.255.255.0
DeviceA(config-if-GigabitEthernet 0/21)# exit
DeviceA(config)# interface GigabitEthernet 0/24
DeviceA(config-if-GigabitEthernet 0/24)# no switchport
DeviceA(config-if-GigabitEthernet 0/24)# ip address 10.100.2.1 255.255.255.0
DeviceA(config-if-GigabitEthernet 0/24)# exit
DeviceA(config)# router ospf 49
DeviceA(config-router)# network 10.100.1.0 0.0.0.255 area 0
DeviceA(config-router)# network 10.100.2.0 0.0.0.255 area 0
DeviceA(config-router)# exit
```

Configure IP addresses and enable unicast routing protocols on interfaces of 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)# ip address 10.100.8.1 255.255.255.0
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)# ip address 10.100.2.2 255.255.255.0
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)# ip address 10.100.5.2 255.255.255.0
DeviceB(config-if-GigabitEthernet 0/32)# exit
DeviceB(config)# interface Loopback 49
DeviceB(config-if-Loopback 49)# ip address 49.49.49.49 255.255.255.255
DeviceB(config-if-Loopback 49)# exit
DeviceB(config)# router ospf 49
DeviceB(config-router)# network 10.100.2.0 0.0.0.255 area 0
DeviceB(config-router)# network 10.100.5.0 0.0.0.255 area 0
DeviceB(config-router)# network 10.100.8.0 0.0.0.255 area 0
DeviceB(config-router)# network 49.49.49.49 0.0.0.0 area 0
DeviceB(config-router)# exit
```

Configure IP addresses and enable unicast routing protocols on interfaces of device C.

```
DeviceC> enable
DeviceC# config terminal
DeviceC(config)# interface GigabitEthernet 0/18
DeviceC(config-if-GigabitEthernet 0/18)# no switchport
DeviceC(config-if-GigabitEthernet 0/18)# ip address 10.100.11.1 255.255.255.0
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)# ip address 10.100.5.1 255.255.255.0
DeviceC(config-if-GigabitEthernet 0/20)# exit
DeviceC(config)# interface GigabitEthernet 0/22
DeviceC(config-if-GigabitEthernet 0/22)# no switchport
DeviceC(config-if-GigabitEthernet 0/22)# ip address 10.100.4.1 255.255.255.0
DeviceC(config-if-GigabitEthernet 0/22)# exit
DeviceC(config)# interface Loopback 50
DeviceC(config-if-Loopback 50)# ip address 50.50.50.50 255.255.255.255
DeviceC(config-if-Loopback 50)# exit
DeviceC(config)# router ospf 49
DeviceC(config-router)# network 10.100.4.0 0.0.0.255 area 0
DeviceC(config-router)# network 10.100.5.0 0.0.0.255 area 0
DeviceC(config-router)# network 10.100.11.0 0.0.0.255 area 0
DeviceC(config-router)# network 50.50.50.50 0.0.0.0 area 0
DeviceC(config-router)# exit
```

Configure IP addresses and enable unicast routing protocols on interfaces of device D.

```
DeviceD> enable
DeviceD# config terminal
DeviceD(config)# interface GigabitEthernet 0/47
DeviceD(config-if-GigabitEthernet 0/47)# no switchport
DeviceD(config-if-GigabitEthernet 0/47)# ip address 10.100.12.1 255.255.255.0
DeviceD(config-if-GigabitEthernet 0/47)# exit
DeviceD(config)# interface GigabitEthernet 0/48
DeviceD(config-if-GigabitEthernet 0/48)# no switchport
DeviceD(config-if-GigabitEthernet 0/48)# ip address 10.100.11.2 255.255.255.0
DeviceD(config-if-GigabitEthernet 0/48)# exit
DeviceD(config)# router ospf 49
DeviceD(config-router)# network 10.100.11.0 0.0.0.255 area 0
DeviceD(config-router)# network 10.100.12.0 0.0.0.255 area 0
DeviceD(config-router)# exit
DeviceD(config)# router ospf 49
DeviceD(config-router)# network 10.100.11.0 0.0.0.255 area 0
DeviceD(config-router)# network 10.100.12.0 0.0.0.255 area 0
DeviceD(config-router)# exit
```

Configure IP addresses and enable unicast routing protocols on interfaces of device E.

```
DeviceE> enable
DeviceE# config terminal
DeviceE(config)# interface GigabitEthernet 0/5
DeviceE(config-if-GigabitEthernet 0/5)# no switchport
DeviceE(config-if-GigabitEthernet 0/5)# ip address 10.100.13.1 255.255.255.0
DeviceE(config-if-GigabitEthernet 0/5)# exit
DeviceE(config)# interface GigabitEthernet 0/7
DeviceE(config-if-GigabitEthernet 0/7)# no switchport
```

```
DeviceE(config-if-GigabitEthernet 0/7)# ip address 10.100.4.2 255.255.255.0
DeviceE(config-if-GigabitEthernet 0/7)# exit
DeviceE(config)# router ospf 49
DeviceE(config-router)# network 10.100.4.0 0.0.0.255 area 0
DeviceE(config-router)# network 10.100.13.0 0.0.0.255 area 0
DeviceE(config-router)# exit
```

- (2) Enable the multicast and PIM-SM functions on all multicast devices, and enable the IGMP function on all multicast devices connected to hosts.

Enable the multicast and PIM-SM functions on device A.

```
DeviceA(config)# ip multicast-routing
DeviceA(config)# interface GigabitEthernet 0/21
DeviceA(config-if-GigabitEthernet 0/21)# ip pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/21)# exit
DeviceA(config)# interface GigabitEthernet 0/24
DeviceA(config-if-GigabitEthernet 0/24)# ip pim sparse-mode
DeviceA(config-if-GigabitEthernet 0/24)# exit
```

Enable the multicast, PIM-SM, and IGMP functions on device B, and set the IGMP version to v3.

```
DeviceB(config)# ip multicast-routing
DeviceB(config)# interface GigabitEthernet 0/30
DeviceB(config-if-GigabitEthernet 0/30)# ip pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/30)# ip igmp version 3
DeviceB(config-if-GigabitEthernet 0/30)# exit
DeviceB(config)# interface GigabitEthernet 0/31
DeviceB(config-if-GigabitEthernet 0/31)# ip pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/31)# exit
DeviceB(config)# interface GigabitEthernet 0/32
DeviceB(config-if-GigabitEthernet 0/32)# ip pim sparse-mode
DeviceB(config-if-GigabitEthernet 0/32)# exit
DeviceB(config)# interface Loopback 49
DeviceB(config-if-Loopback 49)# ip pim sparse-mode
DeviceB(config-if-Loopback 49)# exit
```

Enable the multicast and PIM-SM functions on device C.

```
DeviceC(config)# ip multicast-routing
DeviceC(config)# interface GigabitEthernet 0/18
DeviceC(config-if-GigabitEthernet 0/18)# ip pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/18)# exit
DeviceC(config)# interface GigabitEthernet 0/20
DeviceC(config-if-GigabitEthernet 0/20)# ip pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/20)# exit
DeviceC(config)# interface GigabitEthernet 0/22
DeviceC(config-if-GigabitEthernet 0/22)# ip pim sparse-mode
DeviceC(config-if-GigabitEthernet 0/22)# exit
DeviceC(config)# interface Loopback 50
DeviceC(config-if-Loopback 50)# ip pim sparse-mode
```

```
DeviceC(config-if-Loopback 50)# exit
```

Enable the multicast and PIM-SM functions on device D.

```
DeviceD(config)# ip multicast-routing
DeviceD(config)# interface GigabitEthernet 0/47
DeviceD(config-if-GigabitEthernet 0/47)# ip pim sparse-mode
DeviceD(config-if-GigabitEthernet 0/47)# exit
DeviceD(config)# interface GigabitEthernet 0/48
DeviceD(config-if-GigabitEthernet 0/48)# ip pim sparse-mode
DeviceD(config-if-GigabitEthernet 0/48)# exit
```

Enable the multicast, PIM-SM, and IGMP functions on device E, and set the IGMP version to v3.

```
DeviceE(config)# ip multicast-routing
DeviceE(config)# interface GigabitEthernet 0/5
DeviceE(config-if-GigabitEthernet 0/5)# ip pim sparse-mode
DeviceE(config-if-GigabitEthernet 0/5)# ip igmp version 3
DeviceE(config-if-GigabitEthernet 0/5)# exit
DeviceE(config)# interface GigabitEthernet 0/7
DeviceE(config-if-GigabitEthernet 0/7)# ip pim sparse-mode
DeviceE(config-if-GigabitEthernet 0/7)# exit
```

- (3) Enable the SSM function and configure an address range of multicast groups on all multicast devices.

Set the address range of an SSM multicast group to 232.1.1.0/24 on device A.

```
DeviceA(config)# ip access-list standard 59
DeviceA(config-std-nacl)#permit 232.1.1.0 0.0.0.255
DeviceA(config-std-nacl)#exit
DeviceA(config)# ip pim ssm range 59
```

Set the address range of an SSM multicast group to 232.1.1.0/24 on device B.

```
DeviceB(config)# ip access-list standard 59
DeviceB(config-std-nacl)#permit 232.1.1.0 0.0.0.255
DeviceB(config-std-nacl)#exit
DeviceB(config)# ip pim ssm range 59
```

Set the address range of an SSM multicast group to 232.1.1.0/24 on device C.

```
DeviceC(config)# ip access-list standard 59
DeviceC(config-std-nacl)#permit 232.1.1.0 0.0.0.255
DeviceC(config-std-nacl)#exit
DeviceC(config)# ip pim ssm range 59
```

Set the address range of an SSM multicast group to 232.1.1.0/24 on device D.

```
DeviceD(config)# ip access-list standard 59
DeviceD(config-std-nacl)#permit 232.1.1.0 0.0.0.255
DeviceD(config-std-nacl)#exit
DeviceD(config)# ip pim ssm range 59
```

Set the address range of an SSM multicast group to 232.1.1.0/24 on device E.

```
DeviceE(config)# ip access-list standard 59
DeviceE(config-std-nacl)#permit 232.1.1.0 0.0.0.255
```



```
DeviceE(config-std-nacl)#exit
DeviceE(config)# ip pim ssm range 59
```

5. Verification

- (1) Run the **show ip pim sparse-mode interface** command to display PIM-SM running information on the interfaces. The PIM-SM running information on the interfaces of device A is as follows. The PIM-SM running information on the interfaces of devices B, C, D, and E is the same.

```
DeviceA> enable
DeviceA# show ip pim sparse-mode interface
Address          Interface          VIFindex Ver/Mode
Nbr-Count DR-Prior DR
10.100.1.1       GigabitEthernet 0/21           3         v2/S      0
1                10.100.1.1
10.100.2.1       GigabitEthernet 0/24           1         v2/S      0
1                10.100.2.1
DeviceA#
```

- (2) Run the **show ip pim sparse-mode mroute** command to display the multicast routing tables of PIM-SM. Host A needs to receive packets sent from source 1 (10.100.1.2/24) and source 2 (10.100.12.2/24) to the multicast group (232.1.1.10/24). Host B needs to receive packets sent from source 1 (10.100.1.2/24) to the multicast group (232.1.1.10/24). The information output is as follows:

The routing table information on device A is as follows:

```
DeviceA> enable
DeviceA# show ip pim sparse-mode mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 0
(S,G) Entries: 1
(S,G,rpt) Entries: 0
FCR Entries: 0
REG Entries: 0

(10.100.1.2, 232.1.1.10)
RPF nbr: 0.0.0.0
RPF idx: None
SPT bit: 1
Upstream State: JOINED
kat expires in 133 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
0 . . . . .
. . . . .
1 . . . . .
. . . . .
```



```

7 . . . . .
. . . . .
Outgoing
0 . . . . .
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

DeviceA#
    
```

The routing table information on device B is as follows:

```

DeviceB> enable
DeviceB# show ip pim sparse-mode mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 0
(S,G) Entries: 2
(S,G,rpt) Entries: 0
FCR Entries: 0
REG Entries: 0

(10.100.1.2, 232.1.1.10)
RPF nbr: 10.100.2.1
RPF idx: GigabitEthernet 0/31
SPT bit: 1
Upstream State: JOINED
jt_timer expires in 40 seconds
kat expires in 190 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
    
```



```
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Outgoing
0 . . o .
o . . . . .
. .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

(10.100.12.2, 232.1.1.10)
RPF nbr: 10.100.5.1
RPF idx: GigabitEthernet 0/32
SPT bit: 1
Upstream State: JOINED
jt_timer expires in 40 seconds
kat expires in 125 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
0 . . . . .
i . . . . .
. .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
```



```
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

DeviceB#
```

The routing table information on device C is as follows:

```
DeviceC> enable
DeviceC# show ip pim sparse-mode mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 0
(S,G) Entries: 2
(S,G,rpt) Entries: 0
FCR Entries: 0
REG Entries: 0

(10.100.1.2, 232.1.1.10)
RPF nbr: 10.100.5.2
RPF idx: GigabitEthernet 0/20
SPT bit: 1
Upstream State: JOINED
jt_timer expires in 12 seconds
kat expires in 72 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
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
```



```
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

(10.100.12.2, 232.1.1.10)
RPF nbr: 10.100.11.2
RPF idx: GigabitEthernet 0/18
SPT bit: 1
Upstream State: JOINED
jt_timer expires in 8 seconds
kat expires in 98 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
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Joined
0 . . . . .
j . . . . .
. . . . .
```



```
6 . . . . .
. . . . .
7 . . . . .
. . . . .
DeviceC#
```

The routing table information on device D is as follows:

```
DeviceD> enable
DeviceD# show ip pim sparse-mode mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 0
(S,G) Entries: 1
(S,G,rpt) Entries: 0
FCR Entries: 0
REG Entries: 0

(10.100.12.2, 232.1.1.10)
RPF nbr: 0.0.0.0
RPF idx: None
SPT bit: 1
Upstream State: JOINED
kat expires in 62 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
0 . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .
Joined
```



```

5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

DeviceD#
    
```

The routing table information on device E is as follows:

```

DeviceE> enable
DeviceE# show ip pim sparse-mode mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 0
(S,G) Entries: 1
(S,G,rpt) Entries: 0
FCR Entries: 0
REG Entries: 0

(10.100.1.2, 232.1.1.10)
RPF nbr: 10.100.4.1
RPF idx: GigabitEthernet 0/7
SPT bit: 1
Upstream State: JOINED
jt_timer expires in 39 seconds
kat expires in 189 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
0 .
i . . . . .
. . . . .
1 . . . . .
. . . . .
2 . . . . .
. . . . .
3 . . . . .
. . . . .
4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
    
```



```

4 . . . . .
. . . . .
5 . . . . .
. . . . .
6 . . . . .
. . . . .
7 . . . . .
. . . . .

DeviceE#

```

6. Configuration Files

- Device A configuration file

```

hostname DeviceA
!
ip access-list standard 59
 10 permit 232.1.1.0 0.0.0.255
!
ip multicast-routing
!
interface GigabitEthernet 0/21
 no switchport
 ip address 10.100.1.1 255.255.255.0
 ip pim sparse-mode
!
interface GigabitEthernet 0/24
 no switchport
 ip address 10.100.2.1 255.255.255.0
 ip pim sparse-mode
!
router ospf 49
 graceful-restart
 network 10.100.1.0 0.0.0.255 area 0
 network 10.100.2.0 0.0.0.255 area 0
!
ip pim ssm range 59
!

```

- Device B configuration file

```

hostname DeviceB
!
ip access-list standard 59
 10 permit 232.1.1.0 0.0.0.255
!
ip multicast-routing
!

```

```
interface GigabitEthernet 0/30
 no switchport
 ip address 10.100.8.1 255.255.255.0
 ip igmp version 3
 ip pim sparse-mode
!
interface GigabitEthernet 0/31
 no switchport
 ip address 10.100.2.2 255.255.255.0
 ip pim sparse-mode
!
interface GigabitEthernet 0/32
 no switchport
 ip address 10.100.5.2 255.255.255.0
 ip pim sparse-mode
!
interface Loopback 49
 ip address 49.49.49.49 255.255.255.255
 ip pim sparse-mode
!
router ospf 49
 graceful-restart
 network 10.100.2.0 0.0.0.255 area 0
 network 10.100.5.0 0.0.0.255 area 0
 network 10.100.8.0 0.0.0.255 area 0
 network 49.49.49.49 0.0.0.0 area 0
!
ip pim ssm range 59
!
```

- Device C configuration file

```
hostname DeviceC
!
ip access-list standard 59
 10 permit 232.1.1.0 0.0.0.255
!
ip multicast-routing
!
interface GigabitEthernet 0/18
 no switchport
 ip address 10.100.11.1 255.255.255.0
 ip pim sparse-mode
!
interface GigabitEthernet 0/20
 no switchport
 ip address 10.100.5.1 255.255.255.0
 ip pim sparse-mode
```



```
!  
interface GigabitEthernet 0/22  
  no switchport  
  ip address 10.100.4.1 255.255.255.0  
  ip pim sparse-mode  
!  
interface Loopback 50  
  ip address 50.50.50.50 255.255.255.255  
ip pim sparse-mode  
!  
router ospf 49  
  graceful-restart  
  network 10.100.4.0 0.0.0.255 area 0  
  network 10.100.5.0 0.0.0.255 area 0  
  network 10.100.11.0 0.0.0.255 area 0  
  network 50.50.50.50 0.0.0.0 area 0  
!  
ip pim ssm range 59  
!
```

- Device D configuration file

```
hostname DeviceD  
!  
ip access-list standard 59  
  10 permit 232.1.1.0 0.0.0.255  
!  
ip multicast-routing  
!  
interface GigabitEthernet 0/47  
  no switchport  
  ip address 10.100.12.1 255.255.255.0  
ip pim sparse-mode  
!  
interface GigabitEthernet 0/48  
  no switchport  
  ip address 10.100.11.2 255.255.255.0  
  ip pim sparse-mode  
!  
router ospf 49  
  graceful-restart  
  network 10.100.11.0 0.0.0.255 area 0  
  network 10.100.12.0 0.0.0.255 area 0  
!  
ip pim ssm range 59  
!
```

- Device E configuration file

```
hostname DeviceE
!
ip access-list standard 59
 10 permit 232.1.1.0 0.0.0.255
!
ip multicast-routing
!
interface GigabitEthernet 0/5
 no switchport
 ip address 10.100.13.1 255.255.255.0
 ip igmp version 3
 ip pim sparse-mode
!
interface GigabitEthernet 0/7
 no switchport
 ip address 10.100.4.2 255.255.255.0
 ip pim sparse-mode
!
router ospf 49
 graceful-restart
 network 10.100.4.0 0.0.0.255 area 0
 network 10.100.13.0 0.0.0.255 area 0
!
ip pim ssm range 59
!
```

7. Common Errors

- An IPv4 unicast route is incorrectly configured.
- IPv4 multicast routing is not enabled on a multicast device.
- The SSM function is not enabled on a multicast device, or the SSM group address range on this multicast device is not consistent with the configuration on other multicast devices.
- The PIM-SM function is not enabled on an interface, for example, the gateway interface connecting to hosts or a multicast source.
- IGMPv3 is not enabled on an interface connected to hosts.