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1 Configuring PIM-DM

1.1 Introduction

1.1.1 Overview

In multicast packet transmission, devices need to run multicast routing protocols to control multicast packet forwarding. A multicast network can be composed of multiple domains. The most typical multicast routing protocol is Protocol Independent Multicast (PIM). Based on implementation mechanism, PIM is categorized into Protocol Independent Multicast-Dense Mode (PIM-DM) and Protocol Independent Multicast-Sparse Mode (PIM-SM).

PIM-DM runs on multicast devices and is used to discover and maintain multicast routing information and determine a forwarding route of multicast packets.

Compared with PIM-SM, PIM-DM applies to small networks where multicast group members densely reside. Ideally, multicast group members on every path need to receive packets in the PIM network, and each forwarding node pushes and distributes the multicast packets in the entire network.

1.1.2 PIM-DM Network Deployment

Figure 1-1   PIM-DM Deployment Topology
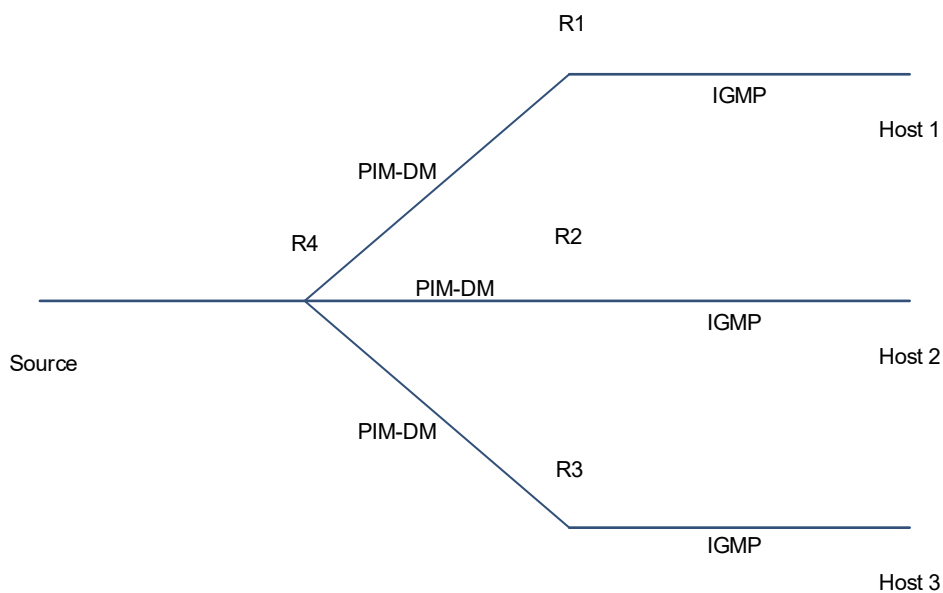
As shown in Figure 1-1, when a multicast device is connected to other multicast devices, PIM must be deployed on this multicast device. Here, PIM-DM is deployed.

1.1.3 Principles

The basic principles of PIM-DM are as follows:

(1) Assume that all paths in a network have multicast group members and the multicast source sends multicast packets throughout the entire network.

(2) The entire path can be considered a tree with the source as the root node and group members as leaf nodes. This tree is the shortest path tree (SPT). Initially, some leaf nodes are not group members and they must be pruned to get a correct tree structure.

(3) If a new host joins the tree or an existing node leaves the tree, the tree structure must be readjusted. Multicast packets are forwarded on the paths of this tree, and the forwarding path is the shortest path from the source to the group members.

The working mechanisms of PIM-DM include neighbor creation, flooding, pruning, state refresh, graft, and assertion.

1. Neighbor Creation

Neighbors are the basis of PIM-DM. Neighbor relationships must be created between PIM routers before PIM control messages can be exchanged or multicast packets can be forwarded.

Neighbor creation is implemented based on the hello messages sent by the PIM interfaces and is composed of neighbor discovery, protocol parameter negotiation, and neighbor relationship maintenance.

● Discover neighbors

A PIM interface periodically sends hello messages with the destination address being 224.0.0.13 (ff02::d for IPv6), source address being the IP address of the interface, and time to live (TTL) value being **1**. PIM routers in the same network segment receive the packets with the destination address 224.0.0.13 (ff02::d for IPv6). In this way, the PIM routers obtain neighbor information and create neighbor relationships.

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

Protocol parameters are negotiated by hello messages. The key parameters are described as follows:

○ **DR_Priority**: The priority of a router for designated router (DR) election. The router with a higher priority is selected.

○ **Holdtime**: The neighbor is considered reachable within the hold time.

○ **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 upstream devices.

○ **Override-Interval**: The interval to override the prune.

● Maintain neighbor relationship

A hello message is sent periodically between PIM routers. If a hello message is not received from a PIM neighbor within the hold time, the neighbor is considered unreachable and is deleted from the neighbor list. Any change of PIM neighbors will cause change of the multicast topology in the network. If an upstream or a downstream neighbor in a multicast distribution tree (MDT) is unreachable, multicast routes converge again and the MDT is reshaped.

2. Flooding

Multicast packets flooded to an entire network from a source is referred to flooding. Flooding enables all nodes in a network to receive these packets.

Multicast devices check reverse path forwarding (RPF) in the packets. If the checking fails, the packets are discarded. If the checking is passed and an outbound interface is detected, the multicast packets are forwarded through the outbound interface. This enables all node members in the network to receive these multicast packets.

3. **Pruning**

If no group member exists on a path branch, the path branch is pruned. This enables packets to be forwarded to paths with group members available.

(1) Multicast devices check RPF in the packets. If the checking is passed but no outbound interface exists, no group member exists on this path. A prune packet is sent to the upstream device.

(2) Upon receiving the prune packet, the upstream device marks the packet sending interface as pruned and sets a prune state timer.

(3) After all unnecessary paths are pruned, the remaining paths are necessary and they form an SPT.

● Prune override

After a PIM router sends a prune packet to the upstream device, the PIM router does not prune the downstream path immediately. If the downstream device has multicast requirements, it can send a prune override message to the PIM router to override the prune.

If the PIM router receives a prune override message from the downstream device in the prune-pending timer (PPT), the PIM router cancels pruning. PPT = Propagation delay + Override interval

4. **State Refresh**

A prune state timer is maintained on a device during pruning. When the timer times out, the device continues to forward packets. PIM-DM refreshes the timer state using a state refresh message (SRM) to avoid unnecessary prune state changes.

The multicast device nearest to the source periodically sends the SRM to the downstream devices. Upon receiving the SRM, the downstream devices add the local topology state information to the SRM by modifying some fields in the SRM, and continue to forward the SRM to downstream devices. Finally, the SRM arrives leaf devices and the states of all devices in the network get updated.

5. **Graft**

If a group member sends data to a group corresponding to a path being pruned, the path must be restored to the forwarding state. This is referred to as graft.

(1) When a group member sends data to a group corresponding to a path being pruned, the other devices on this path receive the join message and send a graft packet to the upstream device to apply for joining the SPT.

(2) Upon receiving the graft packet, the upstream device replies a Graft-Ack packet and starts to forward multicast packets to the downstream devices on this path.

(3) The downstream devices receive the Graft-Ack packet. If the downstream devices do not receive the Graft-Ack packet, they send the graft packet again and again until they receive the Graft-Ack packet.

6. Assertion

In a network segment where multiple PIM routers reside, the same multicast packet may be transmitted to the routers in the network segment multiple times. In this case, a special PIM router can be specified to forward multicast packets and avoid duplicate forwarding. This is referred to as assertion.

1.1.4 PIM-DM and MIB

Connected to other agents, the Simple Network Management Protocol (SNMP) manager uses information in the Management Information Base (MIB) to directly manage the PIM-DM function.

The MIB specifies variables (namely information that can be queried and set by the management process) maintained by network elements and directly manages the PIM-DM function.

1.1.5 Protocols and Standards

- RFC3973: Protocol Independent Multicast - Dense Mode (PIM-DM)
- RFC2715: Interoperability Rules for Multicast Routing Protocols

1.2 Restrictions and Guidelines

- If PIM-DM neighbor relationships between devices are created through links and downstream devices have no or few needs to receive multicast packets, the system performance is excessively consumed. In this scenario, PIM-SM is recommended for the environment deployment.
- Before PIM-DM is used, ensure that unicast routes are reachable in the network.

1.3 Configuration Task Summary

The PIM-DM configuration includes the following tasks:

(1) Configuring Basic Functions of PIM-DM

(2) (Optional) Configuring PIM-DM Passive Mode

(3) (Optional) Configuring PIM Neighbors

(4) (Optional) Configuring PIM State Refresh

(5) (Optional) Enabling the PIM-BFD Function

(6) (Optional) Enabling the MIB Function

1.4 Configuring Basic Functions of PIM-DM

1.4.1 Overview

A PIM network is created to provide IPv4 multicast services for sources and hosts in the network. Neighbor relationships must be created between PIM routers before PIM control messages can be exchanged or multicast packets can be forwarded.

1.4.2 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 multicast routing function is disabled by default.

(4) Enter the interface configuration mode.

interface *interface-type interface-number*

(5) Enable the PIM-DM function.

ip pim dense-mode

The PIM-DM function is disabled on an interface by default.

The function can be enabled on the interconnection interfaces of routers, and interfaces connecting to multicast sources and user hosts.

(6) (Optional) Enable the PIM-DM function on a super VLAN interface.

ip pim dense-mode subvlan [**all** | *subvlan-id*]

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

In most scenarios, the PIM-DM protocol is disabled by default and not needed on a super VLAN interface. This interface does not send or receive PIM packets. To enable PIM-DM to run on the super VLAN interface, specify a sub VLAN or all sub VLANs to receive packets. Note that if all sub VLANs are specified to receive packets, the transmission performance may be reduced, causing neighbor flapping.

1.5 Configuring PIM-DM Passive Mode

1.5.1 Overview

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-DM passive mode. After the PIM-SM passive mode is configured, the interface does not process PIM-DM packets.

1.5.2 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 PIM-DM passive mode on an interface.

ip pim dense-mode passive

The PIM-DM passive mode is disabled on an interface by default.

1.6 Configuring PIM Neighbors

1.6.1 Overview

PIM devices support adjustment to protocol parameters in hello messages and neighbor filtering to improve network security.

1.6.2 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) Configure PIM neighbors. The following configuration tasks are optional. Select tasks for configuration according to actual condition.

○ Configure hello message sending interval.

ip pim query-interval *query-interval*

Hello messages are sent at an interval of **30** seconds by default.

Every time when the hello message sending interval is updated, the hello message hold time value is automatically updated as 3.5 times the interval. If the product of the hello message sending interval and 3.5 is greater than 65,535, the hello message hold time value is updated as 65,535.

○ Configure propagation delay of hello messages on an interface.

ip pim propagation-delay *propagation-delay-time*

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

○ Configure prune override interval of hello messages.

ip pim override-interval *override-interval*

The default prune override interval of hello messages is **2500** ms.

○ Configure PIM neighbor filtering.

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

The neighbor filtering function is disabled on an interface by default.

Only addresses that meet ACL filtering conditions can be used as PIM neighbors of the current interface. Otherwise, the addresses filtered out cannot be neighbors.

1.7 Configuring PIM State Refresh

1.7.1 Overview

PIM devices support enabling or disabling PIM state refresh and adjusting PIM SRM sending interval.

1.7.2 Restrictions and Guidelines

- If the state refresh function is disabled, SRMs are not processed or forwarded.

- Disabling the state refresh function may cause the converged PIM-DM MDT to re-converge, which leads to unnecessary bandwidth waste and multicast routing table flapping. Therefore, you are not advised to disable this function in general conditions.

1.7.3 Procedure

(1) Enter the privileged EXEC mode.

  enable

(2) Enter the global configuration mode.

  configure terminal

(3) Enable the PIM-DM state refresh function. The following configuration tasks are optional. Select tasks for configuration according to actual condition.

  ○ Disable the PIM-DM state refresh function on an interface.

    ip pim state-refresh disable

    The PIM-DM SRMs are processed and forwarded by default.

  ○ Configure the PIM-DM SRM sending interval on an interface.

    ip pim state-refresh origination-interval *origination-interval*

    The PIM-DM SRMs are sent at an interval of **60** seconds by default.

1.8 Enabling the PIM-BFD Function

1.8.1 Overview

PIM-DM supports correlation with the bidirectional forwarding detection (BFD) function. After the PIM-BFD function is enabled on the interconnection interfaces of routers, the interfaces are used as BFD interfaces to quickly detect neighbor changes and specify a router to forward multicast packets in a specified network segment based on the assertion rule.

1.8.2 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 PIM-BFD function on an interface.

  ip pim bfd

  The PIM-BFD function is disabled on an interface by default.

1.9   Enabling the MIB Function

1.9.1 Overview

The MIB function allows PIM devices to manage PIM-DM using the elements in the MIB.

1.9.2 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Enable the MIB function to manage PIM-DM.

ip pim mib dense-mode

PIM-DM is not managed by the MIB function by default.

1.10   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 pim dense-mode track	Clears statistical information about PIM-DM protocol packets.
show ip pim dense-mode interface [*interface-type interface-number*] [**detail**]	Displays PIM-DM interface information.
show ip pim dense-mode neighbor [*interface-type interface-number*]	Displays the PIM-DM neighbor information.
show ip pim dense-mode nexthop	Displays the PIM-DM next hop information.
show ip pim dense-mode mroute [*group-or-source-address-1* [*group-or-source-address-2*]] [**summary**]	Displays information about the PIM-DM routing table.
show ip pim dense-mode track	Displays statistical information about PIM-DM protocol packets.