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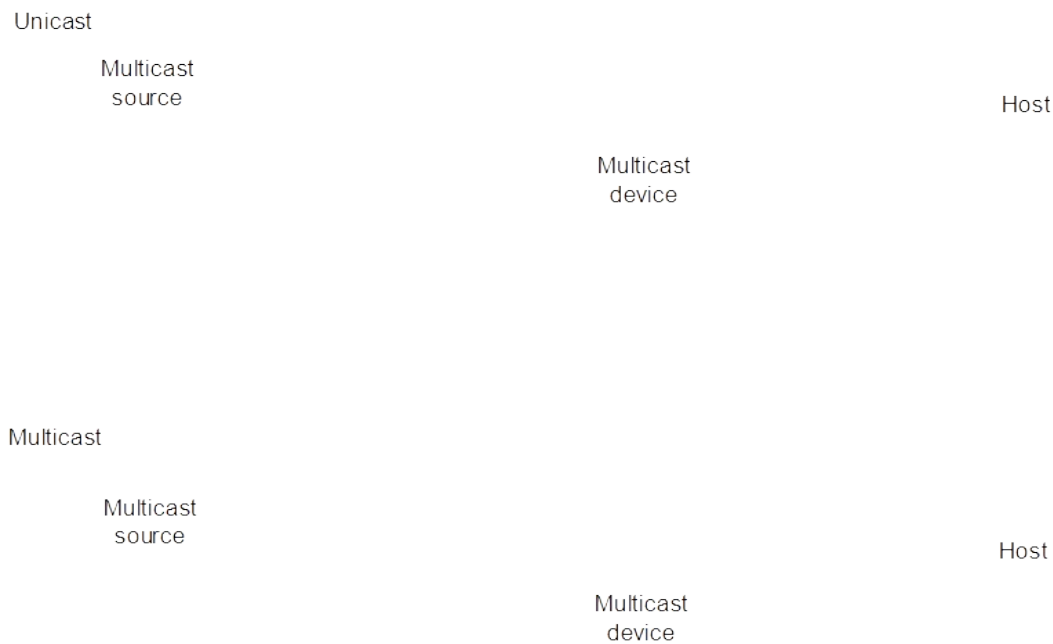
# 1 Configuring IPv4 Multicast Route Management

## 1.1 Introduction

### 1.1.1 Overview

IPv4 multicast transmits a packet from a source to multiple devices. The multicast packet is sent from the source, forwarded by intermediate devices, and then received by receivers in a specified group.

**Figure 1-1 Multicast Topology vs. Unicast Topology**



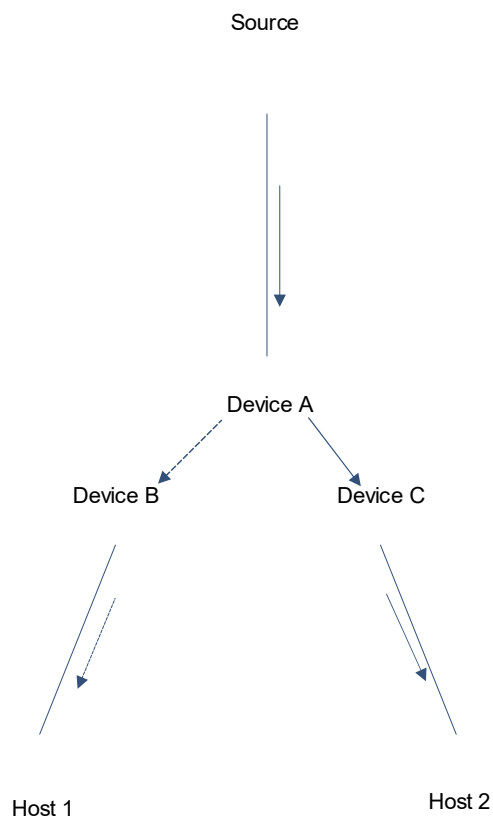
Compared with unicast, multicast reduces redundant traffic, relieves transmission loads of servers and intermediate devices, and completes one-to-multiple content transmission with high efficiency. Multicast is applied to different network services that have high requirements for real timeliness, for example, Internet TV, distance education, live broadcast and multimedia conference.

Proper multicast routes must be configured on the intermediate devices so that IPv4 multicast packets can be correctly forwarded. This chapter describes how to create and maintain IPv4 multicast routes and control multicast packet forwarding based on the multicast routes.

## 1.1.2 Basic Topology of IPv4 Multicast

Figure 1-2 shows a simple multicast topology that includes a multicast source, multicast devices (Device A, Device B, and Device C), and members in a multicast group.

**Figure 1-1 Basic Topology of IPv4 Multicast**



As shown in [Figure 1-1](#), the transmission process of a multicast packet is as follows.

- (1) The multicast source functions as a packet sender and sends a multicast packet to one or more multicast groups.
- (2) The multicast packet is forwarded by the intermediate devices to the packet receivers (members in the multicast group). The intermediate devices are routers or switches that support the multicast function and can correctly forward the multicast packet. They are referred to as multicast devices collectively.
- (3) This multicast group contains multiple members and they reside in different network segments on the network. Therefore, the multicast packet sent from the multicast source may be replicated into multiple copies by the multicast devices and then sent to the members in the multicast group.
- (4) The members in the multicast group receive the multicast packet from the source.

## 1.1.3 Basic Concepts of IPv4 Multicast

### 1. PIM

Protocol Independent Multicast (PIM) is a multicast routing protocol that provides multicast routes based on unicast static routes or unicast routing tables that are generated based on the unicast route protocols. PIM is independent from the unicast routing protocols used and can use the static routes or unicast routing tables

that are generated based on any unicast routing protocol, for example, Routing Information Protocol (RIP), Open Shortest Path First (OSPF), Intermediate System-to-Intermediate System (IS-IS), and Border Gateway Protocol (BGP).

PIM generates multicast routing entries based on the reverse path forwarding (RPF) mechanism, and controls multicast packet forwarding based on the entries. For more information about RPF, see [1.1.5 RPF Checking](#).

## 2. Multicast Routing Entry and Forwarding Entry

A multicast routing entry is generated based on multicast routing protocols. Specific routing entries vary with the routing protocols, and they are a comprehension of the routing protocol entries.

A multicast forwarding entry is used to guide multicast packet forwarding, and it is generated based on routing entry information.

## 3. Multicast Network

Numerous multicast devices constitute a multicast network, and multicast packets are transmitted between multicast sources and members in multicast groups on the network. Multicast packet query and forwarding between multicast devices are completed by running PIM. These PIM running devices are referred to as PIM routers.

PIM takes effect to device interfaces. An interface with PIM enabled is referred to as a PIM interface. A PIM interface that receives a multicast packet is an upstream interface and the interface resides in an upstream network segment. A PIM interface that sends a multicast packet is a downstream interface and the interface resides in a downstream network segment.

PIM routers are connected through PIM interfaces, which constitutes a PIM network.

## 4. Multicast Border

Data in a multicast network is not transmitted boundlessly. You can configure an access control list (ACL) on a PIM interface of a device to filter multicast packets and allow packets of specific multicast groups to pass. That is, set a border to control multicast packet transmission.

By configuring borders on PIM interfaces, you can divide a large PIM network into multiple PIM domains.

### 1.1.4 Principle of IPv4 Multicast Forwarding

To ensure correct forwarding of multicast packets by multicast devices, enable multicast routing protocols on the devices.

Upon receiving a multicast packet, a multicast device checks whether the multicast packet is valid and selects proper paths based on the forwarding table to forward the packet to one or more downstream devices. The basic process of IPv4 multicast forwarding is as follows:

- (1) A multicast device receives a multicast packet from an upstream interface.
- (2) The multicast device queries the multicast forwarding table to obtain proper forwarding paths. If no proper forwarding path is found, the multicast device performs RPF checking to determine forwarding paths and updates the multicast forwarding table.
- (3) The multicast device forwards this packet to the outbound interfaces of all the determined forwarding paths.

### 1.1.5 RPF Checking

#### 1. Basic Principles

In unicast transmission, the destination address in a packet corresponds to a specific address in a network. Provided that the destination address is determined, a network device can determine the outbound interface of the packet. In multicast transmission, a multicast address corresponds to members in a multicast group and a multicast device does not know the IP address of each member. Therefore, the receiver addresses cannot be determined based on the destination address.

RPF checking is used to determine outbound interfaces of a multicast packet. The core idea behind RPF checking is that: An RPF route is generated to check whether the theoretical destination interface of a multicast packet is consistent with the actual interface. If they are not consistent, the packet is discarded. If they are consistent, the packet is forwarded to all the determined outbound interfaces.

#### 2. RPF Checking Procedure

The RPF checking procedure consists of the following steps:

- (1) Select optimal routes.

Take the address (the source IP address in a multicast packet) of the multicast source as the destination address and select optimal routes from the local device to the destination address.

The optimal routes are selected from the unicast routing table, Multiprotocol Extensions for BGP-4 (MBGP) routing table, and multicast static routing table, respectively.

- (2) Determine an RPF route.

Select a route from the determined optimal routes of the routing tables as an RPF route based on rules. Table 1-1 lists the specific rules.

**Table 1-1 RPF Routing Rules**

Select RPF Route Based on the Longest Match	Rule Priority (a Smaller Number Indicates a Higher Priority)	Description
No	1	The route with the highest priority is selected.
	2	An RPF route is selected in the sequence of multicast static route, MBGP route, and unicast route.
Yes	1	The route with the longest match mask is selected.
	2	The route with the highest priority is selected.
	3	An RPF route is selected in the sequence of multicast static route, MBGP route, and unicast route.

An RPF route includes RPF interface information and the information is used for checking the RPF interface.

- o In a unicast route and an MBGP route, the outbound interface in a routing entry is used as an RPF interface, with the next hop being an RPF neighbor.

- In a multicast static routing entry, the RPF interface and RPF neighbor are specified.
- (3) Check the RPF interface.
- Check whether the inbound interface of the multicast packet is consistent with the RPF interface.
- If yes, the RPF interface passes the checking.
  - Otherwise, the RPF interface fails the checking.

### 1.1.6 RPF Checking and Multicast Packet Forwarding

When a multicast packet is forwarded, query a path from the forwarding table first. If no proper path is found, RPF checking is performed. Path information that is generated after RPF checking passes is updated to the forwarding table and can be queried for packet forwarding next time.

The rules of forwarding a multicast packet are as follows:

- No forwarding entry exists in a multicast forwarding table.  
RPF checking is performed for this packet. The RPF interface is used as an inbound interface and updated to the forwarding table.
  - If the RPF interface passes the checking, the packet is forwarded to all outbound interfaces.
  - If the RPF interface fails the checking, this packet is discarded.
- There are forwarding entries in a multicast forwarding table.
  - If the inbound interface of the packet matches the inbound interface in an entry, the packet is forwarded to all outbound interfaces.
  - If the inbound interface of the packet does not match the inbound interface in an entry, RPF checking is performed. If the RPF interface is consistent with the inbound interface in an entry, the packet is discarded. If the RPF interface is not consistent with the inbound interface in an entry, the inbound interface in the entry is updated as an RPF interface and the inbound interface in the packet is compared with the RPF interface to determine whether they are consistent.

## 1.2 Restrictions and Guidelines

- All the configuration items must be configured after the basic functions of IPv4 multicast are configured.
- The multicast routing function is implemented based on unicast routes. Before applying the multicast function, ensure that the unicast communication between network nodes is normal.

## 1.3 Configuration Task Summary

IPv4 multicast route management configuration includes the following tasks:

- (1) [Configuring Basic Functions of IPv4 Multicast](#)
- (2) (Optional) Configuring a packet forwarding rule. The following configuration tasks are optional. Select tasks for configuration according to actual condition.
  - [Configuring RPF Route Selection Based on the Longest Match Rule](#)
  - [Configuring Static Routes of IPv4 Multicast](#)
  - [Configuring IPv4 Multicast Borders](#)



- [Configuring L2 Direction Control for Multicast Streams](#)
  - [Configuring TTL Threshold](#)
  - [Configuring Forced Forwarding of Multicast Packets by Software](#)
- (3) (Optional) Configuring multicast entries. The following configuration tasks are optional. Select tasks for configuration according to actual condition.
- [Configuring Entry Capacity of IPv4 Multicast Routing Table](#)
  - [Configuring the Overwriting Mechanism upon Overflow of Multicast Hardware Forwarding Entries](#)
- (4) (Optional) [Configuring Multicast Non-Stop Forwarding Parameters](#)

## 1.4 Configuring Basic Functions of IPv4 Multicast

### 1.4.1 Overview

To configure basic functions of IPv4 multicast, enable the IPv4 multicast routing function and the IPv4 multicast protocols on a device so that the device has the multicast packet forwarding function and can provide IPv4 multicast services for multicast sources and hosts in multicast groups.

### 1.4.2 Restrictions and Guidelines

- The IPv4 multicast routing function should be enabled on each router unless otherwise specified.
- IPv4 unicast routes must be configured so that PIM can use the unicast routes to generate multicast routes.
- After L3 multicast is enabled for a private virtual local area network (PVLAN) and a super VLAN, if there is a multicast source in a sub VLAN, the entry count increases by 1. This is because the inbound validity will be checked during multicast forwarding, and therefore an extra entry will be generated, and the inbound of this entry is the sub VLAN that the multicast stream enters.

### 1.4.3 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 an IPv4 multicast protocol on an interface. Select at least one of them to configure.

- Enable Protocol Independent Multicast Dense Mode (PIM-DM) on the interface.

**ip pim dense-mode**

PIM-DM is disabled for an interface by default.

PIM-DM is a multicast routing protocol that is used in dense mode and applies to small-sized networks where members in a multicast group are densely distributed. For more information about PIM-DM, see *Configuring PIM-DM*.

- o Enable Protocol Independent Multicast Sparse Mode (PIM-SM) on the interface.

#### **ip pim sparse-mode**

PIM-SM is disabled for an interface by default.

PIM-SM is a multicast routing protocol that is used in sparse mode and applies to large-sized networks where members in a multicast group are sparsely distributed. For more information about PIM-SM, see *Configuring PIM-SM*.

## 1.5 Configuring RPF Route Selection Based on the Longest Match Rule

### 1.5.1 Overview

In multicast routing, there may be different routing tables, for example, multicast static routing table, MBGP routing table, and unicast routing table. An optimal route should be selected from all the routing tables and used as an RPF route.

If the longest match rule is used, the route with the longest match mask is selected from the optimal routes in different routing tables as the RPF route. If the masks are equal in length, the route with the highest priority is selected from the optimal routes. If the priorities are consistent, a route is selected in the sequence of multicast static route, MBGP route, and unicast route.

### 1.5.2 Restrictions and Guidelines

The longest match rule can be configured on each device unless otherwise specified.

### 1.5.3 Procedure

- (1) Enter the privileged EXEC mode.

**enable**

- (2) Enter the global configuration mode.

**configure terminal**

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

**ip multicast rpf longest-match**

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

## 1.6 Configuring Static Routes of IPv4 Multicast

### 1.6.1 Overview

You can configure static routes of IPv4 multicast to specify RPF interfaces or RPF neighbors for multicast packets from specific multicast sources. This function can be used to change and connect RPF routes.

- Change an RPF route: If you want a device to receive multicast packets from a multicast source through a specified interface, but this interface is not the required interface based on the RPF checking result, you

need to configure a multicast static route to specify this required interface as an RPF interface.

- Connect an RPF route: If a unicast route is interrupted, a multicast route failed to be generated by RPF. You can configure a multicast static route to specify an RPF interface to complete RPF checking and realize multicast packet forwarding.

## 1.6.2 Procedure

- (1) Enter the privileged EXEC mode.

**enable**

- (2) Enter the global configuration mode.

**configure terminal**

- (3) Configure a multicast static route.

```
ip mroute source-address mask { [ bgp | isis | ospf | rip | static ] { rpf-address | interface-type interface-number } } [ distance ]
```

No multicast static route is configured by default. To specify an outbound interface for a multicast static route, set the outbound interface to point-to-point type.

## 1.7 Configuring IPv4 Multicast Borders

### 1.7.1 Overview

After IPv4 multicast borders are configured, a multicast network can be divided into different domains so that specified multicast packets are transmitted in a domain.

The multicast border function filters out specified multicast packets based on an ACL to forbid packets of this type from entering or leaving an interface.

### 1.7.2 Restrictions and Guidelines

IP multicast borders can be configured on each PIM router interface unless otherwise specified.

### 1.7.3 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 an IP multicast border.

```
ip multicast boundary access-list [ in | out ]
```

No multicast border is configured by default.

This command can associate a standard ACL with an extended ACL. For an extended ACL, only the destination address is matched and the source address is not matched.

## 1.8 Configuring L2 Direction Control for Multicast Streams

### 1.8.1 Overview

By configuring L2 direction control for multicast streams, you can control multicast stream forwarding on an interface.

You can configure this command multiple times for a multicast stream. That is, configure multiple interfaces to forward the stream. After direction control is configured for a multicast stream, this multicast stream can be forwarded only by these configured interfaces. Other interfaces are not allowed to forward the stream.

### 1.8.2 Restrictions and Guidelines

This command controls only the forwarding of multicast streams on interfaces, but does not directly affect the processing of protocol packets by the multicast protocols. However, some features of the multicast protocols (PIM-DM or PIM-SM) depend on the multicast streams. Behaviors of the multicast routing protocols may be affected.

### 1.8.3 Procedure

- (1) Enter the privileged EXEC mode.

**enable**

- (2) Enter the global configuration mode.

**configure terminal**

- (3) Configure L2 direction control for multicast streams.

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

No L2 direction control is configured for multicast streams by default.

## 1.9 Configuring TTL Threshold

### 1.9.1 Overview

The time to live (TTL) value in an IP packet is used to define the maximum number of hops that this packet can transmit through.

To configure a TTL threshold means to configure the minimum TTL value of multicast packets allowed on an interface. Before forwarding a multicast packet on an interface, the device checks whether the TTL value in the packet is greater than the TTL threshold. If yes, the device forwards the packet. Otherwise, the device discards this packet.

### 1.9.2 Restrictions and Guidelines

- A TTL threshold can be configured on each PIM router interface unless otherwise specified.
- The TTL threshold must be configured on router interfaces and takes effect only to multicast packets.

### 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 TTL threshold for an interface.

**ip multicast ttl-threshold** *ttl-threshold-value*

The default TTL threshold for an interface is **0**.

## 1.10 Configuring Forced Forwarding of Multicast Packets by Software

### 1.10.1 Overview

After the mechanism of forced forwarding of multicast packets by software is configured, multicast packets destined to the local device can be forwarded to other interfaces by software.

### 1.10.2 Procedure

- (1) Enter the privileged EXEC mode.

**enable**

- (2) Enter the global configuration mode.

**configure terminal**

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

**msf force-forwarding**

The mechanism of forced forwarding of multicast packets by software is disabled by default.

## 1.11 Configuring Entry Capacity of IPv4 Multicast Routing Table

### 1.11.1 Overview

A device creates and maintains a multicast route forwarding entry for each received multicast packet. Therefore, the entry quantity increases continuously. If the number of entries maintained by a device surpasses the limited hardware resources of the device, hardware forwarding may be changed to software forwarding, which consumes device memory and reduces device performance.

The entry capacity of an IPv4 multicast routing table refers to the maximum number of entries that can be added to the IPv4 multicast routing table. The entry capacity of an IPv4 multicast routing table is 1000 entries by default, and it can be configured based on actual network situation and service performance without affecting running of the device.

### 1.11.2 Procedure

- (1) Enter the privileged EXEC mode.

**enable**

- (2) Enter the global configuration mode.

**configure terminal**

- (3) Configure entry capacity of an IPv4 multicast routing table.

```
ip multicast route-limit route-limit [ max-threshold ]
```

The default entry capacity of an IPv4 multicast routing table is **1000** entries.

## 1.12 Configuring the Overwriting Mechanism upon Overflow of Multicast Hardware Forwarding Entries

### 1.12.1 Overview

The hardware forwarding entries are limited. If they are used up, the device uses software forwarding entries. Compared with hardware forwarding entries, software forwarding entries feature lower performance, occupy device memory, and deteriorate device performance.

After the overwriting mechanism upon overflow of multicast hardware forwarding entries is enabled, new entries can overwrite the earliest entries when hardware forwarding entries are used up.

### 1.12.2 Procedure

- (1) Enter the privileged EXEC mode.

```
enable
```

- (2) Enter the global configuration mode.

```
configure terminal
```

- (3) Enable the overwriting mechanism upon overflow of multicast hardware forwarding entries.

```
msf ipmc-overflow override
```

The overwriting mechanism upon overflow of multicast hardware forwarding entries is disabled by default.

## 1.13 Configuring Multicast Non-Stop Forwarding Parameters

### 1.13.1 Overview

On a device that includes multiple management boards, after a management board is switched over, multicast protocols such as PIM-SM and Internet Group Management Protocol (IGMP) Snooping need re-convergence. You can configure non-stop forwarding parameters to ensure continuous forwarding of multicast streams during re-convergence of the multicast protocols.

### 1.13.2 Procedure

- (1) Enter the privileged EXEC mode.

```
enable
```

- (2) Enter the global configuration mode.

```
configure terminal
```

- (3) Configure multicast non-stop forwarding parameters.

```
msf nsf { convergence-time convergence-time | leak leak-time }
```

The maximum period for multicast protocol convergence is **20** seconds and the packet leakage time is **30** seconds by default.

After the configured protocol convergence period times out, all multicast forwarding entries that are not updated during the convergence period are deleted.

## 1.14 Monitoring

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

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

### ⚠ Caution

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

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

### ⚠ Caution

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

**Table 1-1 Monitoring**

Command	Purpose
<b>clear ip mroute</b> { *   <i>group-address</i> [ <i>source-address</i> ] }	Clears the IPv4 multicast forwarding table.
<b>clear ip mroute statistics</b> { *   <i>group-address</i> [ <i>source-address</i> ] }	Resets the statistics in the IPv4 multicast forwarding table.
<b>show ip mroute summary</b>	Displays the IPv4 multicast forwarding table.
<b>show ip mroute static</b>	Displays the information about IPv4 multicast static route.
<b>show ip rpf</b> <i>source-address</i>	Displays the RPF information of a specified IPv4 source address.
<b>show ip mvif</b> [ <i>interface-type</i> <i>interface-number</i> ]	Displays the information about IPv4 multicast interfaces.
<b>show ip mrf mfc</b>	Displays the IPv4 L3 multicast forwarding table.
<b>show msf nsf</b>	Displays the configuration of IPv4 multicast non-stop forwarding.
<b>show msf msc</b>	Displays the IPv4 multi-layer multicast forwarding table.
<b>debug nsm mcast all</b>	Debugs the running procedure of the multicast core.
<b>debug nsm mcast fib-msg</b>	Debugs the communication procedure between

Command	Purpose
	the IPv4 multicast core and the protocol module.
<b>debug nsm mcast vif</b>	Debugs the interface running procedure about the IPv4 multicast core.
<b>debug nsm mcast stats</b>	Debugs the interface and entry statistics processing procedure about the IPv4 multicast core.
<b>debug ip mrf forwarding</b>	Debugs the IPv4 L3 multicast packet forwarding procedure.
<b>debug ip mrf mfc</b>	Debugs the operation procedure of L3 multicast forwarding entries on an IPv4 network.
<b>debug ip mrf event</b>	Debugs the processing procedure of L3 multicast forwarding events on an IPv4 network.
<b>debug msf forwarding</b>	Debugs the IPv4 multi-layer multicast packet forwarding procedure.
<b>debug msf msc</b>	Debugs the operation procedure of multi-layer multicast forwarding entries on an IPv4 network.
<b>debug msf ssp</b>	Debugs the bottom-layer hardware processing procedure of IPv4 multi-layer multicast forwarding.
<b>debug msf api</b>	Debugs the API calling procedure of IPv4 multi-layer multicast forwarding.
<b>debug msf event</b>	Debugs the processing procedure of multi-layer multicast forwarding events on an IPv4 network.

- 

## 1.15 Common Misconfigurations

- An IPv4 unicast route is incorrectly configured.
- IPv4 multicast routing is not enabled on a router.