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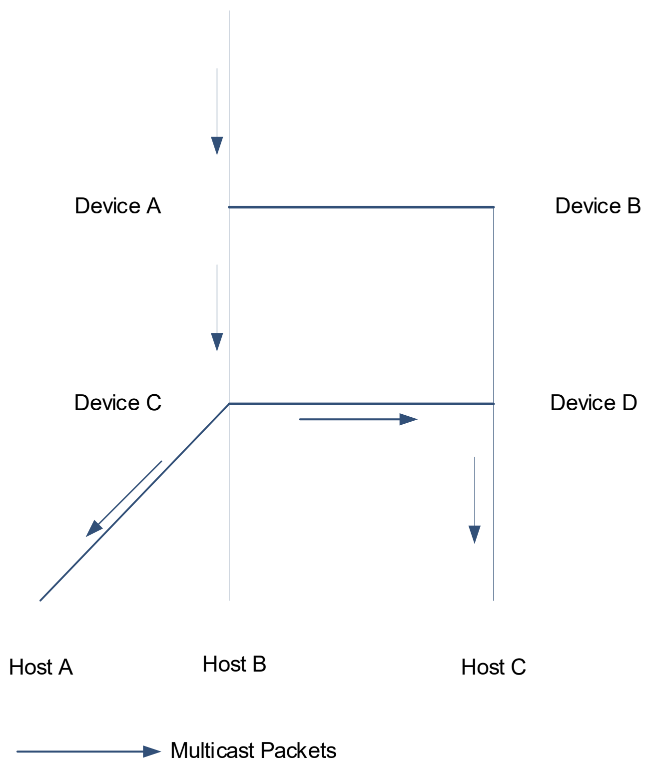
1 Configuring Multicast Basics

IP transmission methods are categorized into unicast, multicast, and broadcast. In IP multicast, an IP packet is sent from a source and forwarded to a specific group of receivers. Compared with unicast and broadcast, IP multicast saves bandwidth and reduces network loads. Therefore, IP 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.

1.1 Basic Concepts of Multicast

As shown in Figure 1-1, there are packet sending sources and receivers on a network. Users who are interested in information raise information requirements. Then, the information sending source sends information only to these users.

Figure 1-1 Topology of Multicast Data Transmission



- Multicast group: It is marked based on a multicast IP address. After a host is added to a multicast group, the host becomes a member of the multicast group and can receive multicast packets destined to the multicast group.
- Multicast source: Indicates a packet sender, for example, the source in Figure 1-1. Different multicast sources can send packets to a multicast group, and a multicast source can send multicast packets to

different multicast groups.

- Member of multicast group: Indicates a host that is added to a multicast group, for example, Host A and Host C in Figure 1-1. Members in a multicast group can be dynamically added to or removed from the multicast group.
- Multicast device: Indicates a router or switch that supports the multicast function. For example, the devices in Figure 1-1 can provide multicast routing and member management functions.

1.2 Multicast Service Models

Based on members in a multicast group, the service models of multicast can be categorized into Any-Source Multicast (ASM) and Source-Specific Multicast (SSM). The two service models use different address ranges of multicast groups.

1.2.1 ASM Model

In the ASM model, multicast data is assigned to multicast groups. The address of a multicast group is used as a network service ID. Any multicast source can send packets to this multicast group, and hosts join the group to receive multicast packets from this multicast group. The address of the multicast group in the ASM model is unique on the multicast network.

1.2.2 SSM Model

In the SSM model, multicast data is assigned to specific multicast sources and multicast groups. When you add a host to a multicast group, you can configure it to receive or not receive data from the specified multicast sources After the host is added to the multicast group, the host can receive only multicast data that is sent to this multicast group by the specified multicast sources. In the SSM model, different multicast sources can use the same address of a multicast group.

1.3 Multicast Address

The multicast technology provides network layer multicast for communication between a multicast source and members in a multicast group based on a multicast IP address. The multicast technology ensures transmission of multicast data in a local physical network based on a multicast MAC address. The IP address must be mapped to the MAC address to ensure correct transmission of the multicast data, because the members in the multicast group are unknown.

1.3.1 IPv4 Multicast Address

The four higher-order bits of a class D IP address are 1110, and the IP address range is from 224.0.0.0 to 239.255.255.255. These four bits are assigned by the Internet Assigned Numbers Authority (IANA) to IPv4 multicast. Table 1-1 lists how IPv4 multicast addresses are allocated.

Table 1-1 Assignment of IPv4 Multicast Addresses

Address Range	Description
224.0.0.0~224.0.0.255	Address of a permanent group
224.0.1.0~231.255.255.255	ASM multicast address

Address Range	Description
233.0.0.0~238.255.255.255	
232.0.0.0~232.255.255.255	Default SSM multicast address
239.0.0.0~239.255.255.255	Address of a local management group

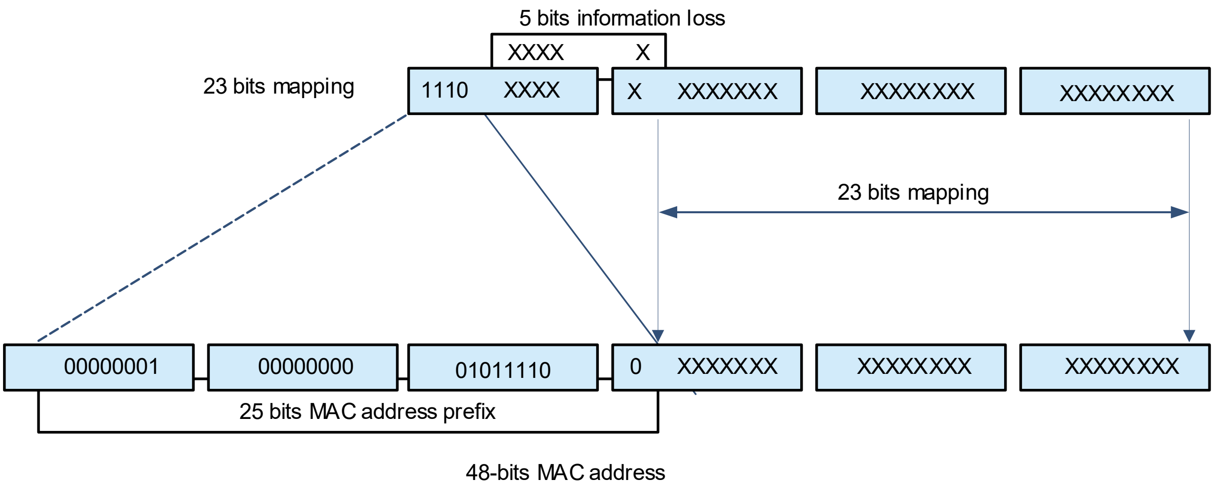
Table 1-2 Addresses of Common Permanent Groups

Address of a Permanent Group	Description
224.0.0.0	Unallocated
224.0.0.1	All hosts and routers in a network segment
224.0.0.2	All multicast devices
224.0.0.3	Unallocated
224.0.0.4	Distance Vector Multicast Routing Protocol (DVMRP) router
224.0.0.5	Open Shortest Path First (OSPF) router
224.0.0.6	OSPF specified router
224.0.0.7	Shared tree (ST) router
224.0.0.8	ST host
224.0.0.9	Routing Information Protocol version 2 (RIP-2) router
224.0.0.11	Mobile proxy
224.0.0.12	Dynamic Host Configuration Protocol (DHCP) server/relay proxy
224.0.0.13	All Protocol Independent Multicast (PIM) devices
224.0.0.14	Resource Reservation Protocol (RRP) encapsulation
224.0.0.15	All Core-Based Tree (CBT) routers
224.0.0.16	Specified Subnetwork Bandwidth Management (SBM)
224.0.0.17	All SBMs
224.0.0.18	Virtual Router Redundancy Protocol (VRRP)

1.3.2 IPv4 Multicast MAC Address

Based on IANA regulation, the higher-order 24 bits of an IPv4 multicast MAC address is 0x01005e, the 25th bit is 0, and the lower-order 23 bits are those of the IPv4 multicast address. Figure 1-1 shows the mapping. The four higher-order bits of an IPv4 multicast address is fixed at 1110, corresponding to the higher-order 25 bits of the MAC address. The lower-order 23 bits in the later 28 bits of the IPv4 multicast address map to the lower-order bits of the multicast MAC address. The lost information indicating by five bits causes the 32 IPv4 addresses to map to the same MAC address.

Figure 1-1 Mapping of IPv4 Multicast Address to IPv4 Multicast MAC Address



1.3.3 IPv6 Multicast Address

An IPv6 address consists of 128 bits. An IPv6 multicast address always starts with FF.

Table 1-1 Assignment of IPv6 Multicast Addresses

Address Range	Description
FF0x::/32	Addresses of a reserved group
FF1x::/32 (x cannot be 1 or 2) FF2x::/32 (x cannot be 1 or 2)	ASM multicast address
FF3x::/32 (x cannot be 1 or 2)	Default SSM multicast address

Table 1-2 Common IPv6 Multicast Addresses and Description

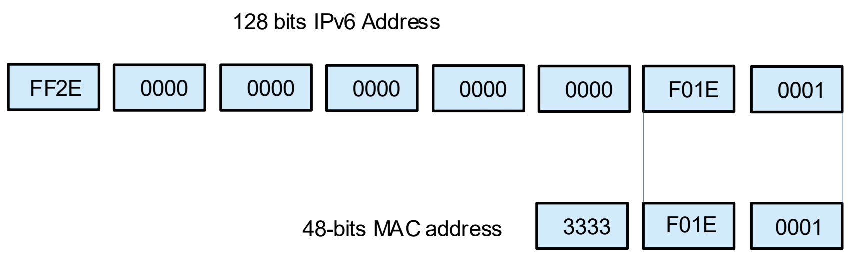
Range	IPv6 Multicast Address	Description
Local range of a node (or an interface)	FF01::1	Addresses of all nodes (interfaces)
	FF01::2	Addresses of all routers
Local range of a link	FF02::1	Addresses of all nodes
	FF02::2	Addresses of all routers
	FF02::3	Unallocated
	FF02::4	DVMRP router

Range	IPv6 Multicast Address	Description
	FF02::5	OSPF IGP router
	FF02::6	OSPF IGP DR
	FF02::7	ST router
	FF02::8	ST host
	FF02::9	RIP router
	FF02::A	EIGRP router
	FF02::B	Mobile proxy
	FF02::D	All PIM routers
	FF02::E	RSVP encapsulation
	FF02::1:1	Link name
	FF02::1:2	All DHCP proxies
	FF02::1:FFXX:XXXX	Solicited-Node address. XX:XXXX indicates the lower-order 24 bits of an IPv6 address of a node.
Local range of station	FF05::2	Addresses of all routers
	FF05::1:3	All DHCP servers
	FF05::1:4	All DHCP relays
	FF05::1:1000~FF05::1:13FF	Service location

1.3.4 IPv6 Multicast MAC Address

The higher-order 16 bits of an IPv6 multicast MAC address is 0x3333, and the lower-order 32 bits are those of the IPv6 multicast address. Figure 1-1 shows the mapping of the IPv6 multicast address FF2E::F01E:1 to the MAC address. There are more IPv6 multicast addresses mapped to the same MAC address.

Figure 1-1 Mapping of IPv6 Address to Multicast MAC Address



1.4 IPv4 Multicast Protocols

A complete set of protocols is developed during the development of multicast to complete multicast data transmission. IPv4 multicast covers the following protocols:

- Internet Group Management Protocol (IGMP): Manages IPv4 multicast members and runs in the network segment that hosts are connected to. IGMP supports data communication with the upstream multicast routing protocols, and maintains and manages relationship of members by adding or removing the members. Three versions of IGMP are available:
  - IGMPv1: Supports the ASM model, and supports the SSM model only when SSM mapping is configured.
  - IGMPv2: Supports the ASM model, and supports the SSM model only when SSM mapping is configured.
  - IGMPv3: Supports the ASM and SSM models.
- PIM: It is a multicast routing protocol in an IPv4 network, and used for route-based query and forwarding of multicast data. PIM includes the following two types:
  - Protocol Independent Multicast Dense Mode (PIM-DM): Applies to a small-size network in which members of a multicast group are densely distributed. The protocol is not distinguished in the ASM and SSM models.
  - Protocol Independent Multicast Sparse Mode (PIM-SM): Applies to a network in any form, and especially applies to a large-size network in which members of a multicast group are sparsely distributed. The protocol is distinguished in the ASM and SSM models based on the data and the multicast addresses in protocol packets.
- Internet Group Management Protocol Snooping (IGMP Snooping): Creates a multicast L2 forwarding table by listening to the IGMP packets between upstream L3 devices and member hosts, and manages and controls multicast packet forwarding on L2 network to suppress multicast data flooding.
- Multicast Source Discovery Protocol (MSDP): Connects multiple PIM-SM domains, shares multicast sources among the PIM-SM domains, and forwards multicast packets across the domains.

1.5 IPv6 Multicast Protocols

IPv6 multicast covers the following protocols:

- Multicast Listener Discovery (MLD): Manages IPv6 multicast members and runs in the network segment that hosts are connected to. MLD supports data communication with the upstream multicast routing protocols, and maintains and manages relationship of members by adding or removing the members. Two versions of MLD are available:
  - MLDv1: Supports the ASM model, and supports the SSM model only when SSM mapping is configured.
  - MLDv2: Supports the ASM and SSM models.
- PIM (IPv6): It is a multicast routing protocol in an IPv6 network, and used for route-based query and forwarding of multicast data. This protocol applies to a network in any form, and especially applies to a large-size network in which members of a multicast group are sparsely distributed. The protocol is distinguished in the ASM and SSM models based on the data and the multicast addresses in protocol packets.
- Multicast Listener Discovery Snooping (MLD Snooping): Creates a multicast L2 forwarding table by listening

to the MLD packets between upstream L3 devices and member hosts, and manages and controls multicast packet forwarding on L2 network to suppress multicast data flooding.

1.6 Basic Concepts of PIM

- PIM device

  A device on which PIM is enabled. Multicast packets are forwarded on the PIM device.

- PIM interface

  An interface on which PIM is enabled. The PIM interface that receives multicast packets is an upstream interface, and the PIM interface that sends multicast packets is a downstream interface. The network segment where the upstream interface resides is an upstream network segment, and the network segment where the downstream interface resides is a downstream network segment.

- PIM network

  Connections of PIM devices through the PIM interfaces constitute a PIM network.

- PIM domain

  On some PIM interfaces, borders can be set to divide a large PIM network into multiple PIM domains. The borders can reject specified multicast packets or control transmission of PIM messages.

- Rendezvous point (RP)

  A PIM device functioning as an RP collects multicast source and group member information on a network.

- Candidate-RP (C-RP)

  A device selects RPs from C-RPs based on the election mechanism, and enables the RPs to serve different multicast groups.

- Designated router (DR)

  A PIM device can function as a DR. A DR that is connected to a multicast source and reports multicast source information to the RP is referred to as a source DR. A DR that is connected to members of a multicast group and reports the group member information to the RP is referred to as a member DR.

- Candidate-BSR (C-BSR)

  PIM devices can be configured as C-BSRs, from which a BSR is elected. When the BSR becomes faulty, other C-BSRs initiate a new election request to elect a new BSR. This avoids service interruption.

- Bootstrap router (BSR)

  A PIM device functioning as a BSR collects and releases RP information in a PIM-SM domain. A BSR is elected from candidate-BSRs. Only one BSR is available in a PIM-SM domain. However, there can be multiple candidate-BSRs in the PIM-SM domain.

- Multicast distribution tree

  Multicast packets are transmitted from one point to multiple points. The forwarding path is displayed as a tree. This forwarding path is referred to as a multicast distribution tree (MDT). There are two types of MDTs:

  - RP tree (RPT): The RP is regarded as the root, and the DRs that connect group members are regarded as leaves.
  - Shortest path tree (SPT): The DR that connects multicast sources is regarded as the root, and the RPs

or DRs that connect group members are regarded as leaves.

- (*, G) and (S, G)
  - (*, G) refers to a routing entry corresponding to packets that are sent from any multicast source to Group G. The forwarding path corresponding to the packets that are sent from any multicast source to Group G is referred to as an RPT.
  - (S, G) refers to a routing entry corresponding to packets that are sent from source S to Group G. The forwarding path corresponding to the packets that are sent from source S to Group G is an SPT.