CHAPTER 9

Implementing Multicast on Catalyst Switches

Multicast deployments have increased exponentially over the past 4 years. A single host sources traffic to a multicast group, which has multiple members associated with the group. Instead of forwarding unicast traffic to each host on the network, multicast allows the source to send the traffic once, and any host that joins that specific multicast group can receive the stream. As a result, multicast is a one-to-many model that helps reduce network traffic. This chapter will cover Internet Group Management Protocol (IGMP) snooping and Cisco Group Management Protocol (CGMP) in detail.

Understanding IGMPv1 and IGMPv2

Communication between the router and the host is done via the IGMP, which has two versions. In IGMPv1, two IGMP packets are defined. The first packet is a membership query sent by the query router every 1 minute on the segment to find out what multicast groups are still in use. The second packet is a membership report. The hosts use a membership report to inform the query router of their interest for a specific multicast traffic. No leave process exists in IGMPv1. If the query router does not receive a membership report within 3 minutes, the router will prune the interface. A pruned interface stops receiving the multicast feed for that group. The **show mroute** command displays which interface has been pruned for a specific multicast stream. In IGMPv1, no selection process exists for the query router. The designated router (DR) is responsible for forwarding multicast traffic and also performs the query router function.

Example 9-1 shows the packet format for IGMPv1. As noted in Example 9-1, Protocol number 2 in IP protocol is defined for IGMP. The source address is 10.1.3.5 and the multicast group is 239.1.1.1. Any host interested in receiving the multicast stream from 10.1.3.5 will join the 239.1.1.1 group.

Example 9-1 *IGMP Sniffer Trace*

```
          IP: Protocol        = 2 (IGMP)
          IP: Header checksum = 8455 (correct)
          IP: Source address      = [10.1.3.5]
          IP: Destination address = [239.1.1.1]
          IP: No options
          IP:
```

continues

Example 9-1 *IGMP Sniffer Trace (Continued)*

```
     IGMP: ----- IGMP header -----
           IGMP:
           IGMP: Version       = 1
         IGMP: Type        = 2 (Ver1 Membership Report)         IGMP: Unused
= 0x00
           IGMP: Checksum      = AC99 (correct)
           IGMP: Group Address = [239.1.1.1]
           IGMP:
           IP: Protocol        = 2 (IGMP)
!Protocol is IGMP
           IP: Header checksum = 8455 (correct)
```

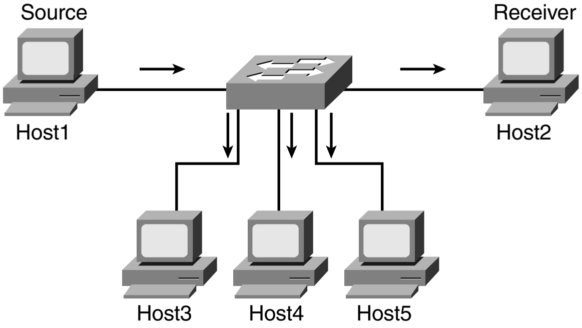
IGMPv2 has additional functionality defined by the following IGMP packet types and is currently deployed in today's networks:

- **Query election process**—All routers on the segment send query messages to all hosts, 224.0.0.1. The router with the lowest IP address wins and becomes the query router. Re-election process starts after 250 seconds if the query router is not heard from.
- **Maximum Response Time field**—This field tweaks the report suppression mechanism (default is 10 seconds). The purpose of this field is to reduce burstiness, especially on segments with a lot of multicast receivers. In large segments, it is desirable to tune this value higher to prevent multiple hosts sending membership reports.
- **Group-specific query message**—After the query router has received a leave group message, the router sends a group-specific query message to ensure no other hosts require the multicast flow. The maximum response time field for a group-specific query message is 1 second to keep the latency short. The other query message is a general membership query message also found in IGMPv1.
- **Leave group messages**—The host sends a leave group message to all routers 224.0.0.2 that it is leaving a specific multicast group. The query router sends back a group-specific query message to ensure no other hosts are part of the multicast group. It does this twice for a total of 2 seconds and then it stops sending that specific multicast flow down to the segment.

Multicast Flooding

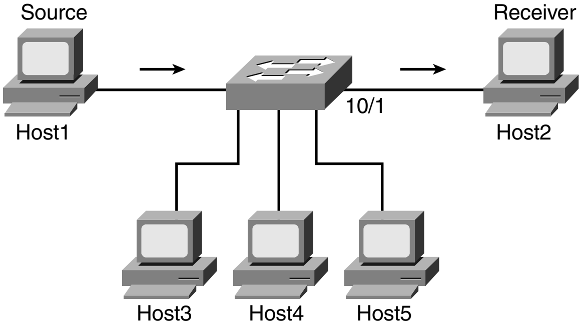
Because no specific host is associated with the multicast MAC address in the content-addressable memory (CAM) table, multicast traffic is flooded throughout the VLAN. (See Figure 9-1.) This type of setup creates unnecessary traffic on the VLAN and wastes precious network resources. Each host machine has to process the packet as it arrives on the interface card, thus, wasting CPU cycles. If the volume of the multicast stream is high enough, it could potentially cause other relevant and control traffic to be dropped. This problem worsens if the VLAN is extended to various other campus switches.

Figure 9-1 *Each Host Receives the Multicast Stream*



One easy method to address this problem is to manually map the ports that require the multicast traffic to the multicast MAC address. For example, Host2 on port 10/1 is interested in receiving the multicast stream 239.1.1.1 as shown in Figure 9-2.

Figure 9-2 *Multicast Traffic Is Sent Only to Host2*



To manually configure ports to receive the multicast stream, it is important to know how to derive the Layer 2 MAC address for the multicast group 239.1.1.1. The first 4 bits of the 32-bit address are defined as a Class D address (1110); now, only 28 bits of meaningful address space remain. A Layer 2 MAC address has 48 bits. The first 25 bits are static (01005e), leaving only 23 bits for the IP address to be placed. Because there are 28 bits of meaningful IP addresses, 5 bits must be thrown away to allow the remaining 23 bits to fit. As a result of the 5 bits thrown away, 32 multicast IP addresses (2^5) are mapped to a single Layer 2 MAC address.

The calculation in Figure 9-3 shows how to derive the Layer 2 MAC address for multicast group 239.1.1.1.

Figure 9-3 *Calculating MAC Address for Multicast Group*

25 Bits (Static = 01005e) + Last 23 Bits from IP Address

IP Address 239.1.1.1

11101111.00000001.00000001.00000001 ← First 9 bits are thrown away.
0000001.00000001.00000001 ← Convert to hex.
01-00-5e-01-01-01 ← Finally, the MAC address.

Port 10/1 is configured to accept the 239.1.1.1 stream on VLAN 3. (See Example 9-2.) All other ports should not receive this traffic anymore because the CAM table has only one port associated with the multicast traffic. After the configuration change, the **show mac** command shows port 10/1 as the recipient for the multicast traffic.

Example 9-2 *Creating a Static CAM Entry*

```
Switch1 (enable) set cam static 01-00-5e-01-01-01 10/1 3
Static multicast entry added to CAM table.
Switch1 (enable) show mac 10/1
Port     Rcv-Unicast          Rcv-Multicast        Rcv-Broadcast
-------- -------------------- -------------------- --------------------
10/1                        2                    5                    0
Port     Xmit-Unicast         Xmit-Multicast       Xmit-Broadcast
-------- -------------------- -------------------- --------------------
10/1                        1                13766                    0
Port     Rcv-Octet            Xmit-Octet
-------- -------------------- --------------------
10/1                      504             20684066
```

Realistically, manually associating ports with specific multicast streams is not a viable option. Each time a new multicast stream is generated, manual intervention is required to configure specific ports to receive the traffic. In a different situation, if Host3 now wants to receive 239.1.1.1 traffic or Host2 no longer wants the traffic, this, too, must be manually configured. Multicast support on a switch needs to be efficient, dynamic, and relatively easy to implement.

IGMP Snooping

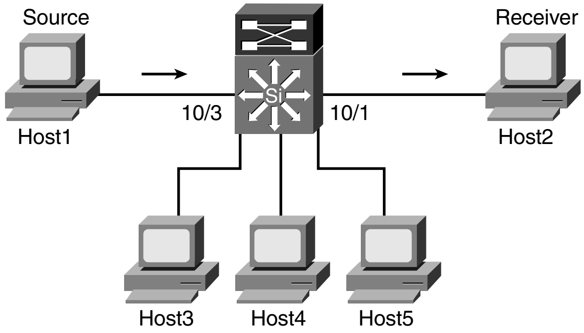
IGMP snooping prevents multicast flows from flooding to all ports on a VLAN by monitoring the Layer 3 IGMP packets. Multicast streams are sent to ports that explicitly request the flow. The switch via the IGMP snooping mechanism listens to the conversation between the router and the host machine. The switch learns at Layer 3 which port is signaling for or leaving a multicast group. The switching engine forwards this message to the Network Management Processor (NMP), where the port is added to or removed from the Layer 2 multicast forwarding group based on the IGMP message type.

The first step that is required for IGMP snooping is that the switch needs to learn the router port. Typically, a Protocol Independent Multicast (PIM) hello message signals the switch where the router port is located. The following messages are used for locating the router port:

- IGMP Group Membership Queries (01-00-5e-00-00-01 or 224.0.0.1)
- PIM v1 Queries (01-00-5e-00-00-02 or 224.0.0.2)
- PIM v2 Queries (01-00-5e-00-00-0d or 224.0.0.13)
- DVMRP messages (01-00-5e-00-00-04 or 224.0.0.4)
- MOSPF messages (01-00-5e-00-00-05 or 224.0.0.5 and 01-00-5e-00-00-06 or 224.0.0.6)

Figure 9-4 shows that the source and receivers are directly connected to the same switch. The switch has a multilayer switch feature card (MSFC), which will handle inter-VLAN communication. Therefore, the MSFC, port 15/1, will be the router port.

Figure 9-4 *IGMP Snooping*



Membership Report

This section reviews various IGMP snooping scenarios.

Scenario 1: IGMP Snooping Process Between Source and Receiver on the Same VLAN

This scenario will go step by step through the IGMP snooping process (refer to Figure 9-4). The first objective is to know what the configuration looks like on the router, as shown in Example 9-3. The router is configured with PIMv2 and the PIM query interval is set at 30 seconds. The DR is the local router, MSFC, 10.1.3.10. At this point, only VLAN 3 is configured for multicast.

Example 9-3 *IGMP Configuration on the Router and Switch*

```
msfc_15#show ip pim interface vlan3
Address          Interface                Version/Mode    Nbr   Query     DR
                                                          Count Intvl
10.1.3.10        Vlan3                    v2/Sparse-Dense  1    30     10.1.3.10
```

In Catalyst 6500 switches, IGMP snooping is enabled by default. (See Example 9-4.) Note that RGMP and GMRP are beyond the scope of this book and will not be discussed.

Example 9-4 *Supervisor Multicast Information*

```
Switch1 (enable) show multicast protocols status
IGMP enabled
IGMP fastleave disabled
RGMP disabled
GMRP disabled
```

Example 9-5 shows the IGMP max query response set at 10 seconds. A router must receive a membership report within the max query response time interval, or else it will prune the interface. The Last member query response interval allows for the router to check once more before pruning the interface. The Multicast groups joined shows the multicast groups that the router knows on VLAN 3.

Example 9-5 *IGMP Interface Information*

```
msfc_15#show ip igmp interface vlan 3
Vlan3 is up, line protocol is up
  Internet address is 10.1.3.10/24
  IGMP is enabled on interface
  Current IGMP host version is 2
  Current IGMP router version is 2
  IGMP query interval is 60 seconds
  IGMP querier timeout is 120 seconds
  IGMP max query response time is 10 seconds
  Last member query response interval is 1000 ms
  Inbound IGMP access group is not set
  IGMP activity: 2 joins, 0 leaves
  Multicast routing is enabled on interface
  Multicast TTL threshold is 0
  Multicast designated router (DR) is 10.1.3.10 (this system)
  IGMP querying router is 10.1.3.10
  Multicast groups joined (number of users):
      239.1.1.1(1) 224.0.1.40(1)
```

The **show igmp groupinfo**, a hidden command, will show whether or not the multicast traffic from the source has any receivers. In Example 9-6, the multicast source only field is set at false, which means that receivers exist for the 239.1.1.1 traffic. If the value was set at true, the source is sending traffic but no receivers exist to get the multicast stream. The **show IGMP groupinfo** command can be useful when troubleshooting multicast-related issues.

Example 9-6 *Multicast Source Only*

```
Switch1 (enable) show igmp groupinfo 3 01-00-5e-01-01-01
MAC Address:              01-00-5e-01-01-01
Multicast Flag:           TRUE
confMask:                [0-4-0-0]
ltl_index:                0x500
mcast_info->protocol_type 2 = PROTO_TYPE_IGMP
mcast_info->protocol_type->info::
tx_v1_report:                FALSE
tx_v2_report:                TRUE
wait_count:               0
mcast_source_only:        FALSE
IP Address:               239.1.1.1
Host List::               15/1
Router Port  List::       10/1,15/1
User Conf Port List::     <null>
V1 Host List::
report_rx_portlist::      15/1
```

The following steps outline the IGMP snooping process for the first host on VLAN 3 that sends a membership report for group 239.1.1.1:

Step 1 Host2 sends an unsolicited IGMP membership report to 239.1.1.1. The MSFC, port 15/1, is the router port for this traffic:

```
Switch1 (enable) show multicast router
Port       Vlan
---------- ----------------
15/1       3
Total Number of Entries = 3
'*' - Configured
'+' - RGMP-capable
```

Step 2 The switch that intercepted the IGMP message creates an EARL entry for Host2:

```
MCAST-IGMPQ:recvd an IGMP V2 Report on the port 10/1 vlanNo 3 GDA
  239.1.1.1
     In ModifyMulticastEarlEntry
     Creating new entry because it's the first Node
     Creating initial node in ModifyMulticast
     Updating portlist for initial hostlist add
```

The entry now is in the multicast forwarding table for the Group Destination Address (GDA), 239.1.1.1 (01-00-5e-01-01-01):

```
Switch1 (enable) show multicast group 01-00-5e-01-01-01
VLAN  Dest MAC/Route Des   [CoS]  Destination Ports or VCs/[Protocol Type]
----  -----------------  -----  -------------------------------------
3     01-00-5e-01-01-01           10/1,15/1
```

Multicast MAC addresses that appear in the forwarding table are stored as static entries in the CAM table. From the switch perspective, 239.1.1.1 is now associated with ports 10/1 and 15/1 on VLAN 3:

```
Switch1 (enable) show cam static 3
* = Static Entry. + = Permanent Entry. # = System Entry. R = Router Entry.
X = Port Security Entry $ = Dot1x Security Entry
VLAN  Dest MAC/Route Des   [CoS]  Destination Ports or VCs/[Protocol Type]
----  -----------------  -----  -------------------------------------
3     01-00-5e-00-01-28           10/1,15/1
3     01-00-5e-01-01-01           10/1,15/1
```

Step 3 The switch then sends the IGMP packet to the MSFC on port 15/1:

```
     MCAST-RELAY:Relaying packet on port 15/1 vlanNo 3
     MCAST-SEND: Inband Transmit Succeeded for IGMP RELAY msg on port
15/1 vlanNo 3
```

Step 4 The router receives the unsolicited IGMP Join from the receiver, Host2 with an IP address of 10.1.3.2:

```
*Sep 30 05:58:47.830: IGMP: Received v2 Report on Vlan3 from 10.1.3.2
  for 239.1.
1.1
```

Step 5 The MSFC updates its IGMP membership table. The IGMP group membership provides information on the last host that requested the multicast traffic for that subnet:

```
msfc_15#show ip igmp group
IGMP Connected Group Membership
Group Address    Interface           Uptime    Expires   Last Reporter
239.1.1.1        Vlan3               00:21:54  00:02:39  10.1.3.2
```

Step 6 Next, the MSFC populates the mroute table, which is the equivalent of the IP route table for multicast. It will create the (*, g) and (S, G) entries for 239.1.1.1 and forward the traffic out on VLAN 3:

```
msfc_15#show ip mroute 239.1.1.1
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, s - SSM Group, C - Connected, L - Local,
       P - Pruned, R - RP-bit set, F - Register flag, T - SPT-bit set,
      J - Join SPT, M - MSDP created entry, X - Proxy Join Timer Running
      A - Advertised via MSDP, U - URD, I - Received Source Specific Host
           Report
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(*, 239.1.1.1), 00:06:25/00:02:59, RP 0.0.0.0, flags: DJC
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan3, Forward/Sparse-Dense, 00:06:25/00:00:00
(10.1.3.5, 239.1.1.1), 00:00:18/00:02:41, flags: PCT
  Incoming interface: Vlan3, RPF nbr 0.0.0.0
  Outgoing interface list: Null
```

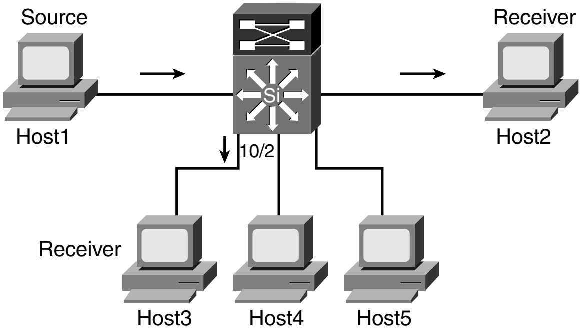
Step 7 Multicast multilayer switching (MMLS) is enabled by default on Catalyst 6500 switches. In this case, because both source and destination are on the same VLAN, no hardware shortcut is created on the MSFC. This flow is already being handled by hardware switching. As a result, there will be no multicast MLS entry:

```
msfc_15#show mls ip multicast group 239.1.1.1
Multicast hardware switched flows:
Total hardware switched flows : 0
Switch1 (enable) show mls multicast entry
Router-IP       Dest-IP         Source-IP       Pkts                 Bytes
          InVlan Type OutVlans
--------------- --------------- --------------- -------------------- -
--------- ------ ---- -------------------------------------------
Total Entries Displayed: 0 (0 complete flow (C) and 0 partial flow (P))
```

Scenario 2: IGMP Snooping Process Between the Source and a Second Receiver on the Same VLAN

Figure 9-5 illustrates what happens when a second host from the same VLAN sends a membership report to the router.

Figure 9-5 *Host3 Sends a Membership Report*



The following explains the process:

Step 1 Host3, on port 10/2, sends an unsolicited IGMP membership report to 239.1.1.1.

Step 2 The switch intercepts the IGMP message:

```
MCAST-IGMPQ:recvd an IGMP V2 Report on the port 10/2 vlanNo 3 GDA
  239.1.1.1
     In ModifyMulticastEarlEntry
```

The multicast forwarding table is updated with port 10/2:

```
Switch1 (enable) show multicast group 01-00-5e-01-01-01
VLAN  Dest MAC/Route Des   [CoS]  Destination Ports or VCs/[Protocol Type]
----  -----------------   -----  ---------------------------------------
3      01-00-5e-01-01-01           10/1-2,15/1
```

Step 3 The switch then sends the IGMP packet to the MSFC on port 15/1:

```
     MCAST-RELAY:Relaying packet on port 15/1 vlanNo 3
     MCAST-SEND: Inband Transmit Succeeded for IGMP RELAY msg on port
15/1 vlanNo 3
```

Step 4 The router receives the unsolicited IGMP Join from the receiver:

```
*Sep 30 06:07:41.434: IGMP: Received v2 Report on Vlan3 from 10.1.3.3
  for 239.1.
1.1
```

Step 5 MSFC updates its IGMP membership table:

```
msfc_15#show ip igmp group
IGMP Connected Group Membership
Group Address    Interface             Uptime    Expires   Last Reporter
239.1.1.1        Vlan3                     00:31:16  00:02:11  10.1.3.3
```

Step 6 Because the MSFC already has an outgoing interface (OIF) for VLAN 3, it will not do anything on the mroute table.

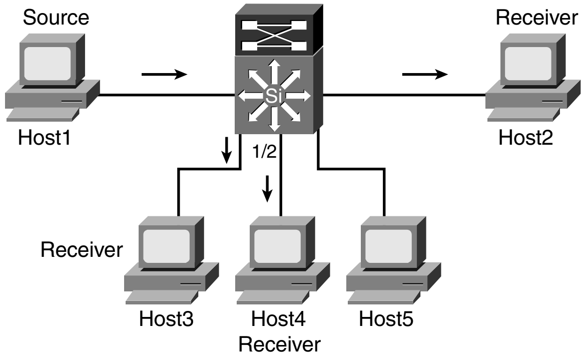
Step 7 No changes are made to the MMLS table. The MSFC does not send any shortcut information to the MMLS-Switching Engine (MMLS-SE) because Host3 is also part of VLAN 3:

```
msfc_15#show mls ip multicast group 239.1.1.1
Multicast hardware switched flows:
Total hardware switched flows : 0
Switch#1 (enable) show mls multicast entry
Router-IP       Dest-IP        Source-IP       Pkts                 Bytes
          InVlan Type OutVlans
--------------- -------------- -------------- ------------------ ----------
--------- ------ ---- ----------------------------------------
Total Entries Displayed: 0 (0 complete flow (C) and 0 partial flow (P))
```

Scenario 3: IGMP Snooping Process Between Source and Receiver on Different VLANs

Host4 from a different VLAN has requested the multicast stream 239.1.1.1. (See Figure 9-6.)

Figure 9-6 *Host4 Sends a Membership Report*



A hardware shortcut is created by the MSFC in this scenario because traffic is between different VLANs:

Step 1 Host4, on port 1/2, sends an unsolicited IGMP membership report to 239.1.1.1.

Step 2 The switch intercepts the IGMP message:

```
MCAST-IGMPQ:recvd an IGMP V2 Report on the port 1/2 vlanNo 30 GDA
  239.1.1.1
     In ModifyMulticastEarlEntry
     Creating new entry because it's the first Node
     Creating initial node in ModifyMulticast
     Updating portlist for initial hostlist add
```

The multicast forwarding table adds an additional line for VLAN 30 and its associate port of 1/2 for Host4:

```
Switch1 (enable) show multicast group
VLAN  Dest MAC/Route Des    [CoS]  Destination Ports or VCs/[Protocol Type]
----  -----------------     -----  -------------------------------------
3     01-00-5e-01-01-01             10/1-2,15/1
30    01-00-5e-01-01-01             1/2,15/1
```

Step 3 The switch then sends the IGMP packet to the MSFC on port 15/1:

```
     MCAST-RELAY:Relaying packet on port 15/1 vlanNo 30
     MCAST-SEND: Inband Transmit Succeeded for IGMP RELAY msg on port
15/1 vlanNo 30
```

Step 4 The router receives the unsolicited IGMP Join from the receiver:

```
*Sep 30 09:06:58.881: IGMP: Received v2 Report on Vlan30 from 10.1.4.1
for 239.1.1.15. The MSFC updates its IGMP membership table.
```

Step 5 The router updates its IGMP membership table:

```
msfc_15#show ip igmp groups
IGMP Connected Group Membership
Group Address    Interface           Uptime    Expires   Last Reporter
239.1.1.1        Vlan30              00:00:46  00:02:55  10.1.4.1
```

Step 6 Interface VLAN 30 is added to the OIF list. The letter H denotes hardware switched:

```
msfc_15#show ip mroute 239.1.1.1
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, s - SSM Group, C - Connected, L - Local,
       P - Pruned, R - RP-bit set, F - Register flag, T - SPT-bit set,
      J - Join SPT, M - MSDP created entry, X - Proxy Join Timer Running
      A - Advertised via MSDP, U - URD, I - Received Source Specific Host
          Report
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(*, 239.1.1.1), 00:05:45/00:02:59, RP 0.0.0.0, flags: DJC
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Vlan3, Forward/Sparse-Dense, 00:01:44/00:00:00
    Vlan30, Forward/Sparse-Dense, 00:05:45/00:00:00
(10.1.3.5, 239.1.1.1), 00:00:21/00:02:59, flags: CT
  Incoming interface: Vlan3, RPF nbr 0.0.0.0, RPF-MFD
  Outgoing interface list:
    Vlan30, Forward/Sparse-Dense, 00:00:21/00:00:00, H
```

Step 7 The packets are now hardware switched between VLAN 3, the multicast source, and VLAN 30, Host4, for 239.1.1.1 traffic:

```
msfc_15#show mls ip multicast group 239.1.1.1
Multicast hardware switched flows:
(10.1.3.5, 239.1.1.1) Incoming interface: Vlan3, Packets switched:
  508380
Hardware switched outgoing interfaces: Vlan30
RPF-MFD installed
Total hardware switched flows : 1
```

An MMLS entry is created because the multicast packets are hardware switched:

```
Switch1 (enable) show mls multicast entry
Router-IP       Dest-IP         Source-IP       Pkts                 Bytes
          InVlan Type OutVlans
--------------- --------------- --------------- -------------------- -----------
--------- ------ ---- -------------------------------------------
10.1.3.10         239.1.1.1       10.1.3.5      534751               794639986
           3      C    30
Total Entries Displayed: 1 (1 complete flow (C) and 0 partial flow (P))
```

For the MMLS entry to be created and updated, the MMLS-route processor (MMLS-RP), MSFC, and the MMLS-SE, the supervisor, must communicate with each other to ensure consistent data on both devices. The **show multicast statistics** command displays communication information between the MMLS-RP and MMLS-SE. (See Example 9-7.)

Example 9-7 *Multicast Statistics on the Switch*

```
Switch1 (enable) show mls multicast statistics
Router IP          Router Name        Router MAC
---------------    ------------------ -----------------
10.1.3.10          ?                  00-05-5e-96-76-c0
Transmit:
                     Feature Notifications: 0
            Feature Notification Responses: 2
           Shortcut Notification Responses: 3
!Switch's response back to the MSFC regarding the shortcut messages

                      Delete Notifications: 0
                           Flow Statistics: 47
                   Total Transmit Failures: 0
Receive:
                     Feature Notifications: 2
                         Shortcut Messages: 3

! Switch received 3 shortcut messages from the MSFC

               Duplicate Shortcut Messages: 0
                      Shortcut Install TLV: 1
!One hardware shortcut created

                      Selective Delete TLV: 0
                          Group Delete TLV: 0
                                Update TLV: 0
                     Input VLAN Delete TLV: 0
                    Output VLAN Delete TLV: 0
                         Global Delete TLV: 0
                           MFD Install TLV: 1
                            MFD Delete TLV: 0
                     Global MFD Delete TLV: 0
                               Invalid TLV: 0
```

The next section discusses what happens when a receiver leaves a multicast group, and how IGMP snooping handles such an event.

IGMP Leave Process

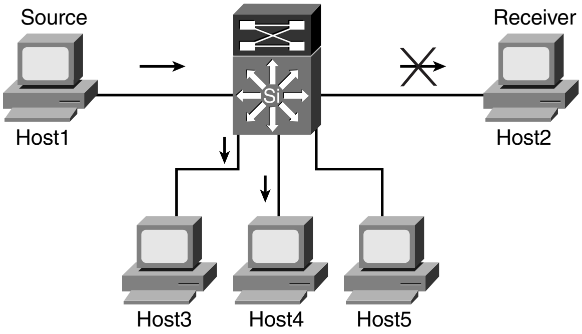
This section explores two types of leave process. The first leave process involves a single host leaving a multicast session while other hosts from the same VLAN are still receiving the multicast traffic. In the second example, the host is the last member to leave a multicast session.

The IGMP query router, MSFC, will send queries every 60 seconds to both VLAN 3 and VLAN 30 to check for members for the multicast group 239.1.1.1 (refer to Figure 9-6). As these queries are sent by the router to the switch, the switch forwards the queries to ports that are participating in the multicast session. Upon receiving the query message, the hosts will send back an IGMP membership report. The switch again intercepts these IGMP messages from the hosts and only forwards one membership report to the MSFC. A router does not need to receive membership reports from more than one host from a single VLAN for a multicast traffic. So long as there is one host, the multicast stream still needs to be forwarded to that interface. For this reason, the switch drops the other IGMP membership reports.

Scenario 1: IGMP Snooping Leave Process Between the Source and Multiple Receivers on the Same VLAN

Figure 9-7 and the subsequent steps outlined address the issue of a receiver leaving a multicast group while another receiver on the same VLAN is still interested in the traffic.

Figure 9-7 *Host2 Sends an IGMP Leave*



Step 1 Host2 sends a leave group message to all routers, 224.0.0.2, for multicast traffic 239.1.1.1.

Step 2 The Catalyst switch intercepts the IGMP leave message:

```
MCAST-IGMPQ:recvd an IGMP Leave on the port 10/1 vlanNo 3 GDA 239.1.1.1
```

Step 3 The switch sends a MAC-based general query to port 10/1. A random deletion timer value (1 to 3 seconds) will be set. If the host is communicating via IGMPv1, the random deletion timer is set at 10 seconds:

```
MCAST-DEL-TIMER: Deletion Timer Value set to Random Value 3
```

Step 4 If the switch does not hear a membership report during the random deletion timer, it will drop the port from its multicast forwarding table:

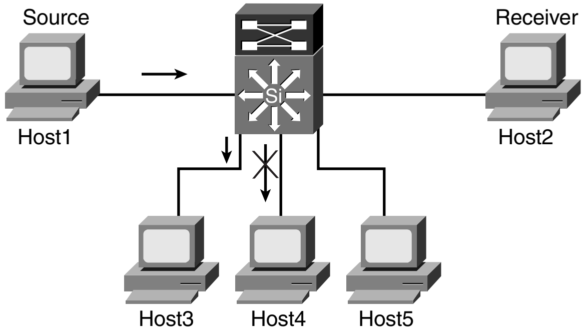
```
MCAST-TIMER:IGMPLeaveTimer expired on port 10/1 vlanNo 3 GDA 01-00-5e-
  01-01-01
Delete UpdatePortOnMulticast
```

Step 5 The switch does not send the IGMP leave message to the MSFC because the switch knows that Host3, which is on the same VLAN as Host2, is still accepting the 239.1.1.1 traffic. The MSFC does not even know that Host2 has left the multicast group. Also, no changes have been made to the MMLS table because Host3 on the VLAN 3 is still accepting the traffic.

Scenario 2: IGMP Snooping Leave Process Between the Source and Last Receivers

Figure 9-8 illustrates the last receiver, Host4, on VLAN 30 leaving the multicast group 239.1.1.1. When Host4 leaves the multicast group, both switch and MSFC will have to update their appropriate tables.

Figure 9-8 *Host4 Sends IGMP Leave*



The following steps outline the IGMP snooping process when Host4 leaves the multicast group.

Step 1 Host4 sends a leave group message to all routers, 224.0.0.2, for multicast traffic 239.1.1.1.

Step 2 The Catalyst switch intercepts the IGMP leave message:

```
MCAST-IGMPQ:recvd an IGMP Leave on the port 1/2 vlanNo 30 GDA 239.1.1.1
```

Step 3 The switch sends a MAC-based general query to port 1/2:

```
MCAST-DEL-TIMER: Deletion Timer Value set to Random Value 3
```

Step 4 The switch updates its multicast forwarding table:

```
In ModifyMulticastEarlEntry
     Delete UpdatePortOnMulticast
     Delete UpdatePortOnMulticast - Last Port
```

Step 5 Because Host4 is the last member for the multicast group, the switch forwards an IGMP leave message to the MSFC:

```
MCAST-SEND:Transmitting IGMP Leave msg on port 15/1 vlanNo 30
```

Step 6 Upon receiving the IGMP leave message, the MSFC sends two group-specific queries to check for any members for VLAN 30:

```
IGMP: Received Leave from 10.1.4.1 (Vlan30) for 239.1.1.1
IGMP: Send v2 Query on Vlan4 to 239.1.1.1
IGMP: Send v2 Query on Vlan4 to 239.1.1.1
```

Step 7 Not hearing any response, MSFC deletes multicast traffic 239.1.1.1 to VLAN 30:

```
IGMP: Deleting 239.1.1.1 on Vlan30
```

Step 8 The MSFC updates the MMLS-SE engine to clear the shortcut between VLAN 3 and VLAN 30 for the multicast 239.1.1.1 traffic.

IGMP Fastleave

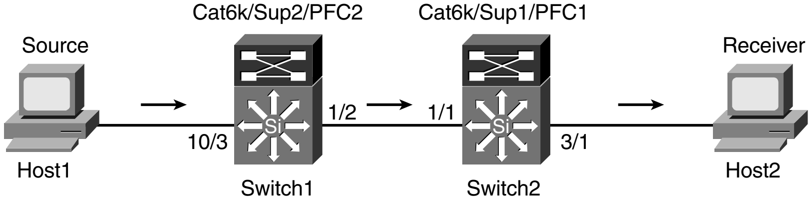
With IGMP fastleave enabled, the switch removes the port from the multicast forwarding table without sending a MAC-based query to the port. The purpose behind fastleave is to quickly transition the port or VLAN off the multicast stream. Most customers have not deployed fastleave today. Fastleave should not be enabled on ports that have hubs connected to them. For example, two hosts are off the same hub, which is connected to a port on a Catalyst switch with IGMP fastleave enabled. If one host leaves, the switch immediately takes the port off the multicast forwarding table. As a result, the second host on the hub will lose its multicast traffic. IGMP fastleave is disabled on trunk ports.

Address Aliasing

Address aliasing is defined as mapping 32 multicast IP addresses to a single Layer 2 MAC address. A multicast Layer 3 address could map to a system MAC address that is used by the switch, which is a potential risk. Any packets destined to the system CAM entries are directly sent to the NMP because it is assumed that the packets are part of the control traffic rather than user traffic. As a result, network outages can occur if multicast user traffic is mapped to a system CAM entry.

Look at an example to solidify the problem with address aliasing. Both Host1 and Host2 are in VLAN 3 as shown in Figure 9-9. Two types of supervisors are used in this design. Their handling of address aliasing will become apparent shortly.

Figure 9-9 *Address Aliasing*



Example 9-8 shows two outputs from Switch1 and Switch2, respectively.

Example 9-8 *System CAM Entries for VLAN 3*

```
Switch1 (enable) show cam system 3
* = Static Entry. + = Permanent Entry. # = System Entry. R = Router Entry.
X = Port Security Entry $ = Dot1x Security Entry
VLAN  Dest MAC/Route Des    [CoS]  Destination Ports or VCs / [Protocol Type]
----  ------------------    -----  -------------------------------------------
3     00-00-0c-07-ac-03 R#          15/1
3     00-05-74-18-04-bc R#          15/1
3     01-00-0c-cc-cc-cc  #          1/3
3     01-00-0c-cc-cc-cd  #          1/3
3     01-00-0c-dd-dd-dd  #          1/3
3     01-80-c2-00-00-00  #          1/3
3     01-80-c2-00-00-01  #          1/3
Total Matching CAM Entries Displayed  =7

Switch2 (enable) show cam system 3
* = Static Entry. + = Permanent Entry. # = System Entry. R = Router Entry.
X = Port Security Entry $ = Dot1x Security Entry
```

continues

Example 9-8 *System CAM Entries for VLAN 3 (Continued)*

```
VLAN  Dest MAC/Route Des    [CoS]  Destination Ports or VCs / [Protocol Type]
----  ------------------    -----  -------------------------------------------
3     01-00-0c-cc-cc-cc  #          1/3
3     01-00-0c-cc-cc-cd  #          1/3
3     01-00-0c-dd-dd-dd  #          1/3
3     01-00-5e-00-00-01  #          1/3
3     01-00-5e-00-00-04  #          1/3
3     01-00-5e-00-00-05  #          1/3
3     01-00-5e-00-00-06  #          1/3
3     01-00-5e-00-00-0d  #          1/3
3     01-00-5e-00-00-16  #          1/3
3     01-80-c2-00-00-00  #          1/3
3     01-80-c2-00-00-01  #          1/3
Total Matching CAM Entries Displayed  =11
```

Unlike Switch1, which has a PFC2 card, Switch2 with its PFC1 card has various multicast MAC addresses in its system table that start with prefix 01005e. Host1 will source 239.0.0.4 multicast traffic that maps to the system CAM entry, 01-00-5e-00-00-04. This MAC entry is also used by DVMRP routers. By sourcing an address that maps to a system CAM entry, the multicast packets will hit the NMP, which will be forced to look at these packets. As a result, the NMP is saturated, causing important control traffic to get dropped. Example 9-9 shows the output generated by Switch2.

Example 9-9 *IGMP Address Aliasing*

```
Total Matching CAM Entries Displayed  =11
Switch2 (enable) 2003 Oct 01 16:15:02 %MCAST-2-IGMP_ADDRAL:IGMP: Address
  Aliasing for 01-00-5e-00-00-04
2003 Oct 01 16:15:02 %MCAST-2-IGMP_FALLBACK:IGMP: Running in FALL BACK mode
2003 Oct 01 16:15:02 %MCAST-2-IGMP_ADDRALDETAILS:IGMP: Multicast address
  aliasing: From 00-05-74-18-04-bc (10.1.3.5) on 1/1 to 01-00-5e-00-00-04
    (239.0.0.4)
```

IGMP Fallback

When the switch receives too much traffic because of address aliasing, it will flush the multicast MAC addresses from the system CAM table. This process is known as *IGMP fallback*.

Compare the **show cam system 3** entries for Switch2 as shown in Example 9-8 and Example 9-10. IGMP fallback has cleared the multicast CAM entries from the system CAM table to protect the switch from pegging at 100 percent.

Example 9-10 *CAM Entries Do Not Have Multicast MAC Addresses*

```
Switch2 (enable) show cam system 3
* = Static Entry. + = Permanent Entry. # = System Entry. R = Router Entry.
X = Port Security Entry $ = Dot1x Security Entry
VLAN  Dest MAC/Route Des    [CoS]  Destination Ports or VCs / [Protocol Type]
----  ------------------    -----  -------------------------------------------
3     01-00-0c-cc-cc-cc  #          1/3
3     01-00-0c-cc-cc-cd  #          1/3
3     01-80-c2-00-00-00  #          1/3
3     01-80-c2-00-00-01  #          1/3
Total Matching CAM Entries Displayed  =4
```

At this point, only IGMP packets are allowed to hit the NMP. IGMP fallback is set for 5 minutes. (See Example 9-11.) If no excessive address aliasing occurs, the switch will reinstall the system MAC addresses in the system CAM table. If address aliasing is still occurring, the switch will cause fallback to occur again. If a third fallback occurs, the switch will stay in fallback mode until IGMP snooping is manually disabled and enabled. A switch reload also removes IGMP fallback state.

Example 9-11 *IGMP Snooping Is Currently in Fallback Mode*

```
Switch2 (enable) show igmp mode
IGMP Mode:                 auto
IGMP Operational Mode:     igmp-only
IGMP Address Aliasing Mode: fallback
```

An interesting point worth noting is that Switch1 was not affected by address aliasing. PFC2 cards identify multicast router control traffic based on the destination IP address rather than the Layer 2 MAC address used in PFC and earlier EARLs. Hence, the 32 IP addresses to a single MAC address is not an issue for the PFC2 card.

Cisco Group Management Protocol

Cisco Group Management Protocol (CGMP) is another widely used protocol to forward multicast traffic to appropriate ports. CGMP is a Cisco proprietary protocol. The router communicates IGMP information with the switch via the CGMP protocol at Layer 2. Unlike IGMP snooping, CGMP-enabled switches do not have any insight into the Layer 3 IGMP packet types. All IGMP information is forwarded to the router, which in turn sends a Layer 2 message informing the switch regarding client participation for multicast traffic. The router translates the IGMP report into a CGMP message and forwards it to the switch. Based on what is contained in the CGMP packet, the switch will either add or delete port(s) for the multicast stream. Some of the switches that support CGMP are the 3500XL, 2924XL, and Catalyst 5500 without a NetFlow Feature Card (NFFC) card. The packet type of CGMP is defined as follows:

Version (4 bits): 1 and 2
Type (4 bits): 0= Join
1= Leave
Reserved (2 bytes): Not used and is set to 0
Count (1 byte): GDA/USA pairs in the CGMP packet
GDA (6 byte): The translated multicast IP group address
USA (6 bytes): MAC address of the client that initiated the IGMP report

Table 9-1 lists the possible CGMP messages. Entry 3 is used by the router to inform the switch of its location. Hence, when a multicast flow gets created, the router port automatically is associated with the multicast stream. Entry 4 is used by the router to leave a multicast stream. Entries 5 and 6 are used to clear multicast CAM entries.

Table 9-1 *Different Types of GDA*

Entry	GDA	USA	Join/Leave	Meaning
1	Multicast MAC	Client MAC	Join	Add port to group
2	Multicast MAC	Client MAC	Leave	Delete port from group
3	00-00-00-00-00-00	Router MAC	Join	Assign router port
4	00-00-00-00-00-00	Router MAC	Leave	Remove router port
5	Multicast MAC	00-00-00-00-00-00	Leave	Delete group
6	00-00-00-00-00-00	00-00-00-00-00-00	Leave	Delete all group

When CGMP is enabled for a VLAN, the switch will automatically associate the CGMP MAC address 01-00-0c-dd-dd-dd with the system CAM entry for that VLAN. (See Example 9-12.)

Example 9-12 *System CAM Table for VLAN 2*

```
Switch3 (enable) show cam system 2
* = Static Entry. + = Permanent Entry. # = System Entry. R = Router Entry. X = Port
Security Entry
VLAN  Dest MAC/Route Des  Destination Ports or VCs / [Protocol Type]
----  ------------------  ----------------------------------------------------
2     00-10-f6-b3-48-00R  3/1
2     01-00-0c-cc-cc-cc#  1/9
2     01-00-0c-cc-cc-cd#  1/9
2     01-00-0c-dd-dd-dd#  1/9
2     01-80-c2-00-00-00#  1/9
2     01-80-c2-00-00-01#  1/9
```

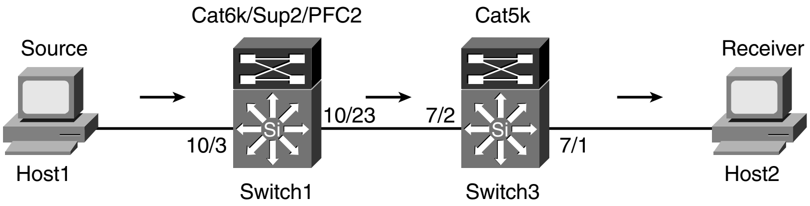
Use the **show cam static** command to view the Layer 2 forwarding table for the multicast traffic on the Catalyst 5000 switches. In Example 9-13, the output from the switch illustrates that Host3 and route switch module (RSM) ports are the only ports accepting the multicast traffic destined to 239.1.1.1 on VLAN 2.

Example 9-13 *239.1.1.1 Is Accepted by Ports 3/1 and 7/3*

```
Switch3 (enable) show cam static 2
* = Static Entry. + = Permanent Entry. # = System Entry. R = Router Entry. X = P
ort Security Entry
VLAN  Dest MAC/Route Des  Destination Ports or VCs / [Protocol Type]
----  ------------------  --------------------------------------------------
2     01-00-5e-01-01-01*  3/1,7/3
```

Figure 9-10 shows Host2 connected to Switch3, a Catalyst 5509 device, which also has an RSM blade. Switch3 is configured for CGMP.

Figure 9-10 *CGMP Communication*



The following steps outline the CGMP process as Host2 sends a membership report for group 239.1.1.1:

Step 1 Host3 sends a IGMP membership report for 239.1.1.1.

Step 2 The switch forwards a message to the RSM.

Step 3 The RSM receives the unsolicited IGMP membership report. It updates its IGMP group table.

Step 4 RSM then updates the mroute table by creating (*, G) and (S, G) for 239.1.1.1. It also puts VLAN 2 in forwarding state to receive 239.1.1.1 traffic.

Step 5 The router translates the IGMP membership report to a Layer 2 CGMP message and forwards it to the switch using CGMP well-known multicast MAC address, 0100.0CDD.DDDD with SNAP value of 0x2001:

— The GDA field will have the translated MAC address of 239.1.1.1= 0010.5e01.0101.

— The User Source Address (USA) will be the MAC address of the client (Host3) that sent the IGMP membership report.

Step 6 The switch examines the CGMP packet. If it does not have a CAM entry for the multicast MAC address, it will create a CAM entry for GDA and associate the router port to it. The switch looks at the USA field and again examines the CAM table. The switch will have a CAM entry for the USA field because Host2 initiated the request for the multicast stream. As a result, the switch also adds the Host2 port to the GDA entry.

Step 7 Any subsequent multicast traffic destined to 239.1.1.1 will be forwarded to the RSM and the host port. In this example, the host port is 7/3.

IGMP Leave Process

The leave process works the same. The router receives the IGMP leave message from the host and translates the information to CGMP and forwards it to the switch. The switch then removes the client port from the CAM entry for that GDA.

Local Leave Process

With more recent implementations, the Catalyst 4000 and 5000 family can actually handle the IGMP leave process locally rather than forwarding it to the router. To enable this feature, use the following command:

```
Switch3 (enable) set cgmp leave <enable | disable>
```

This command will create two multicast MAC entries in the systems CAM table: 01-00-5e-00-00-01 and 01-00-5e-00-00-02. Now, when a host sends an IGMP leave message, the switch intercepts the packet, similar in process to IGMP snooping.

The local leave process is as follows:

Step 1 Host3 sends a leave group message to all routers, 224.0.0.2, for multicast traffic 239.1.1.1.

Step 2 The switch intercepts the IGMP packet. It sends an IGMP general query out the port 7/3.

Step 3 Because port 7/3 is the last host for the multicast traffic, the switch sources an IGMP leave message to the router.

Step 4 Upon receiving the IGMP leave message, the RSM sends two group specific queries to check for any members for VLAN 2:

```
IGMP: Received Leave from 10.1.2.1 (Vlan2) for 239.1.1.1
IGMP: Send v2 Query on Vlan2 to 239.1.1.1
IGMP: Send v2 Query on Vlan2 to 239.1.1.1
```

Step 5 The RSM sends a CGMP message to the switch to delete the GDA from the CAM.

IGMP Snooping Versus CGMP

When comparing IGMP and CGMP, IGMP snooping is a far superior method of handling multicast traffic on a switch. Implementing IGMP snooping over CGMP has various advantages. IGMP is based on a standard whereas CGMP is Cisco proprietary. IGMP can handle IGMP leave message both from GDA and all-routers address. CGMP only understands all-routers address. IGMP is able to handle address aliasing more effectively. CGMP is forwarded to other switches at Layer 2, causing unnecessary traffic on the network. Host leaves are handled sequentially in CGMP because of report suppression. This is not the case with IGMP.

Summary

This chapter illustrated the intricacies involved with IGMP snooping and CGMP. IGMP snooping is enabled by default on Catalyst 6000 switches. CGMP is the default for the Catalyst 5000 family. Unlike IGMP snooping, CGMP requires configuration changes on the router. Via the IGMP snooping feature, the switch is able to listen to the conversation between the router and the host machine. Hence, rather than flooding the VLAN with multicast traffic, the switch forwards the traffic to hosts that explicitly requested the stream. CGMP forwards the IGMP messages to the router, which converts the IGMP packet into a CGMP packet and forwards it back to the switch. Despite CGMP local leave implementation, where the CGMP-enabled switch can intercept the IGMP leave packet and locally query the host, CGMP is slowly becoming obsolete, because all current model Catalyst switches support Layer 3 capabilities.