IGMP Protocol

bintec Dm762-I

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I Related Documents

bintec Dm752-I Access Control

bintec Dm804-I PIM Protocol

Chapter 1 Introduction

1.1 Introduction

Traditional IP communication allows a host to send packets to a single host (unicast transmission) or to all hosts (broadcast transmission). IP multicast provides a third possibility: allowing a host to send packets to a subset of all hosts as a group transmission. This section introduces the mechanisms of IP multicast and specifically those implemented in our routers.

1.2 IP Multicast basics

IP multicast is a bandwidth-conserving technology that reduces traffic by simultaneously delivering a single stream of information to potentially thousands of corporate recipients and homes. Applications that take advantage of multicast include video conferencing, corporate communications, distance learning, and distribution of software, stock quotes, and news.

IP multicast delivers application source traffic to multiple receivers without burdening the source or the receivers while using a minimum of network bandwidth. Multicast packets are replicated in the network at the point where paths diverge by routers enabled with Protocol Independent Multicast (PIM) and other supporting multicast protocols, resulting in the most efficient delivery of data to multiple receivers.

Many alternatives to IP multicast require the source to send more than one copy of the data. Some, such as application-level multicast, require the source to send an individual copy to each receiver. Even low-bandwidth applications can benefit from using IP multicast when there are thousands of receivers. High-bandwidth applications, such as MPEG video, may require a large portion of the available network bandwidth for a single stream. In these applications, IP multicast is the only way to send to more than one receiver simultaneously. Figure 1 shows how IP multicast is used to deliver data from one source to many interested recipients.

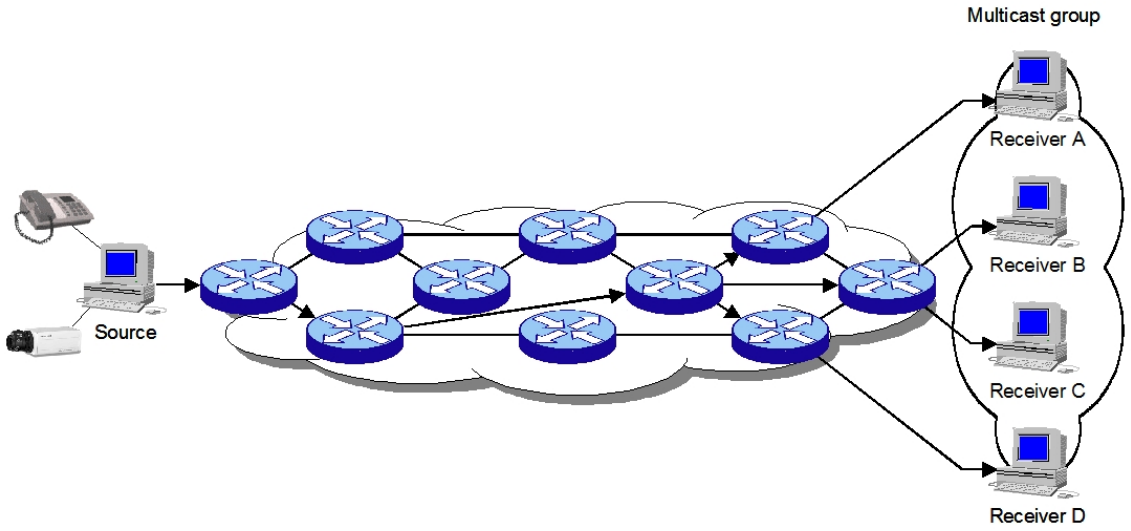

Fig. 1: Multicast transmission to many receivers.

In the example shown in Figure 1, the receivers (the designated multicast group) are interested in receiving the video data stream from the source. The receivers indicate their interest by sending an Internet Group Management Protocol (IGMP) host report to the routers in the network. The routers are then responsible for delivering the data from the source to the receivers. The routers use Protocol Independent Multicast (PIM) to dynamically create a multicast distribution tree. The video data stream will then be delivered only to the network segments that are in the path between the source and the receivers.

1.3 Multicast group concept

Multicast is based on the concept of a group. A multicast group is an arbitrary group of receivers that expresses an interest in receiving a particular data stream. This group has no physical or geographical boundaries – the hosts can be located anywhere on the Internet or any private internetwork. Hosts that are interested in receiving data flowing to a particular group must join the group using IGMP. Hosts must be a member of the group to receive the data stream.

1.4 IP Multicast address

IP multicast addresses specify a set of IP hosts that have joined a group and are interested in receiving multicast traffic designated for that particular group. IPv4 multicast address conventions are described in the following sections.

1.4.1 IP class D addresses

The Internet Assigned Numbers Authority (IANA) controls the assignment of IP multicast addresses. IANA has assigned the IPv4 Class D address space to be used for IP multicast. Therefore, all IP multicast group addresses fall in the range from 224.0.0.0 through 239.255.255.255.

Note

The Class D address range is used only for the group address or destination address for IP multicast traffic. The source address for multicast datagrams is always the unicast source address.

Table 1 gives a summary of the multicast address ranges discussed in this document.

Multicast address range assignments

Description	Range
Reserved Link Local Addresses	224.0.0.0/24
Globally Scoped Addresses	224.0.1.0 a 238.255.255.255
Source Specific Multicast	232.0.0.0/8
GLOP Addresses	233.0.0.0/8
Limited Scope Addresses	239.0.0.0/8

1.4.1.1 Reserved link local addresses

The IANA has reserved addresses in the range 224.0.0.0/24 used by network protocols on a local network segment. Packets with these addresses should never be forwarded by a router. Packets with link local destination addresses are typically sent with a time-to-live (TTL) value of 1 and are not forwarded by a router.

Network protocols use these addresses for automatic router discovery and to communicate important routing information. For example, Open Shortest Path First (OSPF) uses the IP addresses 224.0.0.5 and 224.0.0.6 to exchange link-state information. Table 2 lists some well-known link local IP addresses.

Examples of link local addresses

IP address	Usage
224.0.0.1	All systems on this subnet.
224.0.0.2	All routers on this subnet.
224.0.0.5	OSPF routers.
224.0.0.6	OSPF designated routers.
224.0.0.12	Dynamic Host Configuration. Protocol (DHCP) server/relay agent.

1.4.1.2 Globally scoped addresses

Addresses in the range from 224.0.1.0 through 238.255.255.255 are called globally scoped addresses. These addresses are used to multicast data between organizations and across the Internet.

Some of these addresses have been reserved for use by multicast applications through IANA. For example, IP address 224.0.1.1 has been reserved for Network Time Protocol (NTP).

IP addresses reserved for IP multicast are defined in RFC 1112, Host Extensions for IP Multicasting. More information about reserved IP multicast addresses can be found at the following location: *http://www.iana.org/assignments/multicast-addresses* .

Note

You can find all RFCs and Internet Engineering Task Force (IETF) drafts on the IETF website (*http://www.ietf.org*).

1.4.1.2.1 Source Specific Multicast addresses

Addresses in the 232.0.0.0/8 range are reserved for Source Specific Multicast (SSM). SSM is an extension of the PIM protocol that allows for an efficient data delivery mechanism in one-to-many communications. Some of the RFCs that describe SSM are: RFC 3569 (general perspective), RFC 4607 (SSM for IP), RFC 4604 (IGMPv3 / MLDv2 and SSM) and RFC 4608 (PIM-SSM).

1.4.1.2.2 GLOP addresses

RFC 3180, “GLOP Addressing in 233/8”, describes the use of the 233.0.0.0/8 range, reserved for statically defined addresses for organizations with an assigned AS number (Autonomous System). This practice is known as GLOP addressing. The AS domain address is encoded in the second and third octets of the 233.0.0.0/8 address range. For example, AS 5662 is written in hexadecimal format as 161E. Separating the two octets, 16 and 1E, results in 22 and 30 decimal values. These values are translated in subnet 233.22.30.0/24, which is globally reserved for using AS 5662.

1.4.1.3 Limited scope addresses

Addresses in the 239.0.0.0/8 range are called limited scope addresses or administratively scoped addresses. These addresses are described in RFC 2365, Administratively Scoped IP Multicast, to be constrained to a local group or organization.

Companies, universities, or other organizations can use limited scope addresses to have local multicast applications that will not be forwarded outside their domain. Routers typically are configured with filters to prevent multicast traffic in this address range from flowing outside of an autonomous system (AS) or any user-defined domain.

Within an autonomous system or domain, the limited scope address range can be further subdivided so that local multicast boundaries can be defined. This subdivision is called address scoping and allows for address reuse between these smaller domains.

1.4.2 Layer 2 multicast addresses

Historically, network interface cards (NICs) on a LAN segment could receive only packets destined for their burned-in MAC address or the broadcast MAC address. In IP multicast, several hosts need to be able to receive a single data stream with a common destination MAC address. Some means had to be devised so that multiple hosts could receive the same packet and still be able to differentiate between several multicast groups.

One method to accomplish this is to map IP multicast Class D addresses directly to a MAC address. Today, using this method, NICs can receive packets destined to many different MAC addresses – their own unicast, broadcast, and a range of multicast addresses.

The IEEE LAN specifications made provisions for the transmission of broadcast and multicast packets. In the 802.3 standard, bit 0 of the first octet is used to indicate a broadcast or multicast frame. Figure 2 shows the location of the broadcast or multicast bit in an Ethernet frame.

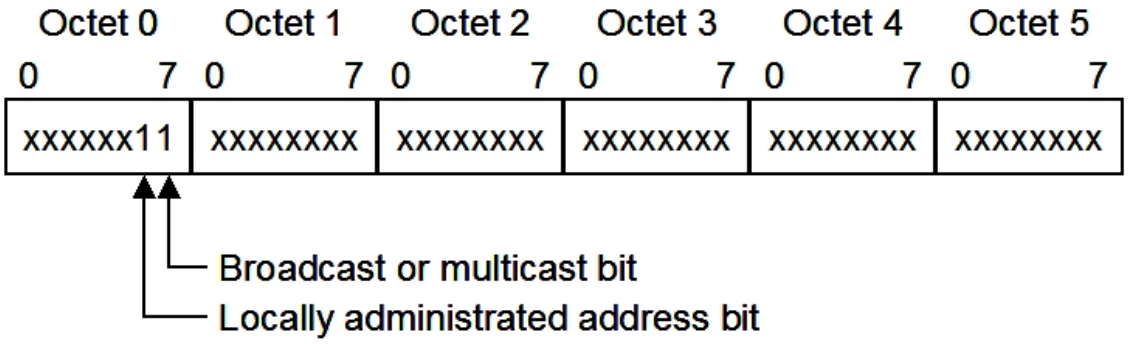

Fig. 2: IEEE 802.3 MAC address format.

This bit indicates that the frame is destined for a group of hosts or all hosts on the network (in the case of the broadcast address, 0xFFFF.FFFF.FFFF).

IP multicast makes use of this capability to send IP packets to a group of hosts on a LAN segment.

1.4.2.1 Ethernet MAC address mapping

The IANA owns a block of Ethernet MAC addresses that start with 01:00:5E in hexadecimal format. Half of this block is allocated for multicast addresses. The range from 0100.5e00.0000 through 0100.5e7f.ffff is the available range of Ethernet MAC addresses for IP multicast.

This allocation allows for 23 bits in the Ethernet address to correspond to the IP multicast group address. The mapping places the lower 23 bits of the IP multicast group address into these available 23 bits in the Ethernet address (see Figure 3).

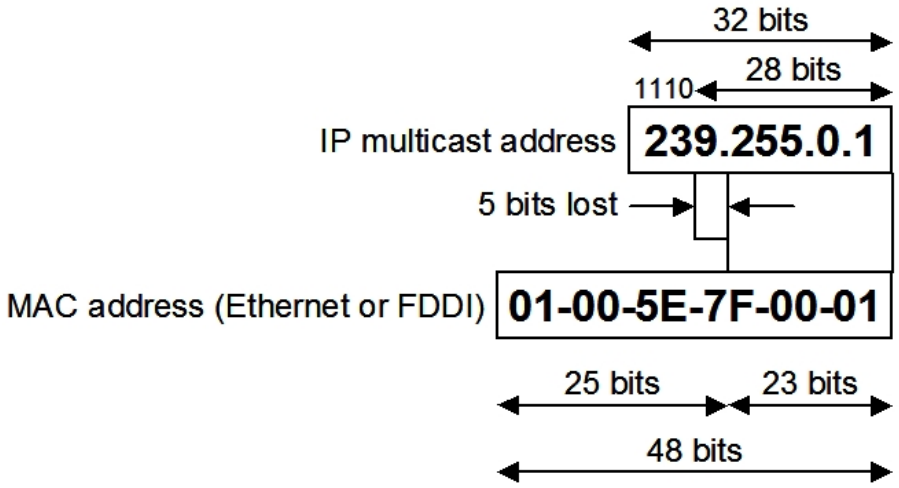

Fig. 3: IP multicast to Ethernet or FDDI MAC address mapping.

Because five bits of the IP multicast address are dropped in this mapping, the resulting address is not unique. In fact, 32 different multicast group IDs map to the same Ethernet address (see Figure 4).

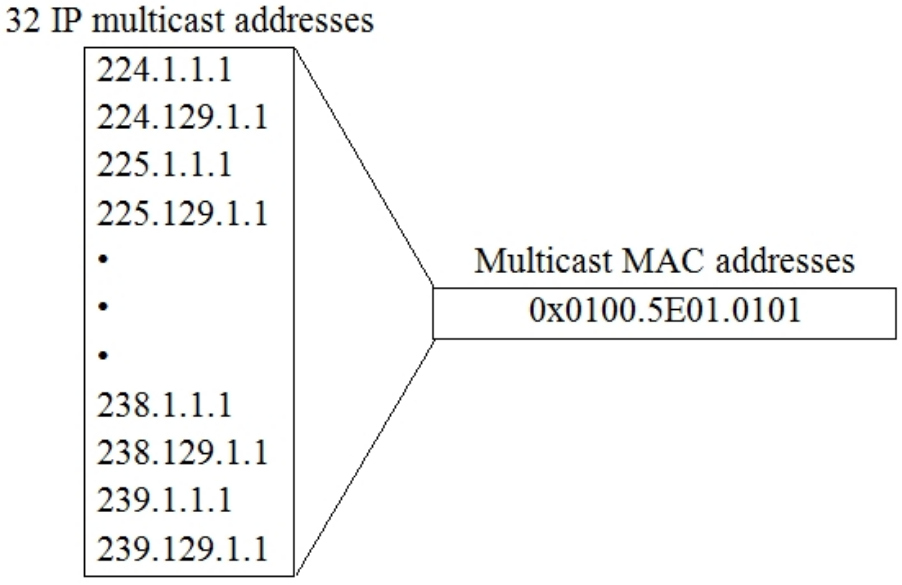

Fig. 4: MAC address ambiguities.

Network administrators should consider this fact when assigning IP multicast addresses. For example, 224.1.1.1 and 225.1.1.1 map to the same multicast MAC address on a Layer 2 switch. If one user subscribed to Group A (as designated by 224.1.1.1) and the other users subscribed to Group B (as designated by 225.1.1.1), they would receive both A and B streams. This situation limits the effectiveness of this multicast deployment.

1.5 Internet Group Management Protocol (IGMP)

IGMP is used to dynamically register individual hosts in a multicast group on a particular LAN. Hosts identify group memberships by sending IGMP messages to their local multicast router. Under IGMP, routers listen to IGMP messages and periodically send out queries to discover which groups are active (or not) on a particular subnet.

IGMP versions are described in the following sections.

1.5.1 IGMP version 1

RFC 1112, Host Extensions for IP Multicasting, describes the specification for IGMP Version 1 (IGMPv1). A diagram of the packet format for an IGMPv1 message is shown in Figure 5.

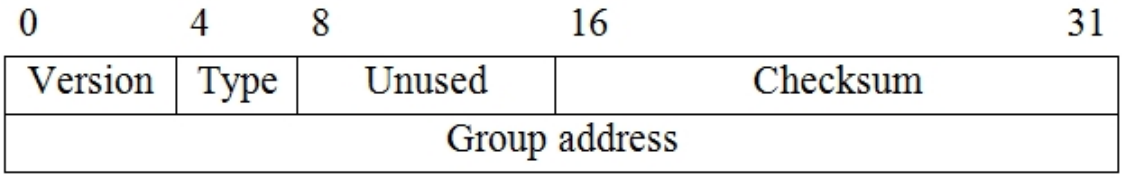

Fig. 5: IGMPv1 message format.

In Version 1, only the following two types of IGMP messages exist:

- Membership query.
- Membership report.

Hosts send out IGMP membership reports corresponding to a particular multicast group to indicate that they are interested in joining that group. The TCP/IP stack running on a host automatically sends the IGMP Membership report when an application opens a multicast socket. The router periodically sends out an IGMP membership query to verify that at least one host on the subnet is still interested in receiving traffic directed to that group. When there is no reply to three consecutive IGMP membership queries, the router times out the group and stops forwarding traffic directed to that group.

1.5.2 IGMP version 2

IGMPv1 has been superceded by IGMP Version 2 (IGMPv2). IGMPv2 is backward compatible with IGMPv1. RFC 2236, Internet Group Management Protocol, Version 2, describes the specification for IGMPv2. A diagram of the packet format for an IGMPv2 message is shown in Figure 6.

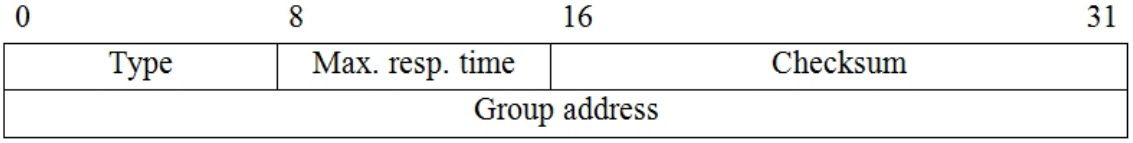

Fig. 6: IGMPv2 message format.

In Version 2, the following four types of IGMP messages exist:

- Membership query.
- Version 1 membership report.
- Version 2 membership report.
- Leave group.

IGMP Version 2 works basically the same way as Version 1. The main difference is that there is a leave group message. With this message, the hosts can actively communicate to the local multicast router that they intend to leave the group. The router then sends out a group-specific query and determines if any remaining hosts are interested in receiving the traffic. If there are no replies, the router times out the group and stops forwarding the traffic. The addition of the leave group message in IGMP Version 2 greatly reduces the leave latency compared to IGMP and be stopped much sooner.

1.5.3 IGMP version 3

IGMP Version 3 (IGMPv3) is the next step in the evolution of IGMP. RFC 3376, Internet Group Management Protocol, Version 3, describes the specification for IGMPv3.

IGMPv3 adds support for source filtering, which enables a multicast receiver host to signal to a router the groups it wants to receive multicast traffic from, from which sources this traffic is expected or from which sources it doesn't want traffic from. This membership information enables routers to forward traffic from only those sources receivers requested the traffic from.

A diagram of the query packet format for an IGMPv3 message is shown in Figure 7.

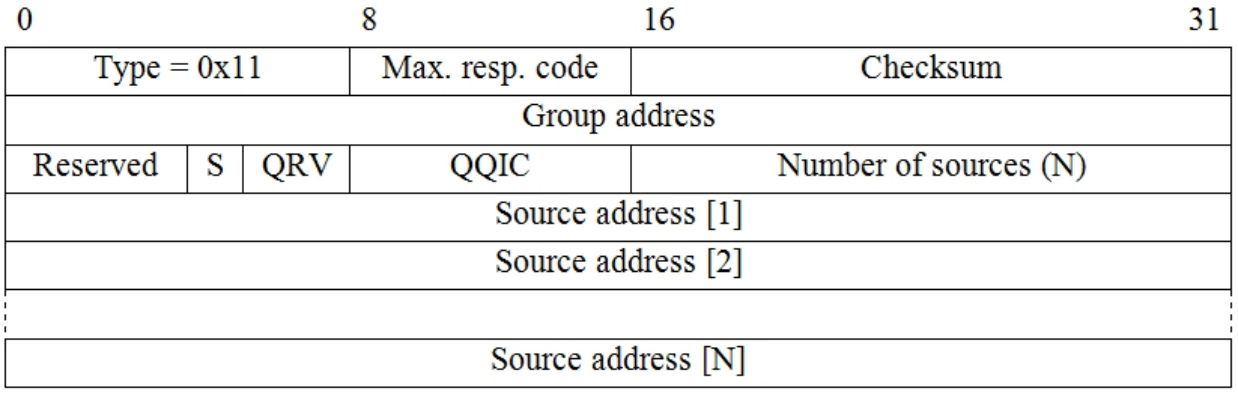

Fig. 7: IGMPv3 Query message format.

Table 3 describes the significant fields in an IGMPv3 query message.

IGMPv3 Query message field descriptions

Field	Description
Type = 0x11	IGMP query.
Max. resp. code	Maximum response code (in tenths of a second). This field specifies the maximum time allowed before sending a responding report.
Group address	Multicast group address. This address is 0.0.0.0 for general queries.
S	S flag. This flag indicates that processing by routers is being suppressed.
QRV	Querier's Robustness Variable. This value affects timers and the number of retries.
QQIC	Querier's Query Interval Code (in seconds). This field specifies the Query Interval used by the querier.
Number of sources (N)	Number of sources present in the query. This number is nonzero for a group-and-source query.
Source address [1…N]	Address of the source(s). If the sources' number (N) is 0 (general and group specific queries) then no source address field is included.

A diagram of the report packet format for an IGMPv3 message is shown in Figure 8.

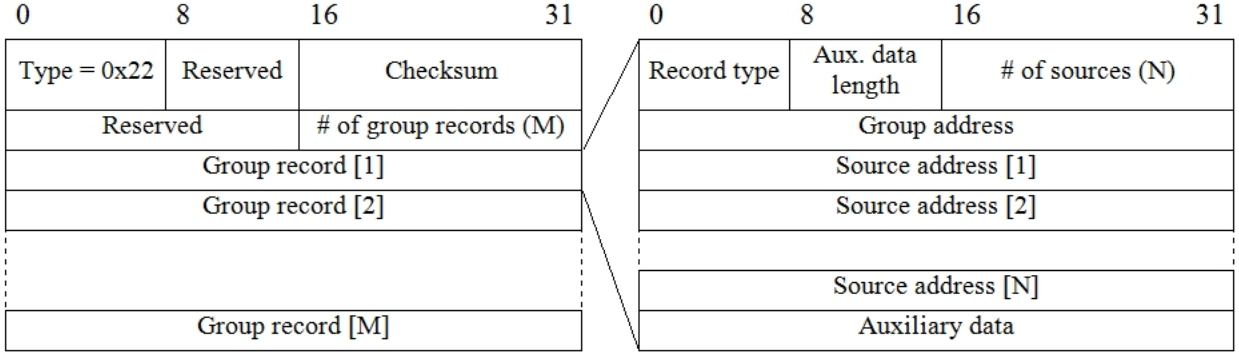

Fig. 8: IGMPv3 Report message format.

Table 4 describes the significant fields in an IGMPv3 report message.

IGMPv3 Report message field descriptions

Field	Description
# of group records (M)	Number of group records present in the report.
Group record [1…M]	Block of fields containing information regarding the sender's membership with a single multicast group on the interface the report was sent from.
Record type	The group record type (e.g., MODE_IS_INCLUDE, MODE_IS_EXCLUDE).
# of sources (N)	Number of sources present in the record.
Source address [1…N]	Address of the source(s).

In IGMPv3, the following types of IGMP messages exist:

- Version 3 membership query.

- Version 3 membership report.

IGMPv3 supports applications that explicitly signal sources they want to receive traffic from. With IGMPv3, receivers signal membership to a multicast host group in the following two modes:

- INCLUDE mode – In this mode, the receiver announces membership to a host group and provides a list of source addresses (the INCLUDE list) it wants to receive traffic from.
- EXCLUDE mode – In this mode, the receiver announces membership to a multicast group and provides a list of source addresses (the EXCLUDE list) it does not want to receive traffic from. The host will receive traffic only from sources whose IP addresses are not listed in the EXCLUDE list. To receive traffic from all sources, which is how IGMPv2 behaves, a host uses EXCLUDE mode membership with an empty EXCLUDE list.

One of the major applications for IGMPv3 is Source Specific Multicast (SSM), standardized by the IETF. This mechanism uses the range of SSM multicast addresses (232.0.0.0/8), which are exclusively destined for the broadcasting of multicast traffic from specific sources. If a host wants to receive traffic destined to one of these multicast groups, it needs to know a priori the source address that it expects to receive traffic from. These groups can only operate in INCLUDE mode, which specifies the sources that it wishes to received traffic from; this does not accept EXCLUDE requests, which reject a set of sources or do not specify the origins. Give that prior IGMP versions did not have the mechanism to specify origins; one of the SSM needs is to use IGMPv3.

1.6 IGMP available feature

The features available in the our routers relative to IGMP are described below. Currently there are two different operating modes for IGMP: the IGMP proxy and the interaction with PIM. In the first of these cases, the multicast routing depends on IGMP exclusively, while in the second the protagonist is the PIM protocol (Protocol Independent Multicast). Both operating modes can co-exist in the same router but are incompatible with each other as they are in the same VRF.

Before entering into more detail on each one of these modes, a set of basic definitions are given:

1.6.1 Definitions

1.6.1.1 Upstream interface

A router's interface that behaves as an IGMP host is also called the Host Interface. This sends membership reports to interested multicast group in the VRF associated to the interface. This only is logical in IGMP proxy.

1.6.1.2 Downstream interface

A router's interface that behaves as an IGMP router is also called router interface. This receives the reports from the hosts in the network that the interface is connected to and, if this is the Querier, it sends IGMP query messages to said network. Apart from the received reports, this maintains a list of members to multicast groups for each downstream interface, including (in this case) specific information on origins.

1.6.1.3 IGMP querier

In a network connected to a downstream interface pertaining to the router, there can be other multicast routers executing IGMP protocol. However only one router can launch IGMP queries in the same segment: this router is the IGMP Querier. To select the querier, this chooses the IGMP router with the lowest IP address.

1.6.1.4 Interface Version

Each interface is configured with a version number: IGMPv1, IGMPv2 or IGMPv3. Although various devices in the same network present different IGMP version, the versions are interoperable. Nevertheless, the RFC indicates that all the potential Queriers must have the same version configured.

1.6.1.5 Group mode

Each multicast group can be in IGMPv1, IGMPv2 or IGMPv3 mode:

- A group is in IGMPv1 mode if an IGMPv1 report is heard.
- A group is in IGMPv2 mode if an IGMPv2 report is heard, but no IGMPv1 report is heard.
- A group is in IGMPv3 mode if an IGMPv3 is heard, but no IGMPv1 or IGMPv2 report is heard.

1.6.1.6 Membership database

The database maintained in each VRF with IGMP proxy, which the membership information of each of its downstream interfaces is merged. Apart from the database, reports sent by the proxy's upstream interfaces are generated.

1.6.2 IGMP proxy

In certain topologies, it is not necessary to run a multicast routing protocol. It is sufficient to learn the proxy group membership information and simply forward based upon that information. This draft describes a mechanism for forwarding based solely upon IGMP membership information. For this we use the IGMP protocol, which serves to gather relevant information pertaining to groups (router mode) and communicate this information to another multicast router (host mode). This mechanism is described in RFC 4605: "IGMP / MLD proxying".

Our routers implement the IGMP protocol in both operating modes, and can act as IGMP proxy, gathering and communicating the information on multicast groups and routing the multicast traffic based on this information.

Note

The use of IGMP proxy is limited to a tree topology, whose root (it is assumed) connects to a higher multicast infrastructure.

A VRF performing IGMP-based forwarding has a single upstream interface and one or more downstream interfaces. These designations are explicitly configured; there is no protocol to determine what type each interface is. It performs the router portion of the IGMP protocol on its downstream interfaces and, the host portion of IGMP on its upstream interface.

Note

Despite the fact that this is the implementation defined in RFC 4605, the use of more than one upstream interface for scenarios where they are necessary is allowed.

For each VRF, a database consisting of the merger of all subscriptions on any downstream interface is maintained on said membership database. The router sends IGMP membership reports on the upstream interface when queried, and sends unsolicited reports or leaves when the database changes.

When the router receives a packet destined for a multicast group, it forwards it over all those interfaces fulfilling any of the following conditions:

- The VRF interface is upstream and is not the interface that received the packet.
- The VRF interface is downstream and is not the interface that received the packet, the router is the IGMP querier on this interface and there is some subscription concurring with the packet (source unicast address and destination multicast group).

Note

For an IGMP proxy, a router interface must be a querier in order to route multicast traffic, therefore the IP addressing is conditioned. The VRFs using IGMP proxy must have lower IP addresses than another potential querier, to insure that no other router is a querier preventing traffic routing.

The choice of which router will route multicast traffic is necessary for links considered as downstream for various routers with IGMP proxy. This rule delegates the choice of the router when selecting the querier. In a link with a single router with IGMP proxy, this rule can be disabled (i.e. allows the router to route traffic even if it is not the querier). However, default behavior is that only the querier may route traffic through IGMP proxy. This behavior is counterproductive with the election of the router carried out by the routers with the PIM protocol instead of IGMP proxy, as explained in the following section.

Note: this does not protect against an upstream loop. For example, as shown in Figure 9:

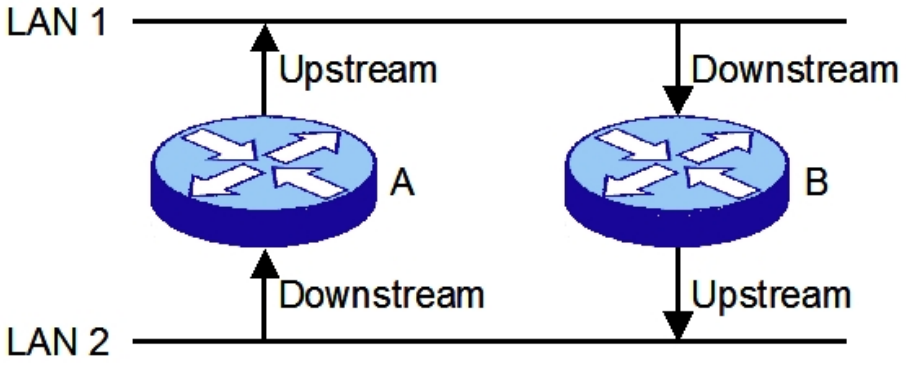

Fig. 9: Example of upstream loop when IGMP proxying.

B will unconditionally forward packets from LAN 1 to LAN 2, and A will unconditionally forward packets from LAN 2 to LAN 1. This will cause an upstream loop. A multicast routing protocol that employs a tree building algorithm is required to resolve loops like this.

1.6.3 IGMP and PIM

The IGMP operating mode is modified when PIM is enabled in the VRF. On this occasion, this does have a multicast routing protocol, PIM. It's this that maintains the information on where the multicast traffic should be routed, constructing the Multicast Routing Table (or MRT), which is the equivalent to the Tree Information Base or TIB described in RFC 4601. This MRT is made up of entries or states of four possible types: (S,G), (S,G,rpt), (*,G) and (*,*,RP), indicated from a specified high to low. Data is maintained as timers in all of them, interfaces the traffic exits through, interface traffic is received through, upstream neighbor, etc. The difference between the various types of state is as follows:

- (S,G): saves the state associated to the pair made up of the G multicast group and the S source. I.e. makes a reference to the G traffic from S. The upstream neighbor is orientated to the S source, to the Shortest Path Tree root.
- (S,G,rpt): Maintains the state of the G multicast group and S source pair, in the same way as the states (S,G), but the upstream neighbor is towards the RP, forming part of the Shared Tree. E.g. this means the S-G pair traffic is not transmitted by the Shared Tree, because it is already being directly received by the Shortest Path Tree.
- (*,G): This brings together everything related to G multicast group traffic, regardless of the source. If there is no other specific entry (S,G), this state governs the traffic behavior. The upstream neighbor is located towards the RP associated with the G group, the Shared Tree root.
- (*,*,RP): State associated to all the multicast traffic concentrated in the Rendezvous-Point RP, without worrying about the multicast group or the source. The upstream neighbor is in the path towards the RP.

The (S,G), (S,G,rpt) and (*,G) states also receive membership information on the interfaces to multicast groups coming from the IGMP protocol. Assigning an interface for the traffic, requested through IGMP to an MRT entry, is known as a leaf, includes an interface. I.e. within the traffic distribution tree constructed by PIM with its multiple branches, through the interface in question the end receptor can be accessed (i.e. a leaf of the tree). Through this, the corresponding multicast traffic is routed through the interfaces that are considered leaves, provided they are not the interface this traffic is expected to reach the router through. If the IGMP reports that traffic is coming from an undesired source through an interface, this is to exclude the interface (**exclude**), for the states (S,G,rpt); this case requires the group's global traffic handled by the (*,G) state, has previously included this interface.

So memberships for IGMP groups affect a (*,G) state, traffic needs to have been requested from the G group: reports IGMPv1, IGMPv2 or IGMPv3 EXCLUDE requests. Also, for (S,G) states, the inclusion of interfaces only occurs after receiving IGMPv3 INCLUDE reports with the G group, where the S source has been included. The exclusion of sources also requires the reports are IGMPv3 EXCLUDE. These reports affect the (*,G) state, while each one of the excluded sources are associated to the corresponding (S,G,rpt) state.

In this topology, only the IGMP router interface function (downstream) makes sense; this collects group memberships per interface. The IGMP host role (upstream) doesn't make sense, since it's not necessary to move this membership information to the higher IGMP routers because the PIM absorbs and acts accordingly. As there are no upstream interfaces, this membership database isn't formed.

Note

You shouldn't configure IGMP upstream interfaces when PIM is enabled in the VRF, only IGMP downstream interfaces should be configured where the presence of IGMP hosts are expected.

So that the IGMP is operative in a VRF when PIM is enabled, at least one of the VRF interfaces must be configured as downstream. You cannot enable IGMP globally in the VRF, it has to be configured in an interface. So this operates correctly, you also need to configure the PIM-SM mode in the interface.

One very important aspect in a scenario with routers with PIM and IGMP is the designation of the multicast traffic router for a determined physical link. PIM selects the Designated Router (DR), and by default selects the PIM router present in the link with the highest IP address. Conflicts arise if there are other devices in the same link with IGMP router features without PIM: e.g. an IGMP proxy. If one of the routers without PIM is the Querier IGMP (as it has the lowest IP address), it also proclaims itself as the router, and consequently the multicast traffic can be duplicated. PIM has a mechanism to resolve this, the Assets, however, the two routers in conflict need to use PIM. Consequently, this situation should be avoided at the administrative level.

For further information on the PIM protocol, please see manual bintec Dm804-I – PIM Protocol.

Chapter 2 Configuration

2.1 Configuring the IGMP Proxy

The main steps to execute for a VRF IGMP Proxy configuration are described in the following sections.

2.1.1 Enabling the IGMP Proxy functions

So a IGMP Proxy can execute its operations, it is essential to enable this general function in the VRF of the device going to execute IGMP Proxy. This is executed in the VRF IP protocol configuration menu.

2.1.2 Configuring IGMP Proxy in the interfaces

To adequately integrate the router executing IGMP Proxy within a multicast network in tree format, configure the device interfaces going to connect to said structure, so the following conditions are fulfilled:

- The multicast network end hosts must always be connected to the router interfaces (downstream) so the hosts can register in the multicast groups.
- In each multicast structure segment in tree, configure – to prevent loops – the interface at the other end (connected in tree root direction) in host interface mode (upstream), and for router interface mode (downstream), the interface at the end connected in the opposite direction from the tree root.

Within the configuration menu for each interface, the first step is to indicate that it is going to support IGMP. Subsequently, depending on the type of interface (downstream / upstream), you can configure a series of specific parameters (**query-interval**, **robustness-variable**, etc), which have different meanings depending on the selected IGMP version (described in previous sections).

2.2 Configuring IGMP with PIM enabled

Configuring IGMP in a VRF where PIM is enabled requires few requirements. The IGMP proxy cannot coexist with the PIM in the same VRF, so you cannot configure both. Considering the premise that the PIM is enabled in the VRF, only the following step needs to be carried out.

2.2.1 Configuring the downstream interfaces

Firstly, determine which VRF interfaces you can expect the presence of IGMP hosts to enable the router interface (downstream) mode, in their respective configuration menus. There are a set of specific parameters available to modify the protocol behavior and are described in the following sections.

The PIM-SM protocol must also be configured in the interfaces that act as IGMP router, to send incoherencies in the selection of the multicast traffic router for the link and, when the inclusion or exclusion of interfaces in the PIM's Multicast Routing Table (MRT) successfully occurs (where it is the DR).

2.3 IGMP Protocol Configuration Commands

This section describes the available commands in the IGMP configuration menu. This only includes the commands common to the IGMP proxy configuration and to the router operating with PIM and IGMP, excluding the configuration through interfaces (also common to both topologies).

Access the IGMP configuration menu as follows:

```
*config
Config>protocol igmp
-- IGMP protocol user configuration --
IGMP cnfg>
```

The following commands can be found in said menu:

Command	Function
LIST	Displays the IGMP configuration for the VRF.
NO	Disables an option.
SSM-AWARE	Adapts the IGMP protocol so it supports RFC 4604.

VRF	Selects the VRF where the IGMP is going to be configured.
EXIT	Exits the IGMP configuration menu.

The **vrf** command requires a special mention as it is used to access the IGMP configuration menu itself for the selected VRF:

```
IGMP cnfg>vrf <vrf_name>

IGMP vrf cnfg>
```

The commands available in the VRF's own configuration are the same as those for the main VRF (with the exception of the **vrf** command, which is no longer valid).

Command	**Function**
LIST	Displays the IGMP configuration for the VRF.
NO	Disables an option.
SSM-AWARE	Adapts the IGMP protocol so it supports RFC 4604.
EXIT	Exits the IGMP configuration menu.

2.3.1 LIST

Displays the IGMP configuration for the VRF.

Syntax:

```
IGMP cnfg>list
```

Example:

```
IGMP cnfg>list

IGMP protocol configured for PIM
IGMP proxy is disabled

IGMP is SSM-aware: range 232.0.0.0/8

   Interface        Mode     IGMP version  RV   QI    QRI    LMQI   Acc
---------------  ----------  ------------  --  ----  -----  ------  ---
ethernet0/1      downstream        3        2   125   10.0     1.0   no
ethernet0/1.7    downstream        3        2   125   10.0     1.0   no

IGMP cnfg>
```

The meaning of the fields that appear in the table is as follows:

Interface	Identifier of the interface connected to the multicast tree.
Mode	Type of connection within the tree: towards the root (upstream) or in opposite direction (downstream).
IGMP version	Number of the IGMP version enabled in the interface.
RV	Robustness Variable: number of transmissions to prevent packet loss.
QI	Query Interval: interval(s) between general IGMP *query* transmissions.
QRI	Query Response Interval: maximum time for response(s) to general IGMP queries.
LMQI	Last Member Query Interval: interval(s) between sending specific query messages from the group.
Acc	Multicast groups that hosts under a router interface can join.

2.3.2 [NO] SSM-AWARE

Modifies the behavior of the IGMP protocol complying with RFC 4604: “Using IGMPv3 and MLDv2 for Source-Specific Multicast” (SSM). According to said RFC, the IGMP behavior is altered for the SSM range of addresses, which IANA has defined as the 232.0.0.0/8 range. As of now, the use of IGMP versions prior to IGMPv3 is not permitted. Given that the upstream interfaces do not currently support IGMPv3, behavior for the SSM range has not been modified, while the downstream interfaces can act complying with the RFC. Therefore, a proxy-IGMP will have SSM-aware downstream interfaces, while upstream interfaces do not.

Default is option enabled. IGMP is SSM-aware. To disable this behavior, configure it and insert the word **no** in front of the command.

Syntax:

```
IGMP proxy cnfg>[no] ssm-aware
```

Example:

```
IGMP cnfg>no ssm-aware
IGMP cnfg>show menu
; Showing Menu Configuration for access-level 15 ...

      no ssm-aware
IGMP cnfg>ssm-aware
IGMP cnfg>show menu
; Showing Menu Configuration for access-level 15 ...

IGMP cnfg>
```

2.3.3 EXIT

Exits the IGMP own protocol configuration environment for the VRF and returns to the previous configuration prompt.

Syntax:

```
IGMP cnfg>exit
```

Example:

```
IGMP cnfg>exit
Config>
```

2.4 IGMP Proxy Configuration Commands

This section describes the commands used in the IGMP Proxy configuration. These configuration commands must be entered at the IGMP Proxy configuration prompt.

Enter the following to access the IGMP Proxy configuration environment located in the IP protocol menu:

```
*config

Config>protocol ip
-- Internet protocol user configuration --
IP config>proxy-igmp
-- IGMP proxy user configuration --
IGMP proxy cnfg>
```

If the VRF where you want to configure the proxy is not the main VRF, first access the specific VRF menu in the IP protocol menu:

```
*config

Config>protocol ip
-- Internet protocol user configuration --
IP config>vrf <vrf_name>

IP vrf config>proxy-igmp
-- IGMP proxy user configuration --
IGMP proxy vrf cnfg>
```

The following commands are available in the IGMP Proxy configuration environment:

Command	Function
DISABLE	Disables the IGMP Proxy.
ENABLE	Enables the IGMP Proxy.
LIST	Displays the configuration.
EXIT	Exits the IGMP Proxy configuration environment.

2.4.1 DISABLE

Disables the IGMP Proxy function.

Syntax:

```
IGMP proxy cnfg>disable
```

Example:

```
IGMP proxy cnfg>disable
IGMP proxy cnfg>
```

Default is IGMP Proxy disabled.

2.4.2 ENABLE

Enables the IGMP Proxy function. This is not permitted if the PIM protocol is enabled in the same VRF.

Syntax:

```
IGMP proxy cnfg>enable
```

Example:

```
IGMP proxy cnfg>enable
IGMP proxy cnfg>list
IGMP proxy is enabled
IGMP is SSM-aware: range 232.0.0.0/8

No configured interfaces
IGMP proxy cnfg>
```

2.4.3 LIST

Displays the IGMP configuration.

Syntax:

```
IGMP proxy cnfg>list
```

Example:

```
IGMP proxy cnfg>list
IGMP proxy is enabled
IGMP is SSM-aware: range 232.0.0.0/8

   Interface        Mode     IGMP version  RV   QI    QRI    LMQI   Acc
---------------  ----------  ------------  --  ----  -----  ------  ---
ethernet0/0      downstream        3        5    50    1.5     1.0    1
serial0/0         upstream         2       --  ----  -----  ------  ---
serial0/1        downstream        2        2   150   20.0     2.0    1
serial0/2        downstream        1        2   130   11.0     1.5   no
IGMP proxy cnfg>
```

The meaning of each of the fields is the same as that explained for the **list** command in the IGMP protocol configuration menu.

2.4.4 EXIT

Exits the IGMP Proxy configuration environment and returns to the previous configuration prompt.

Syntax:

```
IGMP proxy cnfg>exit
```

Example:

```
IGMP proxy cnfg>exit
IP config>
```

2.5 IGMP Configuration Commands per Interface

Finally we are going to explain the IGMP configuration to be executed per interface, which remains in the set of the interface's IP parameters.

Firstly, enter in the interface's own configuration menu. Given that each interface is associated to a VRF, you don't need to specify it. In the following example an ethernet0/0 interface is used:

```
*config

Config>network ethernet0/0

-- Ethernet Interface User Configuration --
ethernet0/0 config>ip igmp ?
  downstream    Downstream interface configuration
  upstream      Upstream interface configuration
ethernet0/0 config>
```

The IGMP configuration commands per interface always take the words **ip igmp**. As we have seen in the help (with the ? question mark), the following options are available to configure IGMP:

Options	Function
DOWNSTREAM	Configures each of the router interfaces. In a proxy, these are not towards multicast tree root.
NO	Configures the default value for a determined option.
UPSTREAM	Configures the host interface, In a proxy this is towards multicast tree root.

2.5.1 Downstream

Configures the VRF interface as router interface. In the proxy IGMP, this is applied to each one of the interfaces in the opposite direction to the multicast tree root. In a configuration with PIM, this is the only interface mode that makes sense.

Syntax:

```
iface cnfg>ip igmp downstream [options]
  default                       Set default configuration
  access-group                  Multicast groups that hosts can join
  last-member-query-interval    Interval between Specific Queries
  query-interval                Interval between General Queries
  query-response-interval       Max Response Time for General Queries
  robustness-variable           Number of transmissions to prevent packet loss
  version                       Igmp version number

iface cnfg>
```

- *<iface>* name of the router interface to configure.

If you don't specify any option on the console, the system will use the default option.

The options available are described below:

2.5.1.1 DOWNSTREAM DEFAULT

Assigns the default configuration to the specified router interface.

Syntax:

```
iface cnfg>ip igmp downstream default
```

Example:

```
ethernet0/0>ip igmp downstream default
ethernet0/0 config>exit
Config>protocol igmp

-- IGMP protocol user configuration --
IGMP cnfg>list

IGMP proxy is enabled

IGMP is SSM-aware: range 232.0.0.0/8

   Interface        Mode     IGMP version  RV   QI    QRI    LMQI   Acc
---------------  ----------  ------------  --  ----  -----  ------  ---
ethernet0/0      downstream        3        2   125   10.0     1.0   no

IGMP cnfg>
```

2.5.1.2 DOWNSTREAM ACCESS-GROUP

Configures the multicast groups the hosts connected under this router interface can join. The multicast groups are specified through an access list, which only allows multicast addresses for required groups. For further information on configuring said access list, please see manual bintec Dm752-I Access Control.

Syntax:

```
iface cnfg>ip igmp downstream access-group <access list>
```

Example:

```
ethernet0/0 cnfg>ip igmp downstream access-group 1
ethernet0/0 cnfg>
```

Default configuration is no access list with multicast groups associated to the router interface.

2.5.1.3 DOWNSTREAM LAST-MEMBER-QUERY INTERVAL

Sets the temporary interval in tenths of a second between specific IGMP query transmissions for a determined group or, source+group within the subnet.

Syntax:

```
iface cnfg>ip igmp downstream last-member-query-interval <decs>
```

Example:

```
serial0/1 FR cnfg>ip igmp downstream last-member-query-interval 20
serial0/1 FR cnfg>
```

Default is 1 second.

2.5.1.4 DOWNSTREAM QUERY-INTERVAL

Establishes the temporary interval in seconds between general IGMP *query* transmissions for the subset.

Syntax:

```
iface cnfg>ip igmp downstream query-interval <secs>
```

Example:

```
serial0/1 FR cnfg>ip igmp downstream query-interval 150
serial0/1 FR cnfg>
```

Default is 125 seconds.

2.5.1.5 DOWNSTREAM QUERY-RESPONSE-INTERVAL

Establishes the maximum query response time in tenths of seconds to general IGMP *queries*, from the hosts wishing to connect to the multicast subset.

Syntax:

```
iface cnfg>ip igmp downstream query-response-interval
```

Example:

```
serial0/1 FR cnfg>ip igmp downstream query-response-interval 200
serial0/1 FR cnfg>
```

Default is 10 seconds.

2.5.1.6 DOWNSTREAM ROBUSTNESS-VARIABLE

Establishes the maximum number of transmissions to carry out to compensate for possible packet loss in a link.

Syntax:

```
iface cnfg>ip igmp downstream robustness-variable <value>
```

Example:

```
ethernet0/0 cnfg>ip igmp downstream robustness-variable 5
ethernet0/0 cnfg>
```

Default is 2.

2.5.1.7 DOWNSTREAM VERSION

Designates the IGMP version to activate in the router interface. The available options are versions 1, 2 or 3.

Syntax:

```
iface cnfg>ip igmp downstream version <version number>
```

Example:

```
serial0/1 FR cnfg>ip igmp downstream version 2
serial0/1 FR cnfg>
```

Default is IGMP version 3 activated.

2.5.2 NO

The command **no** undoes a command. Deletes the configured information establishing the default value for a parameter.

Syntax:

```
iface cnfg>no ip igmp [downstream | upstream] [option]
```

[option] The only available option is access-group if you want to delete the configuration of multicast groups, available through the router interface (downstream).

Examples:

```
serial0/2 FR cnfg>no ip igmp downstream access-group 1
serial0/2 FR cnfg>
```

To change the downstream / upstream mode for an interface, first deconfigure the previous mode using this command, with the word **no** in front of it and then reconfigure it.

2.5.3 Upstream

Configures the VRF interface as host interface. For a proxy IGMP, these will be the interfaces towards the multicast tree root. Meanwhile, if PIM is enabled in the VRF, it doesn't make sense for an interface to be configured as upstream; the IGMP will not be active.

Syntax:

```
iface cnfg>ip igmp upstream [options]
  default                       Set default configuration
  version                       Igmp version number

iface cnfg>
```

- *<iface>* is the name of the host interface to configure.

If you don't specify any option on the console, the system will use the *default* option.

The options available are described below:

2.5.3.1 UPSTREAM DEFAULT

Assigns the default configuration to the specified host interface.

Syntax:

```
iface cnfg>ip igmp upstream default
```

Example:

```
serial0/0 FR cnfg>ip igmp upstream default
serial0/0 FR cnfg>exit
Config>protocol igmp

-- IGMP protocol user configuration --
IGMP cnfg>list

IGMP proxy is enabled

IGMP is SSM-aware: range 232.0.0.0/8

   Interface        Mode     IGMP version  RV   QI    QRI    LMQI   Acc
---------------  ----------  ------------  --  ----  -----  ------  ---
serial0/0         upstream         2       --  ----  -----  ------  ---

IGMP cnfg>
```

2.5.3.2 upstream version

Designates the IGMP version to activate in the host interface. The options available are versions 1 or 2 (version 3 is not currently supported).

Syntax:

```
iface cnfg>ip igmp upstream version <version number>
```

Example:

```
serial0/1 FR cnfg>ip igmp upstream version 1
serial0/1 FR cnfg>
```

Default configuration is IGMP version 2 activated.

Chapter 3 Monitoring

3.1 Monitoring IGMP

IGMP monitoring is in charge of displaying information relative to the VRF operation with respect to the IGMP in the interfaces where this is enabled.

This section summarizes and explains all the IGMP monitoring commands. These commands allow monitoring the IGMP behavior and, consequently, can reach the desired operating specifications.

To access the IGMP monitoring menu, introduce the following commands:

```
*monitor
Console Operator
+protocol igmp
-- IGMP protocol monitor --
IGMP+
```

If you wish to access a VRF that is not the main one (where IGMP is active), this must be specified with the **vrf** command following by the VRF name. If IGMP is not enabled in the VRF, then you cannot access the IGMP monitoring menu for the VRF even if said VRF exists.

```
IGMP+vrf <vrf name>
-- IGMP protocol monitor --
IGMP vrf+
```

You can also access IGMP monitoring from the IGMP proxy menu located within the IP monitoring menu (for the main VRF and for the other VRFs). The differences in the monitoring menu for IGMP are minimal; therefore no difference has been made when explaining the commands from one menu or another. For the main VRF, this is the commands sequence:

```
+protocol ip
-- IP protocol monitor --
IP+proxy-igmp
-- IGMP proxy monitor --
IGMP proxy+
```

For the other VRF:

```
IP+vrf <vrf name>
-- IP protocol monitor for a VRF --
IP vrf+proxy-igmp
-- IGMP proxy monitor --
IGMP proxy vrf+
```

3.2 IGMP Monitoring Commands

The following options appear at the IGMP monitoring prompt.

```
IGMP +?
  clear    Delete statistics
  list     Show protocol information
  vrf      IGMP monitoring in a VPN Routing/Forwarding instance
  exit
IGMP +
```

Command	Function
CLEAR	Deletes the statistics from the interfaces with IGMP functions enabled.
LIST	Lists the distinct information referring to the current status of the IGMP, as well as its groups, including statistics for the latter.
VRF	Selects another VRF instance where the IGMP function is monitored.
EXIT	Exits IGMP monitoring.

3.2.1 CLEAR

Run **clear** to initialize statistics relative to IGMP for interfaces with this protocol.

Syntax:

```
IGMP +clear ?
  interface     Delimitate to an enabled interface
  statistics    Protocol statistics
IGMP +
```

3.2.1.1 CLEAR INTERFACE

Deletes the statistics from the specified router interface relative to the number of times a host or various hosts has joined a multicast group, whose source is connected to the host interface of the router itself.

Syntax:

```
IGMP+clear interface statistics <interface>
```

- *<interface>* the interface name whose statistics you wish to delete.

Example:

```
IGMP +clear interface statistics serial0/0
IGMP +list all

IGMP proxy is ENABLED

IGMP is SSM-aware: range 232.0.0.0/8

IGMP interface status (U - Upstream, D - Downstream, * - Other querier)
Interface      Flags   Version  Groups  Joins   Querier          Querier uptime

ethernet0/0    U up    igmpv2   5       -----   0.0.0.0          24m30s

                     serial0/0      D up    igmpv3   5       0       192.168.1.1      24m24s
serial0/1      D up    igmpv3   1       3       192.168.15.1     20m54s

IGMP group membership
Group address    Interface      Uptime  Expires   Last Reporter
224.0.1.24       ethernet0/0    24m16s  --------  ---------------
224.0.1.24       serial0/0      24m16s  00:03:25  192.168.1.2
224.0.1.60       ethernet0/0    24m22s  --------  ---------------
224.0.1.60       serial0/0      24m22s  00:03:28  192.168.1.2
224.165.15.167   ethernet0/0    17s     --------  ---------------
224.165.15.167   serial0/0      17s     00:04:10  192.168.1.2
227.0.0.2        ethernet0/0    24m21s  --------  ---------------
227.0.0.2        serial0/0      24m21s  00:03:30  192.168.1.2
239.255.255.250  ethernet0/0    24m25s  --------  ---------------
239.255.255.250  serial0/0      24m25s  00:03:29  192.168.1.2
224.12.55.50     ethernet0/0    20m55s  --------  ---------------
224.12.55.50     serial0/1      20m55s  00:03:09  192.168.15.2
IGMP +
```

3.2.1.2 CLEAR STATISTICS

Deletes the IGMP statistics (number of ‘joins’ to multicast groups) for ALL the configured router interfaces.

Syntax:

```
IGMP +clear statistics
```

Example:

```
IGMP +clear statistics
IGMP +list all

IGMP proxy is ENABLED
```

```
IGMP is SSM-aware: range 232.0.0.0/8

IGMP interface status (U - Upstream, D - Downstream, * - Other querier)
Interface      Flags   Version  Groups  Joins   Querier          Querier uptime
ethernet0/0    U up    igmpv2   5       -----   0.0.0.0          24m30s

                     serial0/0      D up    igmpv3   5       0       192.168.1.1      24m24s

                     serial0/1      D up    igmpv3   1       0       192.168.15.1     20m54s

IGMP group membership
Group address    Interface      Uptime  Expires   Last Reporter
224.0.1.24       ethernet0/0    24m16s  --------  ---------------
224.0.1.24       serial0/0      24m16s  00:03:25  192.168.1.2
224.0.1.60       ethernet0/0    24m22s  --------  ---------------
224.0.1.60       serial0/0      24m22s  00:03:28  192.168.1.2
224.165.15.167   ethernet0/0    17s     --------  ---------------
224.165.15.167   serial0/0      17s     00:04:10  192.168.1.2
227.0.0.2        ethernet0/0    24m21s  --------  ---------------
227.0.0.2        serial0/0      24m21s  00:03:30  192.168.1.2
239.255.255.250  ethernet0/0    24m25s  --------  ---------------
239.255.255.250  serial0/0      24m25s  00:03:29  192.168.1.2
224.12.55.50     ethernet0/0    20m55s  --------  ---------------
224.12.55.50     serial0/1      20m55s  00:03:09  192.168.15.2
IGMP +
```

3.2.2 LIST

Run **list** to view the various IGMP dynamic parameters, e.g. statistics (global and own) for each specific multicast group.

Syntax:

```
IGMP +list ?
  all          All the information
  detailed     Detailed information
  groups       Information about one or all multicast groups
  interface    Delimitate to an enabled interface
  mode         IGMP operating mode
  status       Interface configuration and activity
IGMP +
```

3.2.2.1 LIST ALL

Displays ALL generic information on the current status of the IGMP.

Syntax:

```
IGMP +list all
```

Example:

```
IGMP +list all

IGMP proxy is ENABLED

IGMP is SSM-aware: range 232.0.0.0/8

IGMP interface status (U - Upstream, D - Downstream, * - Other querier)
Interface      Flags   Version  Groups  Joins   Querier          Querier uptime
ethernet0/0    D up    igmpv3   5       6       172.24.73.22     12m9s
serial0/0      U up    igmpv2   5       -----   192.168.1.1      11m55s

IGMP group membership
Group address    Interface      Uptime  Expires   Last Reporter
224.0.1.24       ethernet0/0    12m7s   00:03:13  172.24.0.25
224.0.1.24       serial0/0      12m7s   --------  ---------------
224.0.1.60       ethernet0/0    12m6s   00:03:11  172.24.0.22
```

```
224.0.1.60       serial0/0      12m6s   --------  ---------------
224.165.15.167   ethernet0/0    8m30s   00:03:15  172.24.51.104
224.165.15.167   serial0/0      8m30s   --------  ---------------
227.0.0.2        ethernet0/0    12m7s   00:03:14  172.24.51.127
227.0.0.2        serial0/0      12m8s   --------  ---------------
239.255.255.250  ethernet0/0    12m10s  00:03:16  172.24.51.205
239.255.255.250  serial0/0      12m10s  --------  ---------------

IGMP +
```

The meaning of each of the fields is as follows:

- *IGMP interface status*

Interface	Interface identifier where the IGMP is enabled.
Flags	Type of IGMP interface (Upstream/Downstream) and the status (Up/Down/ etc.).
Version	IGMP version active in the interface.
Groups	Number of multicast groups accessible through said interface.
Joins	Indicates the number of times one or various hosts have joined a multicast group, whose source is accessible through the referent interface.
Querier	IP address of the router interface launching IGMP queries in the multicast segment said interface is connected to.
Querier uptime	The time the *IGMP Querier* has been active in the multicast segment said interface is connected to.

- *IGMP group membership*

Group address	IP address for the multicast groups accessible through IGMP.
Interface	Interface identifier where IGMP is enabled.
Uptime	Time the multicast transmission through IGMP has been active.
Expires	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or remain joined) to the multicast group announced in the IGMP query, before this expires.
Last Reporter	IP address of the last host who remitted information (*IGMP report*) to the router interface with the devices interested in joining the multicast group referred to in the first field.

3.2.2.2 LIST DETAILED

Displays detailed information relative to the active multicast groups, interfaces with enabled IGMP and the status of the IGMP.

Syntax:

```
IGMP +list detailed ?
  all          All the information
  groups       Information about one or all multicast groups
  interface    Delimitate to an enabled interface
  status       Interface configuration and activity
IGMP +
```

3.2.2.2.1 LIST DETAILED ALL

Displays ALL detailed information regarding the configuration of interfaces with IGMP enabled, the active multicast groups through IGMP and the status of this.

Syntax:

```
IGMP +list detailed all
```

Example:

```
IGMP +list detailed all
IGMP proxy is ENABLED
IGMP is SSM-aware: range 232.0.0.0/8
IGMP interface status
---------------------
```

```
Interface:              ethernet0/0
Mode:                   downstream
Status:                 up
Version:                igmpv3
Groups:                 1
Joins:                  1
Inbound access-group:   1
Robustness:             2
Query interval:         125 secs
Querier timeout:        255 secs
Query max resp time:    10.0 secs
Last member qry intvl:  1.0 secs
Querier:                172.24.73.22 (this system)
Querier uptime:         1h1m
Querier expiry time:    00:00:00

Interface:              serial0/0
Mode:                   upstream
Status:                 up
Version:                igmpv2
Groups:                 1
Querier:                192.168.1.1
Query max resp time:    10.0 secs
Querier uptime:         1h1m

IGMP group membership
---------------------
Interface:              ethernet0/0
Group:                  224.165.15.167
Uptime:                 1h1m
Last reporter:          172.24.51.104
Expires:                00:03:37
Version:                igmpv2
Version 1 host timer:   00:00:00
Version 2 host timer:   00:03:37
Group mode:             EXCLUDE
Group source list
  Source Address   Uptime  Expires
  172.24.51.128    1h1m    00:03:37

Interface:              serial0/0
Group:                  224.165.15.167
Uptime:                 1h1m

IGMP +
```

The meaning of each of the fields is as follows:

- *IGMP interface status*

Interface	Interface identifier where the IGMP is enabled.
Mode	Type of IGMP interface depending on whether this is connected in the direction of the multicast tree root (upstream) or the opposite direction (downstream).
Status	Status of the interface with IGMP activated (up/down/etc.).
Version	IGMP version active in the interface.
Groups	Number of multicast groups accessible through said interface.
Joins	Indicates the number of times one or various hosts have joined a multicast group whose source is accessible through said interface.
Inbound acces-group	Identifier for the list of multicast groups, which the connected hosts can join under this router interface.
Robustness	Maximum number of transmissions to carry out to compensate for possible loss of packets in a link.
Query interval	Temporary interval between general IGMP query transmissions for the subnet.
Querier timeout	Total maximum time before the *querier* (monitored device) assumes a general IG-

	MP query has expired.
Query max resp time	Maximum response time to the general IGMP queries, for hosts interested in connecting to the multicast subnet.
Last member qry intvl	Temporary interval between specified IGMP queries sending for a determined group or group-source within the subnet.
Querier	IP address of the router interface launching IGMP queries in the multicast segment said interface is connected to.
Querier uptime	The time the *IGMP Querier* has been active in the multicast segment said interface is connected to.
Querier expiry time	Total maximum time before the *querier* (different from the router being monitored) assumes a general IGMP query has expired.

- *IGMP group membership*

Interface	Interface identifier where the IGMP is enabled.
Group	IP address for the multicast groups accessible through the IGMP.
Uptime	Time the multicast transmission through IGMP has been active.
Last Reporter	IP address of the last host who remitted information (*IGMP report*) to the router interface with the devices interested in joining the multicast group referred to in the first field.
Expires	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or continued joined to) to the multicast group announced in the IGMP query, before this expires.
Version	IGMP version active in the interface.
Version 1 host timer	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or continued joined to) the multicast group announced in an IGMP version 1 query, before this expires.
Version 2 host timer	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or continued joined to) the multicast group announced in an IGMP version 2 query, before this expires.
Group mode	Type of multicast group for packet filtering in the subset. Indicates if the host address list *Group source list* is opt-in (INCLUDE) or opt-out (EXCLUDE).
Group source list	List of hosts interested in being included in or excluded from a multicast group (Group mode: INCLUDE or EXCLUDE respectively).
Source address	Host IP address.
Uptime	Time the host has been joined to the multicast group.
Expires	Time remaining to the host to manifest its interest in remaining joined to the multicast group before the IGMP query expires.

3.2.2.2.2 LIST DETAILED GROUPS [<MULTICAST IP>]

Displays detailed information on the active multicast groups enabled through IGMP.

Syntax:

```
IGMP+list detailed groups [<multicast ip>]
```

<multicast ip> the IP address of the multicast group you wish to list the information for. If this is omitted, information on all active multicast groups is shown.

Example:

```
IGMP +list detailed groups 224.165.15.167

IGMP group membership
---------------------
Interface:            ethernet0/0
Group:                224.165.15.167
Uptime:               1h1m
Last reporter:        172.24.51.104
Expires:              00:03:37
Version:              igmpv2
Version 1 host timer: 00:00:00
Version 2 host timer: 00:03:37
```

```
Group mode:           EXCLUDE
Group source list
  Source Address   Uptime  Expires
  172.24.51.128    1h1m    00:03:37

Interface:            serial0/0
Group:                224.165.15.167
Uptime:               1h1m

IGMP +
```

The meaning of each of the fields is as follows:

Interface	Interface identifier where the IGMP is enabled.
Group	IP address for the multicast groups accessible through the IGMP.
Uptime	Time the multicast transmission through IGMP has been active.
Last Reporter	IP address of the last host who remitted information (*IGMP report*) to the router interface with the devices interested in joining the multicast group referred to in the first field.
Expires	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or remain joined to) the multicast group announced in the IGMP query, before this expires.
Version	IGMP version active in the interface.
Version 1 host timer	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or remain joined to) the multicast group announced in an IGMP version 1 query, before this expires.
Version 2 host timer	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or remain joined to) the multicast group announced in an IGMP version 2 query, before this expires.
Group mode	Type of multicast group for packet filtering in the subset. Indicates if the host address list *Group source list* is opt-in (INCLUDE) or opt-out (EXCLUDE).
Group source list	List of hosts interested in being included in or excluded from a multicast group (Group mode: INCLUDE or EXCLUDE respectively).
Source address	Host IP address.
Uptime	Time the host has been joined to the multicast group.
Expires	Time remaining to the host to manifest its interest in remaining joined to the multicast group before the IGMP query expires.

3.2.2.2.3 LIST DETAILED INTERFACE [ALL | GROUPS | STATUS] <INTERFACE>[<MULTICAST IP>]

When this command includes the term *groups*, detailed information is displayed on one or all of the multicast groups enabled in the specified interface (this includes all groups if <*multicast ip*> is omitted). When *status* is used, information is displayed on the configuration status and the activity of said interface; in this case <*multicast ip*> has not been used. If you select *all*, the information on the status and on the groups associated to the selected interface is displayed; in this case, <*multicast ip*> is not used either.

Syntax:

```
IGMP +list detailed interface [all | groups | status] <interface> [<multicast ip>]
```

Example:

```
IGMP +list detailed interface groups serial0/0 224.165.15.167
IGMP group membership
---------------------
Interface:            serial0/0
Group:                224.165.15.167
Uptime:               1h14m

IGMP >list detailed interface status serial0/0

IGMP interface status
---------------------
Interface:             serial0/0
Mode:                  upstream
Status:                up
```

```
Version:               igmpv2
Groups:                5
Querier:               192.168.1.1
Query max resp time:   10.0 secs
Querier uptime:        1h14m

IGMP +
```

The meaning of each of the fields is as follows:

- *Groups option*

Interface	Interface identifier where the IGMP is enabled.
Group	IP address for the multicast groups accessible through the IGMP.
Uptime	Time the multicast transmission through IGMP has been active.

- *Status option*

Interface	Interface identifier where the IGMP is enabled.
Mode	Type of IGMP interface depending on whether this is connected in the direction of the multicast tree root (upstream) or the opposite (downstream).
Status	Status of the interface with IGMP activated (up/down/etc.).
Version	IGMP version active in the interface.
Groups	Number of multicast groups accessible through said interface.
Querier	IP address of the router interface launching IGMP queries in the multicast segment said interface is connected to.
Query max resp time	Maximum response time to the general IGMP queries, for hosts interested in connecting to the multicast subnet.
Querier uptime	Time the *Querier IGMP* has been active in the multicast structure segment the indicated interface is connected to.

3.2.2.2.4 LIST DETAILED STATUS

Displays detailed information on the IGMP status (configuration of interfaces and activity).

Syntax:

```
IGMP +list detailed status
```

Example:

```
IGMP +list detailed status
IGMP interface status
---------------------
Interface:             ethernet0/0
Mode:                  downstream
Status:                up
Version:               igmpv3
Groups:                6
Joins:                 5
Inbound access-group:  not set
Robustness:            2
Query interval:        125 secs
Querier timeout:       255 secs
Query max resp time:   10.0 secs
Last member qry intvl: 1.0 secs
Querier:               172.24.73.22 (this system)
Querier uptime:        1h43m
Querier expiry time:   00:00:00

Interface:             serial0/0
Mode:                  upstream
Status:                up
Version:               igmpv2
Groups:                5
Querier:               192.168.1.1
Query max resp time:   10.0 secs
```

```
Querier uptime:        1h43m

IGMP +
```

The meaning of each of the fields is as follows:

Interface	Interface identifier where IGMP is enabled.
Mode	Type of IGMP interface depending on whether this is connected in the direction of the multicast tree root (upstream) or the opposite direction (downstream).
Status	Status of the interface with IGMP activated (up/down/etc.).
Version	IGMP version active in the interface.
Groups	Number of multicast groups accessible through said interface.
Joins	Indicates the number of times one or various hosts have joined a multicast group, whose source is accessible through said interface.
Inbound acces-group	Identifier for the list of multicast groups, which the connected hosts can join under this router interface.
Robustness	Maximum number of transmissions to carry out to compensate for possible packet loss in a link.
Query interval	Temporary interval between general IGMP query transmissions for the subnet.
Querier timeout	Total maximum time before the *querier* (monitored device) assumes a general IGMP query has expired.
Query max resp time	Maximum response time to the general IGMP queries, for hosts interested in connecting to the multicast subnet.
Last member qry intvl	Temporary interval between specified IGMP queries sending for a determined group or group-source within the subnet.
Querier	IP address of the router interface launching IGMP queries in the multicast segment said interface is connected to.
Querier uptime	The time the *IGMP Querier* has been active in the multicast segment said interface is connected to.
Querier expiry time	Total maximum time before the *querier* (different from the router being monitored) assumes a general IGMP query has expired.

3.2.2.3 LIST GROUPS

Displays general information on one or all multicast groups enabled in the IGMP.

Syntax:

```
IGMP +list groups [<multicast ip>]
```

If you omit <*multicast ip*>, information on all active multicast groups is displayed.

Example:

```
IGMP +list groups

IGMP group membership
Group address    Interface      Uptime  Expires   Last Reporter
224.0.1.24       ethernet0/0    1h48m   00:04:19  172.24.0.6
224.0.1.24       serial0/0      1h48m   --------  ---------------
224.0.1.60       ethernet0/0    1h48m   00:04:16  172.24.0.32
224.0.1.60       serial0/0      1h48m   --------  ---------------
224.165.15.167   ethernet0/0    1h48m   00:04:19  172.24.51.104
224.165.15.167   serial0/0      1h48m   --------  ---------------
227.0.0.2        ethernet0/0    1h48m   00:04:17  172.24.51.130
227.0.0.2        serial0/0      1h48m   --------  ---------------
228.67.43.91     ethernet0/0    1h21m   00:00:00  0.0.0.0
239.255.255.250  ethernet0/0    1h48m   00:04:19  172.24.4.34
239.255.255.250  serial0/0      1h48m   --------  ---------------

IGMP +
```

The meaning of each of the fields is as follows:

Group address	IP address for multicast groups accessible through the IGMP.

Interface	Interface identifier where IGMP is enabled.
Uptime	Time the multicast transmission through IGMP has been active.
Expires	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or remain joined to) the multicast group announced in the IGMP query, before this expires.
Last Reporter	IP address of the last host who remitted information (*IGMP report*) to the router interface with the devices interested in joining the multicast group referred to in the first field.

3.2.2.4 LIST INTERFACE [<ALL/GROUPS/STATUS>]<INTERFACE>[<MULTICAST IP>]

Displays general information on the interfaces configured to execute IGMP functions.

Syntax:

```
IGMP +list interface [all | groups | status] <interface> [<multicast ip>]
```

The <multicast ip> option is available when you have preselected the groups option and this specifies a specific multicast group. If you omit the former option, then information on all groups is displayed.

Example:

```
IGMP +list interface groups ethernet0/0

IGMP group membership
Group address    Interface      Uptime  Expires   Last Reporter
224.0.1.24       ethernet0/0    4m30s   00:02:27  172.24.0.7
224.0.1.60       ethernet0/0    4m30s   00:02:29  172.24.0.32
224.165.15.167   ethernet0/0    4m24s   00:02:36  172.24.51.104
227.0.0.2        ethernet0/0    4m28s   00:02:28  172.24.51.130
239.255.255.250  ethernet0/0    4m30s   00:02:36  172.24.1.1

IGMP+list interface status ethernet0/0

IGMP interface status (U - Upstream, D - Downstream, * - Other querier)
Interface      Flags   Version  Groups  Joins   Querier          Querier uptime
ethernet0/0    D up    igmpv3   5       5       172.24.73.22     4m55s
IGMP +
```

The meaning of each of the fields is as follows:

- *Groups option*

Interface	Interface identifier where the IGMP is enabled.
Group	IP address for the multicast groups accessible through the IGMP.
Uptime	Time the multicast transmission through IGMP has been active.
Expires	Time remaining to the hosts connected to the router interface to manifest their interest in joining (or remain joined to) the multicast group announced in the IGMP query, before this expires.
Last Reporter	IP address of the last host who remitted information (*IGMP report*) to the router interface with the devices interested in joining the multicast group referred to in the first field.

- *Status option*

Interface	Interface identifier where the IGMP Proxy is enabled.
Flags	Type of IGMP interface depending on whether this is connected in the direction of the multicast tree root (upstream) or the opposite direction (downstream) and its state (up/down/...)..
Version	IGMP version active in the interface.
Groups	Number of multicast groups accessible through said interface.
Querier	IP address of the router interface launching IGMP queries in the multicast segment said interface is connected to.
Query max resp time	Maximum response time to the general *query* messages, for hosts interested in connecting to the multicast subnet.
Querier uptime	The time the *Querier IGMP* has been active in the multicast segment said inter-

	face is connected to.

3.2.2.5 LIST MODE

Displays information on the IGMP operating mode. This also indicates if IGMP is SSM-aware or not.

Syntax:

```
IGMP+list mode
```

Different examples are shown, which depend on the IGMP configuration:

IGMP proxy example:

```
IGMP+list mode
IGMP proxy is ENABLED
IGMP is non-SSM-aware
IGMP+
```

IGMP example when PIM is also enabled:

```
IGMP+list mode
IGMP interacting with PIM
IGMP proxy is DISABLED
IGMP is SSM-aware: range 232.0.0.0/8
IGMP+
```

3.2.2.6 LIST STATUS

Displays general information on the IGMP status and activity.

Syntax:

```
IGMP +list status
```

Example:

```
IGMP +list status
IGMP interface status (U - Upstream, D - Downstream, * - Other querier)
Interface      Flags    Version  Groups  Joins   Querier          Querier uptime
ethernet0/0    D up     igmpv3   5       6       172.24.73.22     12m9s
serial0/0      U up     igmpv2   5       -----   192.168.1.1      11m55s
IGMP +
```

The meaning of each of the fields is as follows:

Interface	Interface identifier where the IGMP is enabled.
Flags	Type of IGMP interface (Upstream/Downstream) and the status (Up/Down/ etc.).
Version	IGMP version active in the interface.
Groups	Number of multicast groups accessible through said interface.
Querier	IP address of the router interface launching IGMP queries in the multicast segment said interface is connected to.
Querier uptime	The time the *Querier IGMP* has been active in the multicast segment said interface is connected to.

3.2.3 EXIT

Run **exit** to return to the prompt level where you were previously located. In this example, this returns you to the general monitoring prompt.

Syntax:

```
IGMP +exit
```

Example:

```
IGMP +exit
+
```

3.3 IGMP Protocol Events

There are multiple events directly related to the IGMP protocol, which provide information on the real time functionality of this.

For further in-depth information on all events, please see the events document *els.rtf*, which is attached in the software distribution.

Chapter 4 Examples

4.1 IGMP Proxy Configuration Example

Assuming the situation of the following figure:

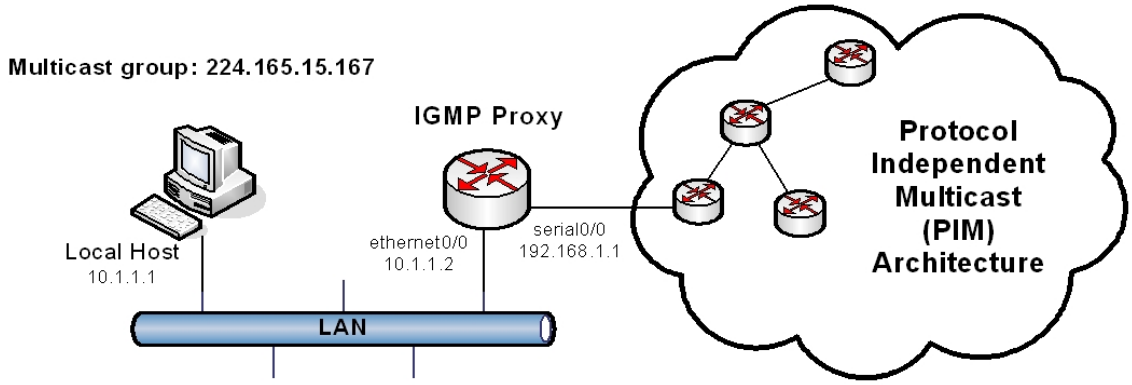

Fig. 10: IGMP Proxy configuration example

We want to configure the router as the IGMP Proxy so the local host can join multicast group 224.165.15.167.

The local area network (LAN) is connected through the *ethernet0/0* interface to the router behaving as IGMP Proxy. In turn, the router is connected to a PIM architecture network (multicast structure in tree format) through interface *serial0/0.*

The steps to take to configure the IGMP Proxy and resolve this situation are described below:

4.1.1 Enabling IGMP Proxy in the router

Access the IGMP Proxy configuration menu and enable its functions.

```
*config

Config>protocol ip
-- Internet protocol user configuration --
IP config>proxy-igmp

-- IGMP proxy user configuration --
IGMP proxy cnfg>enable
IGMP proxy cnfg>
```

4.1.2 Configuring the IGMP Proxy interfaces

Initially define the filter to limit reception and transmission of multicast messages to those pertaining to group 224.165.15.167, using IGMP Proxy. To do this, create an *access-list standard* with said group address.

```
*config

Config>feature access-lists
-- Access Lists user configuration --
Access Lists config>access-list 1

Standard Access List 1>entry 1 source address 224.165.15.167 255.255.255.255
Standard Access List 1>show menu
; Showing Menu Configuration for access-level 15 ...

      entry 1 default
      entry 1 permit
      entry 1 source address 224.165.15.167 255.255.255.255
;
Standard Access List 1>exit
Access Lists config>exit
```

```
Config>
```

Subsequently, access the configuration menus for the membership interfaces to the IGMP Proxy to enable IGMP in them and associate the filter for multicast group 224.165.15.167 to the pertinent interface.

In the *ethernet0/0* interface, the device behaves as a router (*IGMP querier*), executing periodic polls in the LAN (*membership query*) to find out which hosts are interested in joining (or remain joined to) to a multicast group. Consequently, we need to configure the interface as downstream or *router interface*:

```
Config>network ethernet0/0

-- Ethernet Interface User Configuration --
ethernet0/0 config>ip igmp downstream default
```

Additionally we want to limit the multicast traffic to group 224.165.15.167. Therefore we associate the previously created filter to the interface:

```
ethernet0/0 cnfg>ip igmp downstream access-group 1
```

Finally, connect the device to the rest of the multicast network through the *serial0/0* interface. This interface will behave as host towards the PIM architecture network; consequently we must configure this interface as *upstream* or *host interface*:

```
Config>network serial0/0

-- Frame Relay user configuration --
serial0/0 FR config>ip igmp upstream default
```

So, the device, acting as host, remits information to the multicast network indicating “its” attachment (that from host under the subnet connected to the downstream interface) to the multicast group (through *IGMP membership report* messages).

By using the **list** command, the results are as shown below:

```
IGMP proxy cnfg>list

IGMP proxy is enabled
IGMP is SSM-aware: range 232.0.0.0/8

   Interface        Mode     IGMP version  RV   QI    QRI    LMQI   Acc
---------------  ----------  ------------  --  ----  -----  ------  ---
ethernet0/0      downstream        3        2   125   10.0     1.0    1
serial0/0         upstream         2       --  ----  -----  ------  ---
IGMP proxy cnfg>
```

4.1.3 Full Configuration

Once this stage is complete, all that is required now is to save the device configuration (prevent loss) and reboot to activate.

The complete configuration is as follows:

```
no configuration
set data-link frame-relay serial0/0
feature access-lists
; -- Access Lists user configuration --
   access-list 1
      entry 1 default
      entry 1 permit
      entry 1 source address 224.165.15.167 255.255.255.255
   exit
exit
;
network ethernet0/0
; -- Ethernet Interface User Configuration --
   ip address 10.1.1.2 255.255.255.252
;
   ip igmp downstream default
   ip igmp downstream access-group 1
;
exit
```

```
;
network serial0/0
; -- Frame Relay user configuration --
   ip address 192.168.1.1 255.255.255.0
;
   pvc 20 default
;
   ip igmp upstream default
;
   point-to-point-line 20
   no lmi
exit
;
protocol ip
; -- Internet protocol user configuration --
   route 0.0.0.0 0.0.0.0 192.168.1.2
;
   proxy-igmp
; -- IGMP proxy user configuration --
      enable
   exit
;
exit
```

4.2 Configuration example with IGMP and PIM

This new example is similar to the previous one, except that it doesn't require the use of the IGMP proxy:

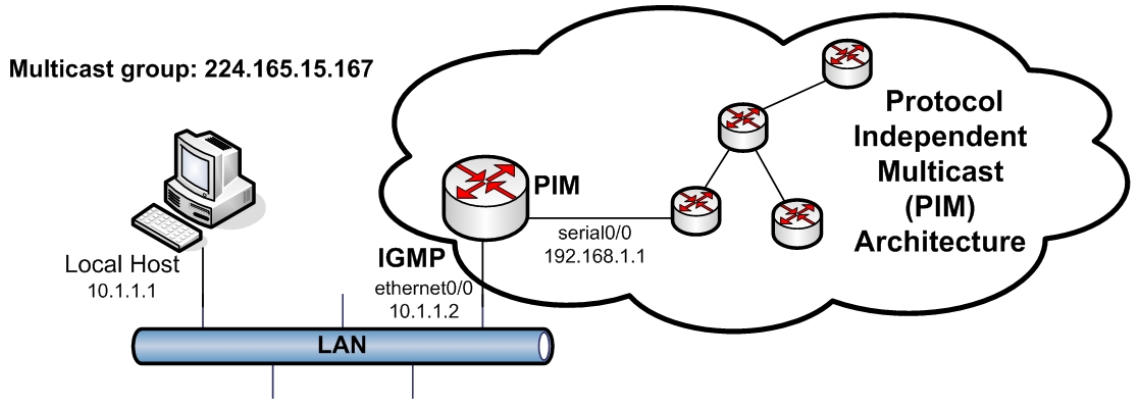

Fig. 11: Configuration example with IGMP and PIM

The router here does not communicate with the PIM architecture through IGMP, as the serial0/0 interfaces has the PIM protocol enabled., therefore the router doesn't implement the IGMP host. The rest of the requirements are the same as in the previous example.

The steps to carry out to configure the router for this scenario are shown below:

4.2.1 Enabling the PIM protocol in the router

Access the PIM protocol configuration menu and enable it:

```
*config

Config>protocol pim
-- PIM protocol user configuration --
PIM Config>enable
PIM Config>
```

4.2.2 Configuring the IGMP router interface

As in the previous example, define a filter to limit the receiving and sending of multicast messages to those from the 224.165.15.167 group, with an *access-list standard* with said group address:

```
*config
```

```
Config>feature access-lists
-- Access Lists user configuration --
Access Lists config>access-list 1

Standard Access List 1>entry 1 source address 224.165.15.167 255.255.255.255
Standard Access List 1>exit
Access Lists config>exit
```

Once again, the ethernet0/0 interface acts as the router (*IGMP querier*), executing periodic polls in the LAN (*membership query)* to discover those hosts who are interesting in joining (or remain joined to) the multicast group. The interface is configured as *downstream* and the access list is associated to limit the multicast traffic to the 224.165.15.167 group:

```
Config>network ethernet0/0

-- Ethernet Interface User Configuration --
ethernet0/0 config>ip igmp downstream default
ethernet0/0 config>ip igmp downstream access-group 1
```

By using the **list** command, the following is seen:

```
IGMP cnfg>list

IGMP protocol configured for PIM
IGMP proxy is disabled

IGMP is SSM-aware: range 232.0.0.0/8

   Interface        Mode     IGMP version  RV   QI    QRI    LMQI   Acc
---------------  ----------  ------------  --  ----  -----  ------  ---
ethernet0/0      downstream        3        2   125   10.0     1.0    1

IGMP cnfg>
```

4.2.3 Configuring PIM in the interfaces

The PIM protocol also needs to be configured in said interfaces, in serial0/0 and in ethernet0/0; at first glance it doesn't appear to be necessary to configure PIM in the ethernet0/0 interface, as there are no other devices that support said protocol in the LAN. However, when PIM is enabled, you must configure PIM in all interfaces that act as IGMP router, as the actions executed by the device from the information from IGMP depends on whether the router is the interface's PIM Designated Router (DR) or not. In the example, the router is the only PIM device in the LAN; consequently it will definitely be established as DR.

```
ethernet0/0 config>ip pim sparse-mode

ethernet0/0 config>exit
Config>network serial0/0

-- Frame Relay user configuration --
serial0/0 FR config>ip pim sparse-mode

serial0/0 FR config>
```

4.2.4 Full Configuration

Save the configuration and reboot the device so the changes are activated.

The complete configuration will look like this:

```
   no configuration
   set data-link frame-relay serial0/0
   feature access-lists
; -- Access Lists user configuration --
      access-list 1
         entry 1 default
         entry 1 permit
         entry 1 source address 224.165.15.167 255.255.255.255
      exit
```

```
   exit
;
   network ethernet0/0
; -- Ethernet Interface User Configuration --
      ip address 10.1.1.2 255.255.255.252
;
      ip igmp downstream default
      ip igmp downstream access-group 1
;
      ip pim sparse-mode
;
   exit
;
   network serial0/0
; -- Frame Relay user configuration --
      ip address 192.168.1.1 255.255.255.0
;
      pvc 20 default
;
      ip pim sparse-mode
;
      point-to-point-line 20
      no lmi
   exit
;
   protocol pim
; -- PIM protocol user configuration --
      enable
;
   exit
;
   protocol ip
; -- Internet protocol user configuration --
      route 0.0.0.0 0.0.0.0 192.168.1.2
;
   exit
```