IGMP for Multicast

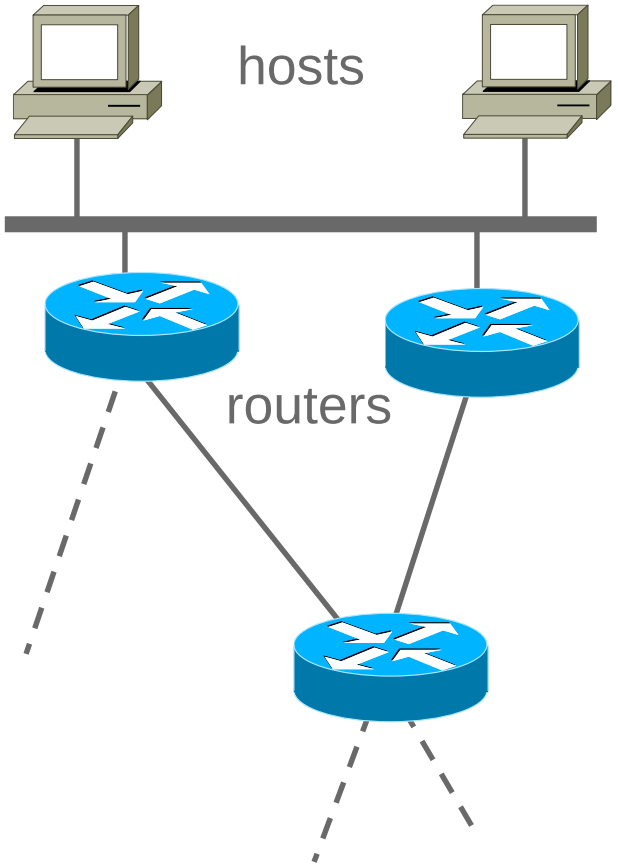
1. Introduction of IGMP
2. IGMPv1
3. IGMPv2
4. IGMPv3

IP Multicast Architecture

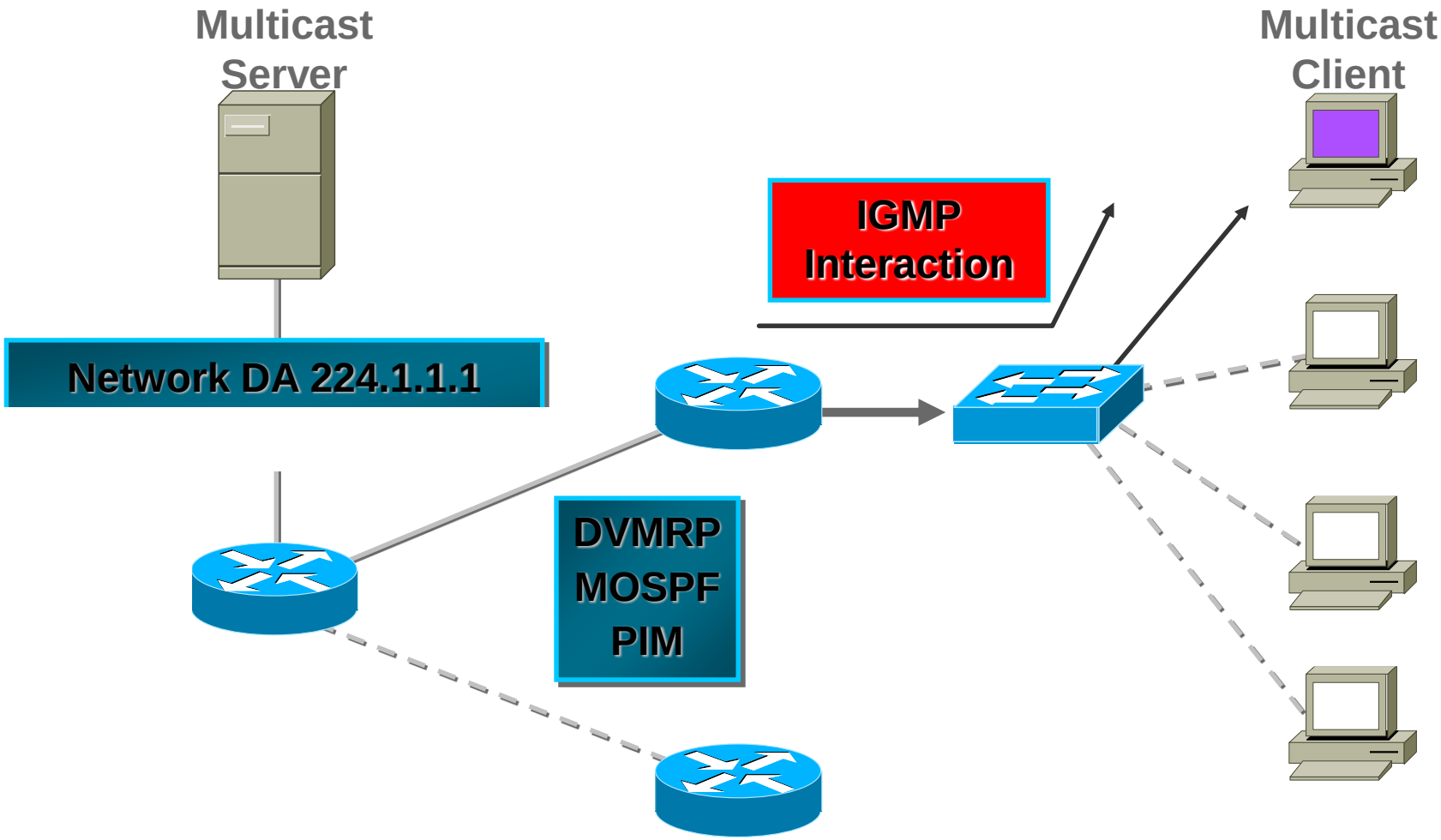
service model

host-to-router protocol
(IGMP)

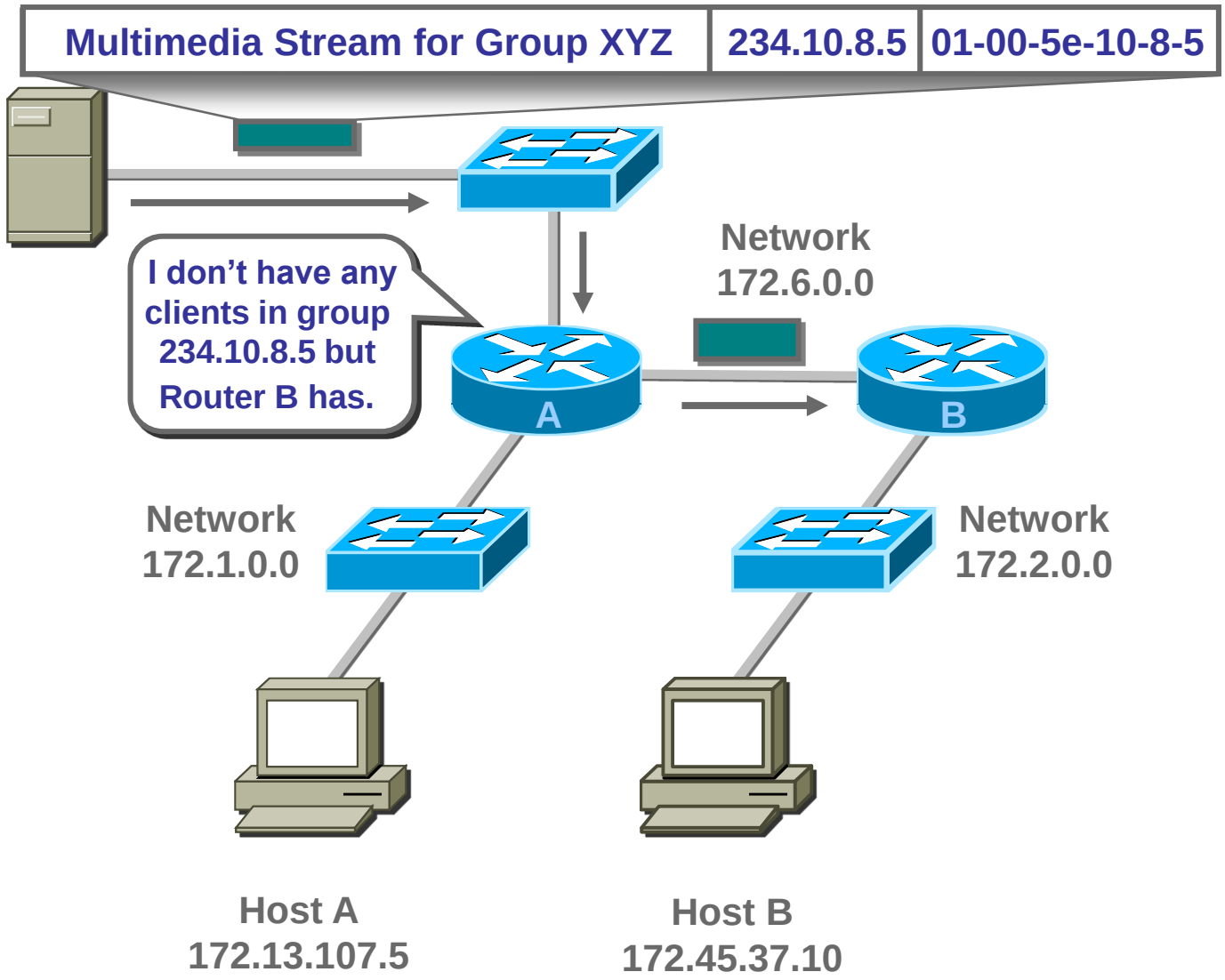
multicast routing protocols
(various)



IP Multicast Elements



Multicast Routing



Reserved address

224.0.0.1 All multicast systems

224.0.0.2 All multicast routers

224.0.0.4 DVMRP

224.0.0.5 OSPF All Routers

224.0.0.6 OSPF Designated Router

224.0.0.9 RIP2 Routers

224.0.0.13 PIM Routers

224.0.0.22 IGMPv3 Report

IGMP

- Internet Group Management Protocol
- End system reports their IP multicast group memberships to any neighboring routers
- Objective is to keep router up-to-date with group membership of entire LAN
- Routers need not know who all the members are, only that members exist

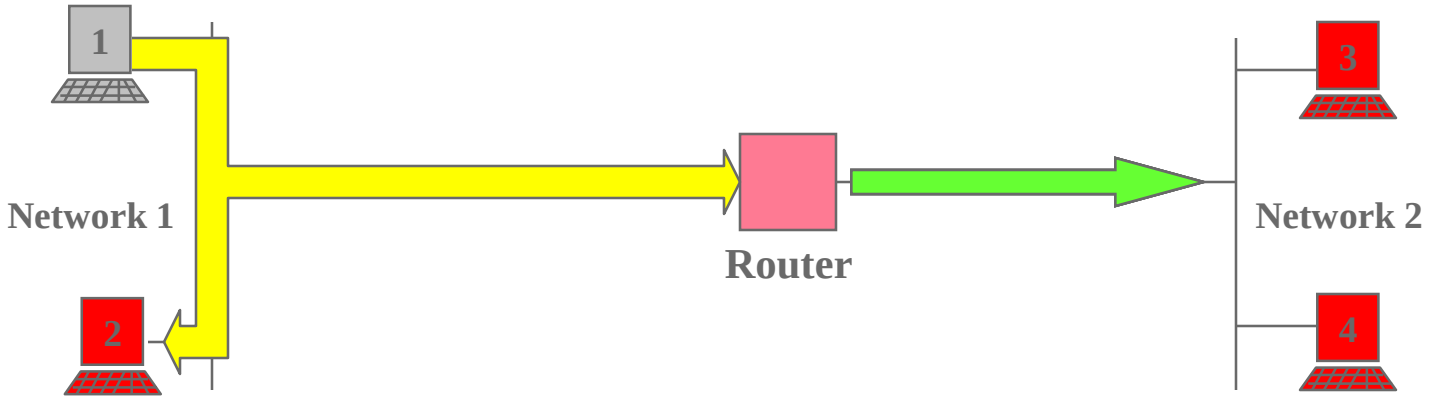
IGMP versions

- **Version 1**, specified in [RFC-1112], was the first widely-deployed version and the first version to become an Internet Standard.

- **Version 2**, specified in [RFC-2236], added support for "low leave latency", that is, a reduction in the time it takes for a multicast router to learn that there are no longer any members of a particular group present on an attached network.

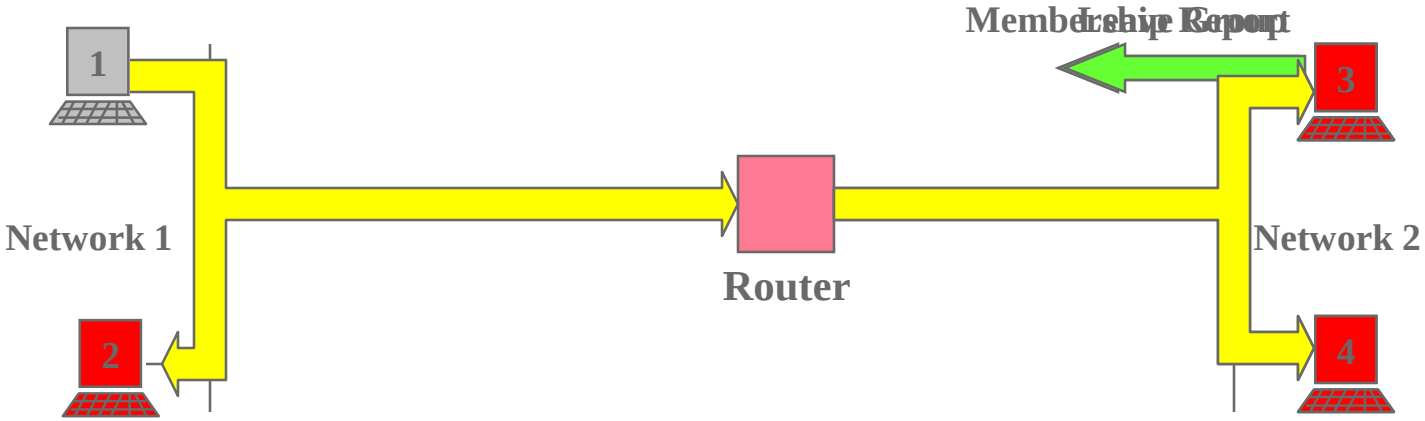
- **Version 3**, specified in [RFC-3376], adds support for "source filtering", that is, the ability for a system to report interest in receiving packets *only* from specific source addresses, or from *all but* specific source addresses, sent to a particular multicast address.

IGMP Example (1)



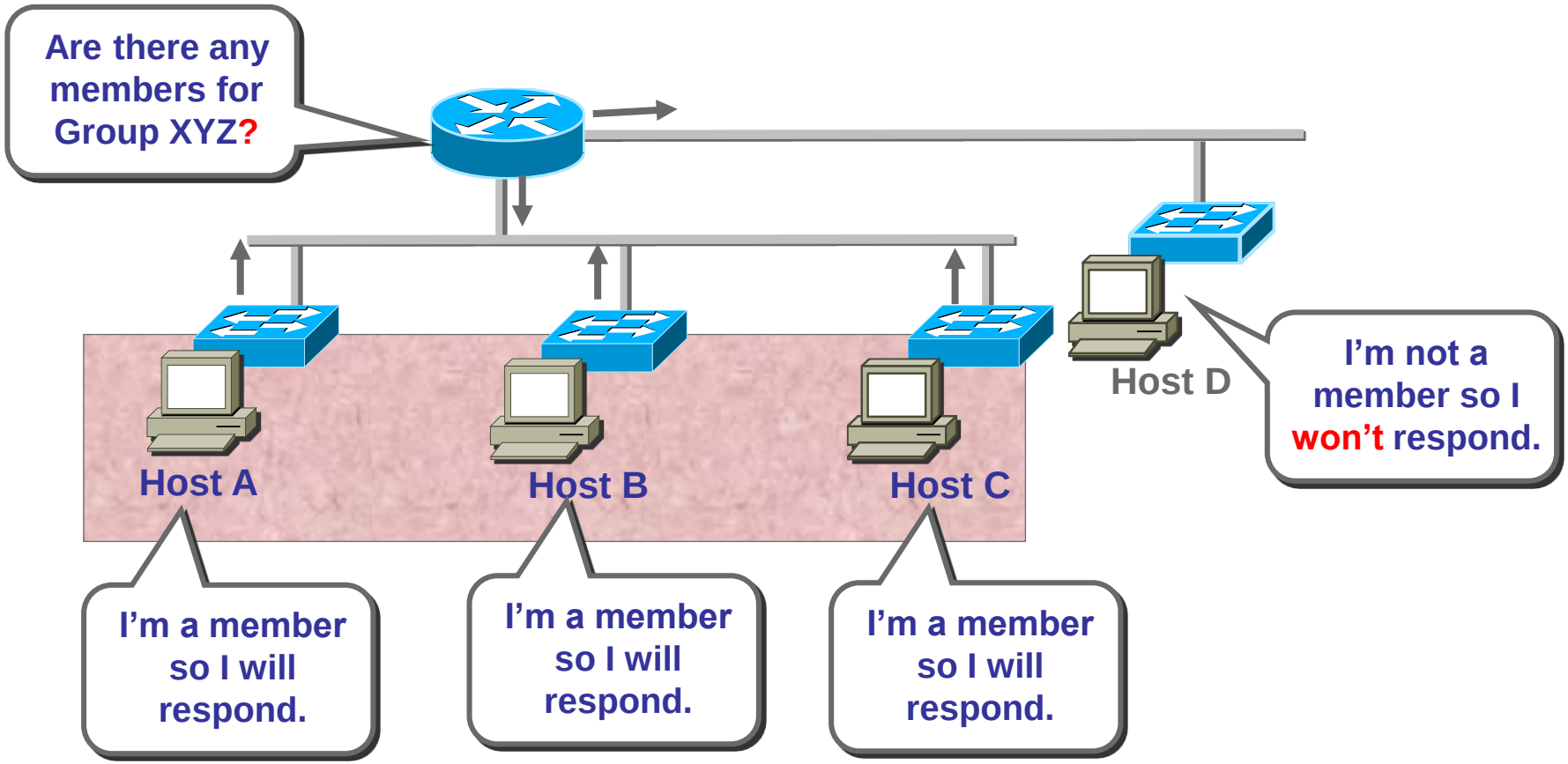
- **Host 1：as resource; Host 3:want to be a membership of this group**
- **Host 1 begins sending packets**
  - No IGMP messages sent
  - Packets remain on Network 1
- **Router periodically sends IGMP Membership Query**

IGMP Example (2)



- **Host 3 joins conference**
  - Sends IGMP Membership Report message
- **Router begins forwarding packets onto Network 2**
- **Host 3 leaves conference**
  - Sends IGMP Leave Group message
  - Only sent if it was the last host to send an IGMP Membership Report message

Group Membership

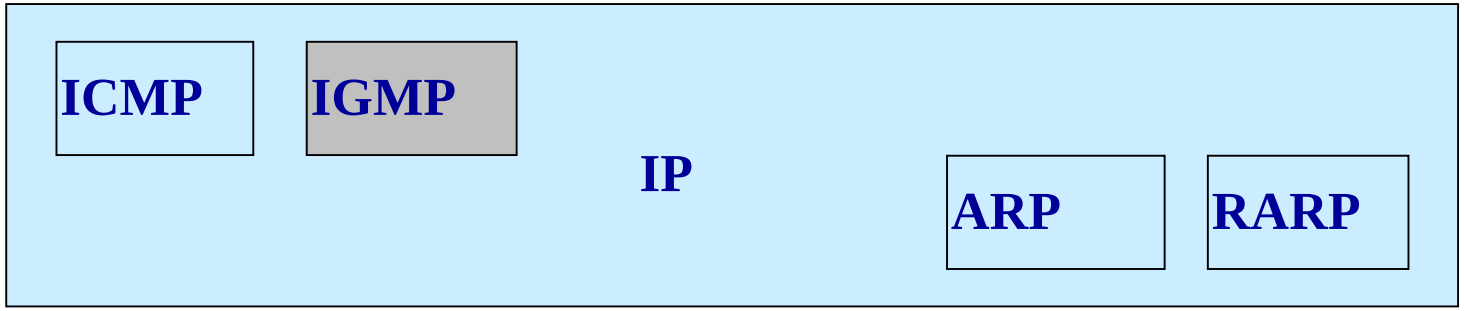


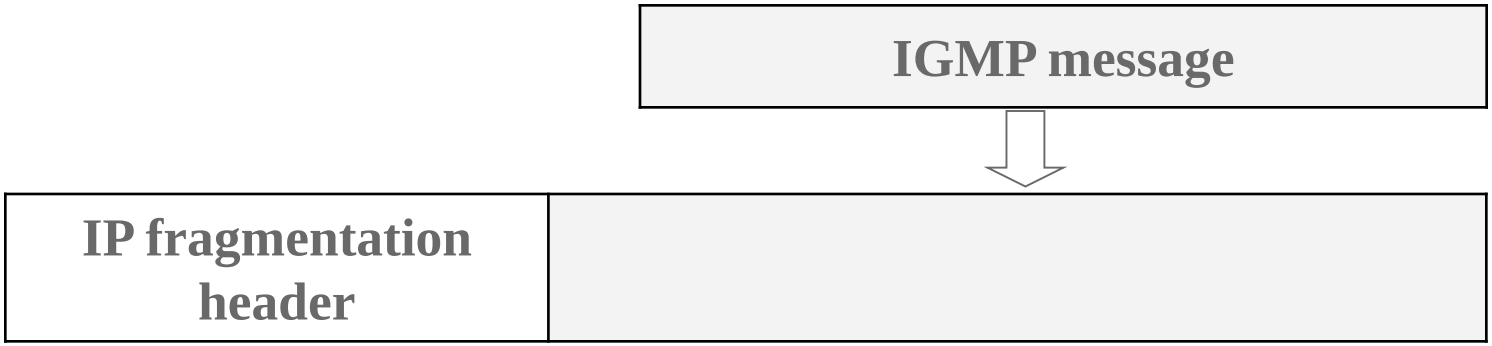
- Multicast uses query and report messages to establish and maintain group membership

IGMP packet encapsulation

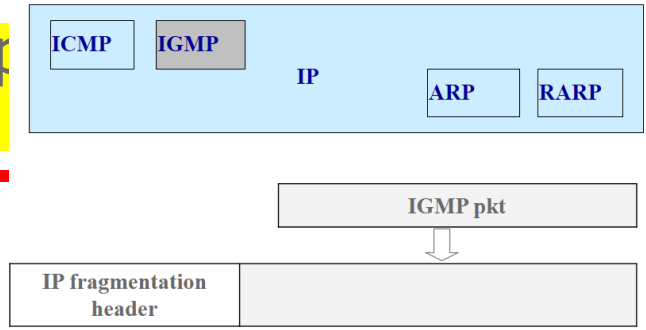
- IGMP messages are encapsulated in IP datagrams, with an IP protocol number of 2
- All IGMP messages are sent with IP TTL 1
- Message Type — Destination Group
  - *General Query — ALL-SYSTEMS (224.0.0.1)
  - *Group-Specific Query — The group being queried
  - *Membership Report — The group being reported
  - *Leave Message — ALL-ROUTERS (224.0.0.2)
  - *V3 Report — 224.0.0.22

IGMP's location in TCP/IP





The three fields that encapsulate the IP p IGMP message



- **TYPE**，**value is 2**，the encapsulated IGMP message is an IGMP message .
- **TTL**，**is 1**，Indicates that IGMP messages can only be transmitted on this network.
- **Destination IP ADDR.**，Its value varies by message type

✓If it is a membership query message, the destination IP address is 224.0.0.1 (all nodes on the network);

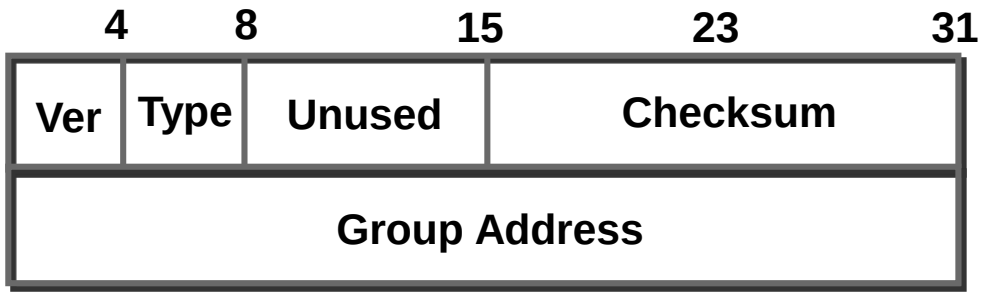
✓If it is a member report message, the destination IP address is the reported multicast address;

✓If it is leaving a group message, the destination IP address should be 224.0.0.2 (all routers on the network).

IGMPv1

- 1 message format of IGMPv1
- 2 The process by which a host joins and leaves a group
- 3 IGMPv1 query - response process
- 4 report suppress
- 5 Query router elections

IGMPv1—Packet Format

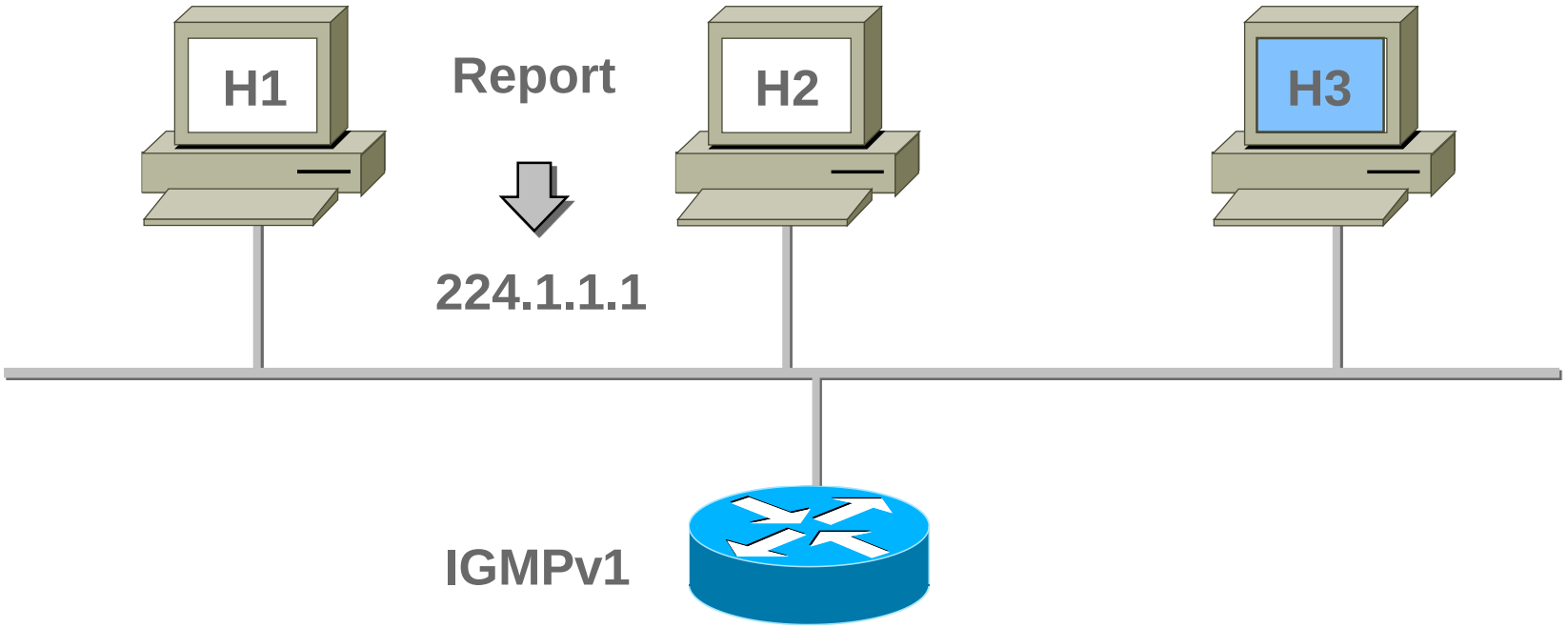


- Ver = 1
- Type:
  - 1 = Host Membership Query,
    2 = Host Membership Report,
- Group Address:
  - Multicast Group Address
  - 0.0.0.0 for General Queries

Group address field, 32 bits.

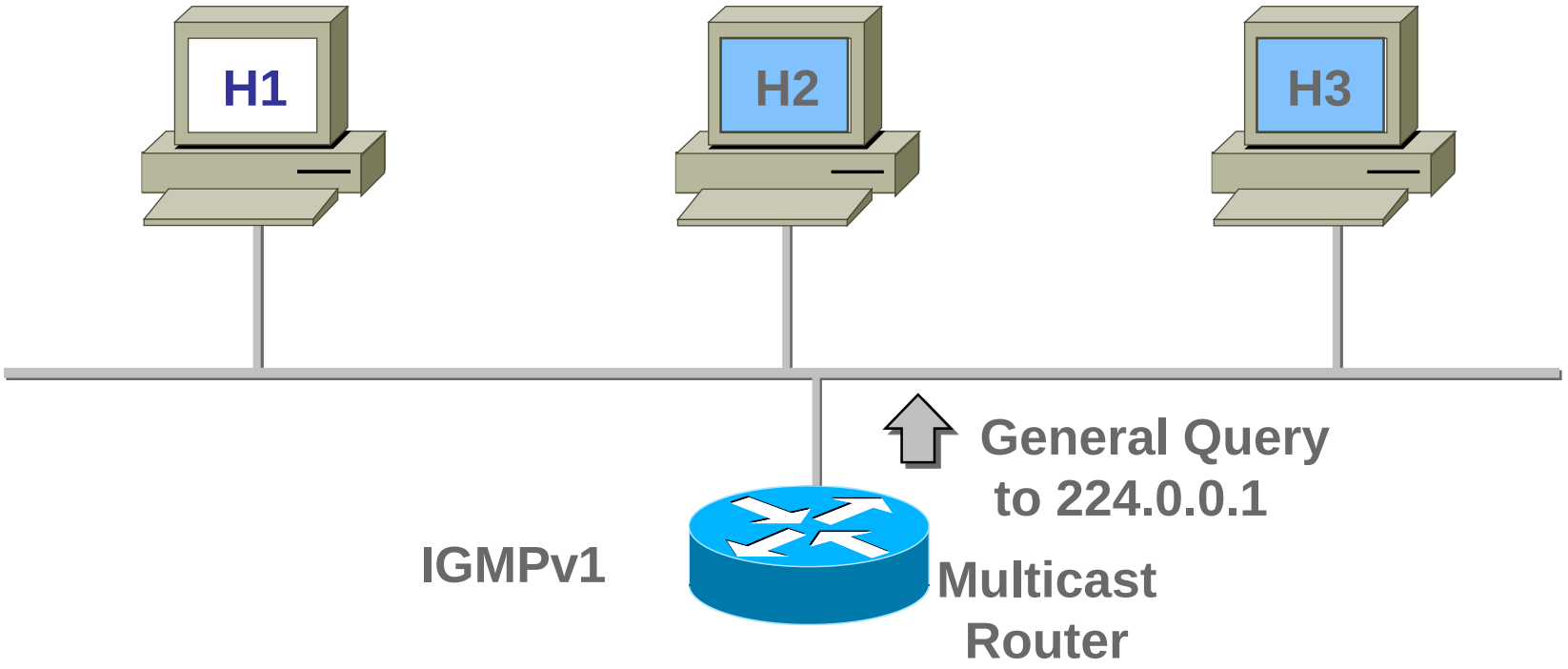
- ✓ If the membership queries the message, set it to 0 (0.0.0.0).Indicates that the multicast router wants the host to send back a report message for each multicast group it wants to join.
- ✓ When used for a membership report message, it contains a multicast group address to which the host is participating, which is a class D IP address

IGMPv1—Joining a Group



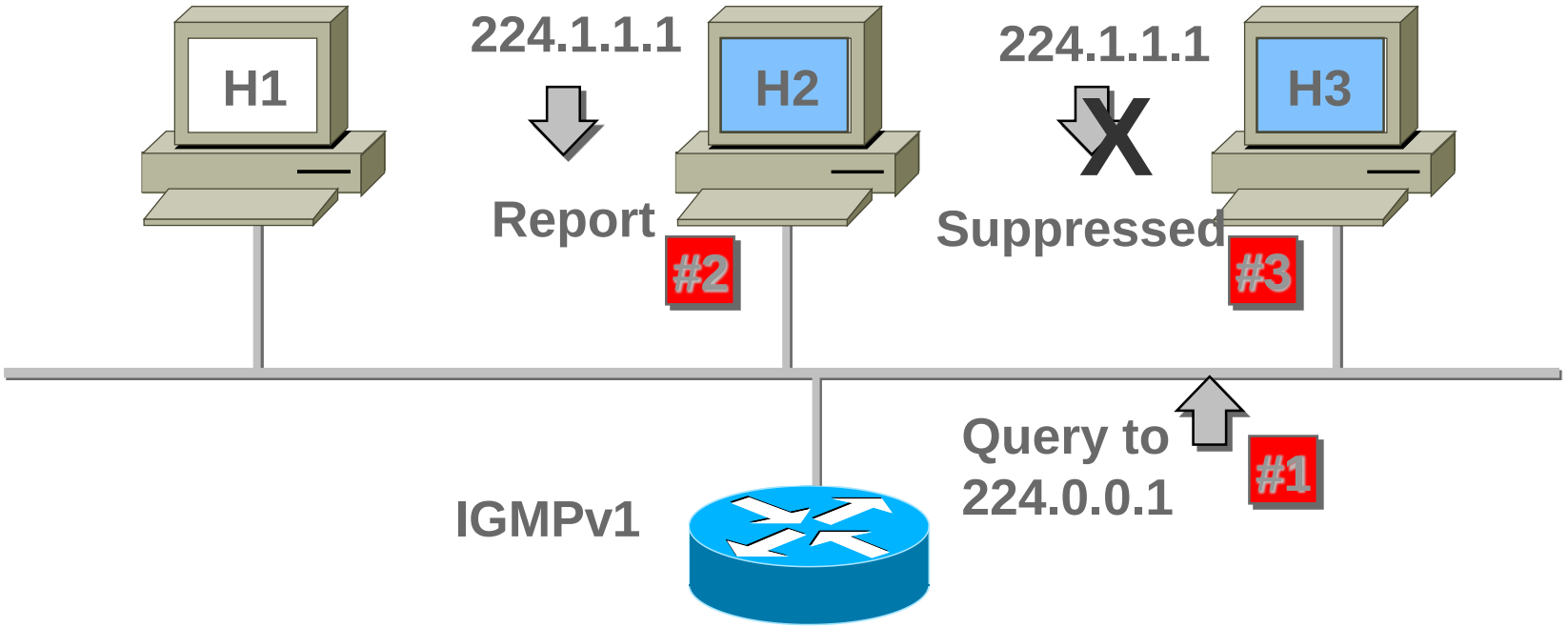
- Joining member sends report to 224.1.1.1 immediately upon joining

IGMPv1—General Queries



- The router periodically sends general queries to 224.0.0.1 to determine memberships

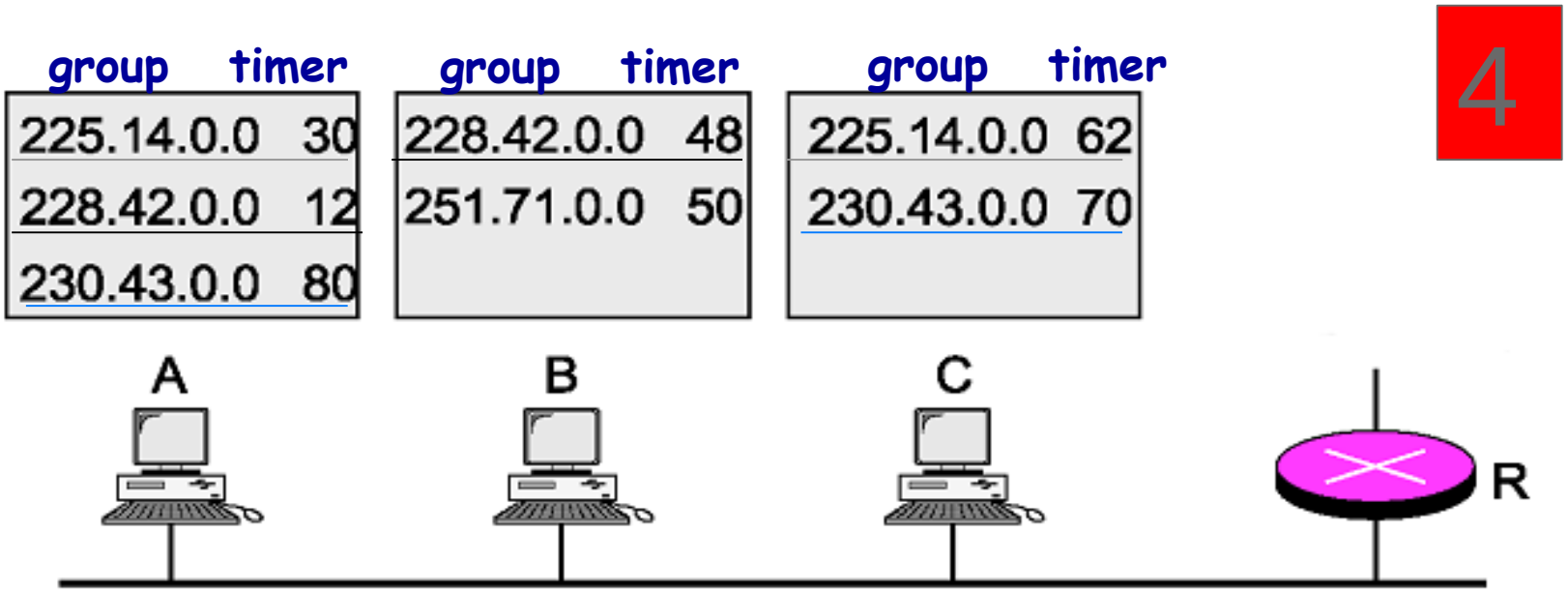
IGMPv1—Maintaining a Group



- Router sends periodic queries
- One member per group per subnet report
- Other members suppress reports

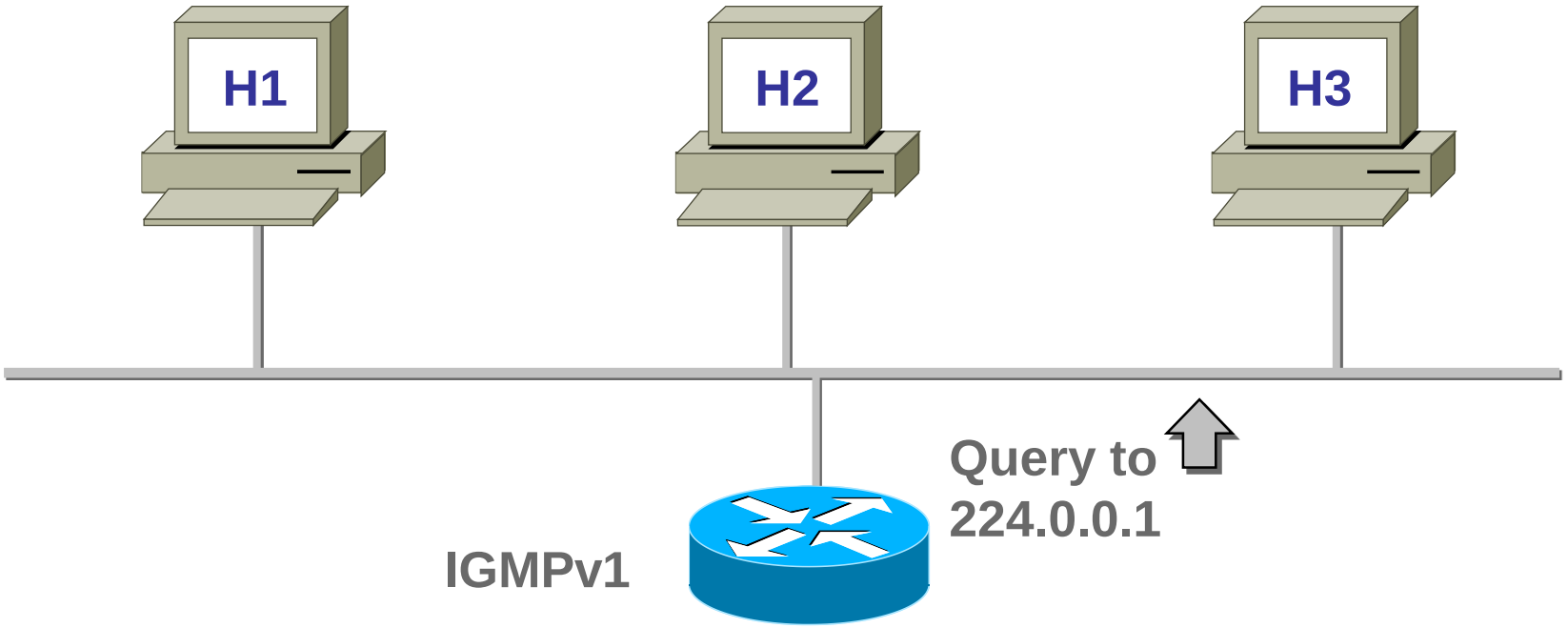
Example of surpress

- For example, three hosts receive query messages at time 0, and the random response time for each group is shown in the figure.
- If each host sends a response message, seven messages are required.How many messages are needed if a delayed response is used?



IGMPv1—Leaving a Group

IGMPv1 lacks an explicit way to leave the group

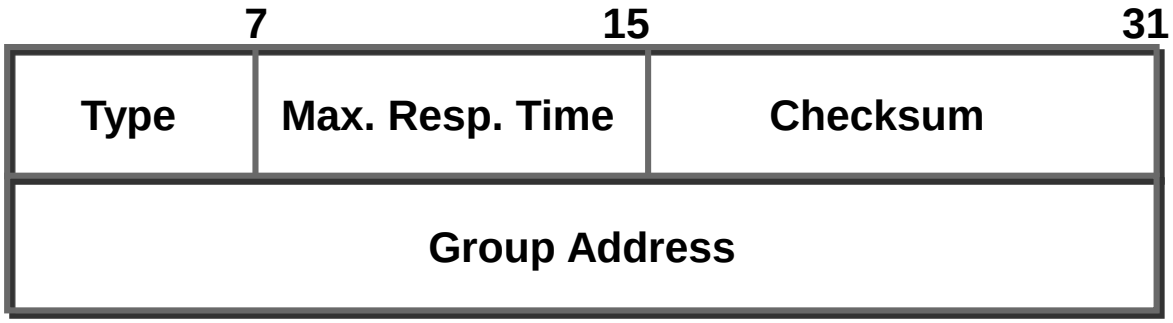


- Router sends periodic queries
- Hosts silently leave group
- Router continues sending periodic queries
- No reports for group received by router
- Group times out

5 Query router elections

- If there are multiple multicast routers in a network, it is wasteful for multiple routers to send IGMP query messages, and one query router should be identified.
- IGMPv1 does not provide a mechanism for election query router, leaving this task to PIM, DVMRP and other multicast routing protocols.
- Because different protocols use different election mechanisms, multiple query routers will appear in one network, which is the disadvantage of IGMPv1.

IGMPv2—Packet Format

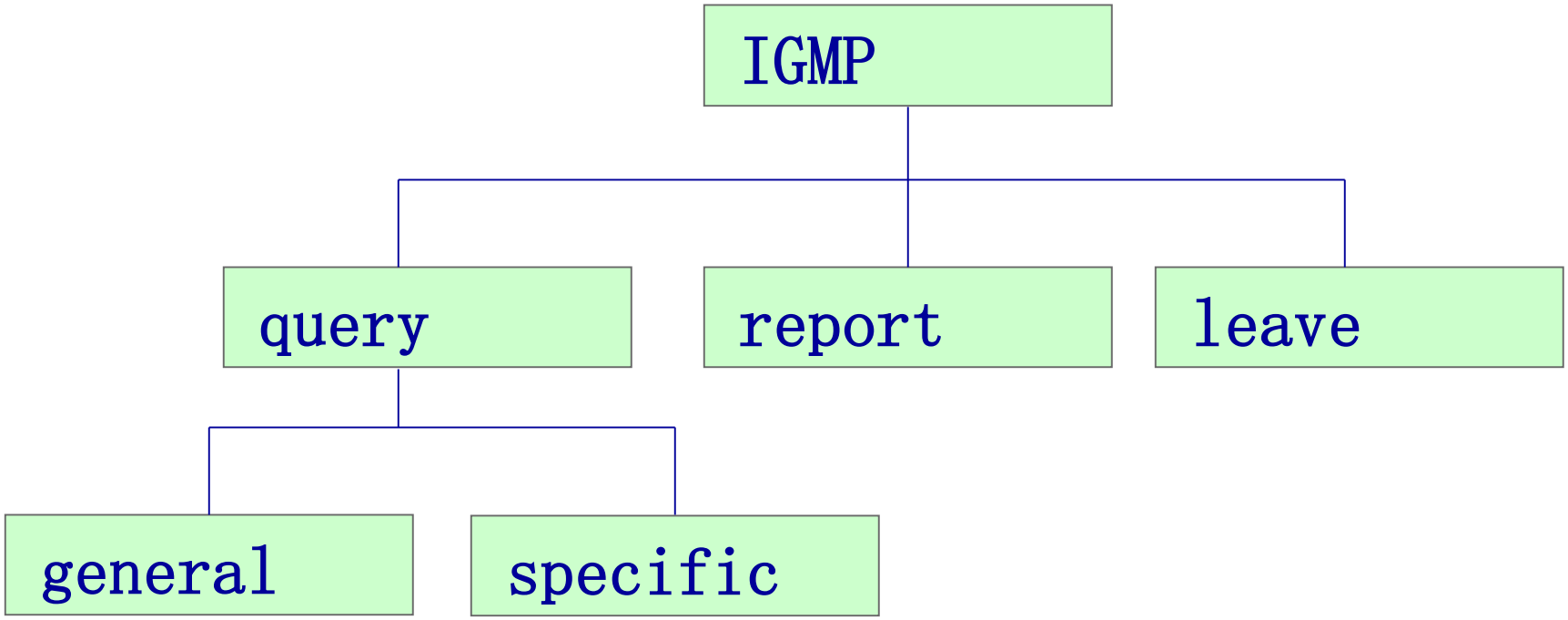


- Multiple message types
  - Query: 0x11 GMQ(general query), GSQ (group-specific query)
  - Report: 0x16
  - Leave: 0x17
  - V1 Report: 0x12

IGMP v1

- ✓ Too much delay to leave the group
- ✓ The election query router needs to rely on multicast routing protocol.

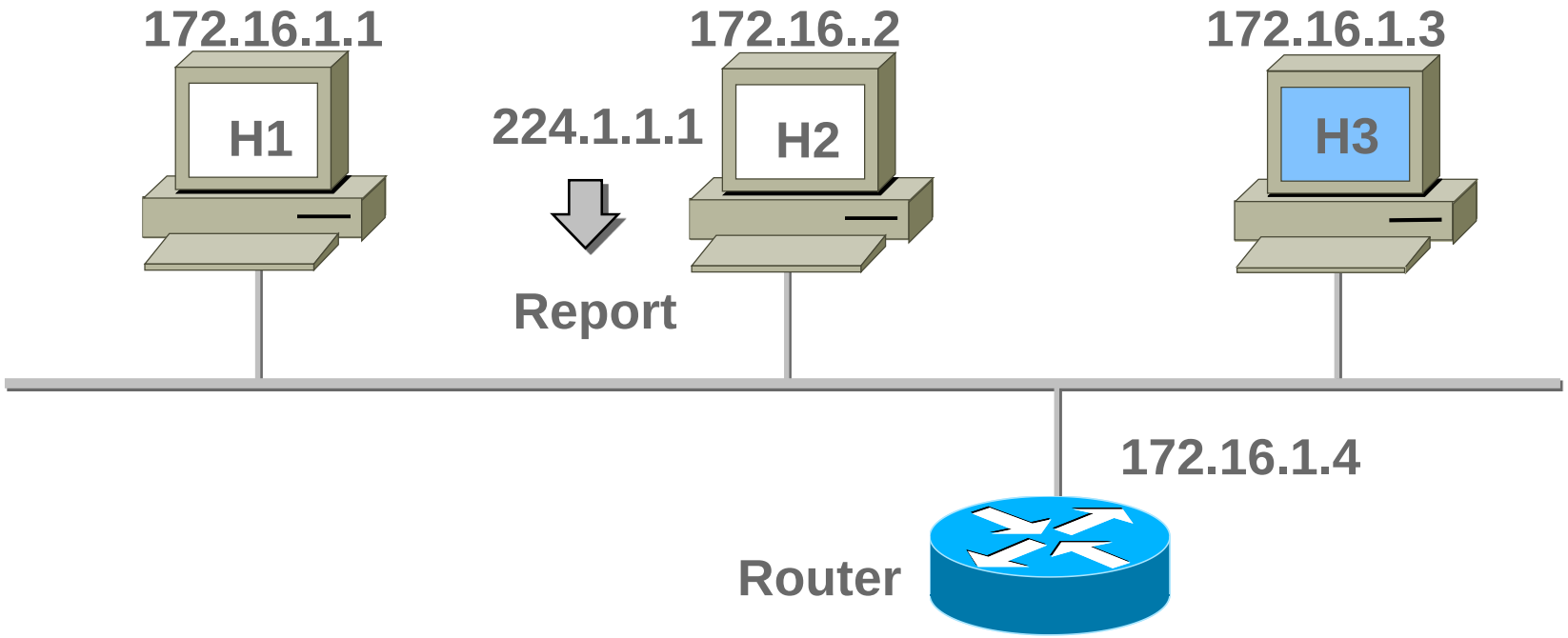
IGMPv2 PKT Type



IGMPv2—Packet Format

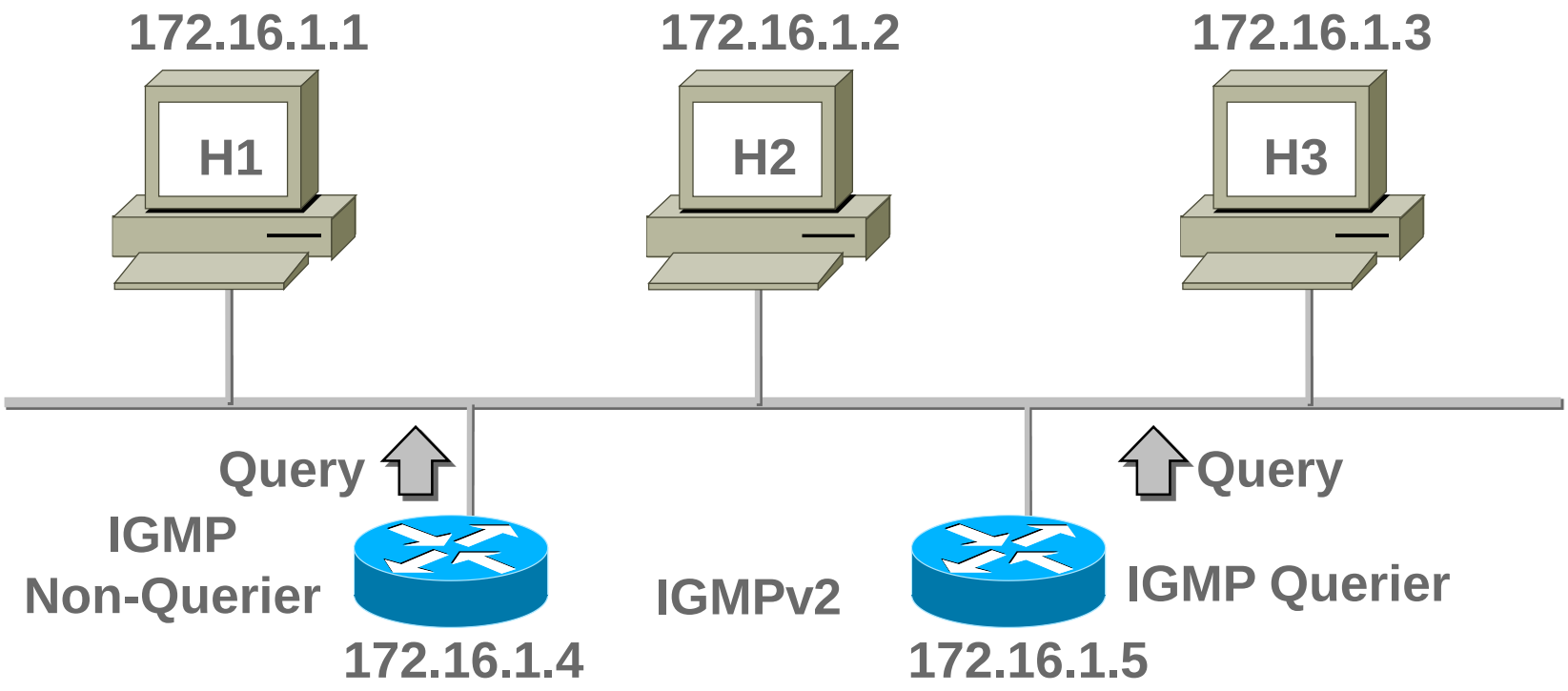
- Max. Resp. Time
  - Max. time before sending a responding
  - unit in 1/10 secs (default = 10 secs)
- Group Address:
  - Multicast Group Address
  - 0.0.0.0 for GMQ

IGMPv2—Joining a Group



- Joining member sends report to 224.1.1.1 immediately upon joining

IGMPv2-Designated Router



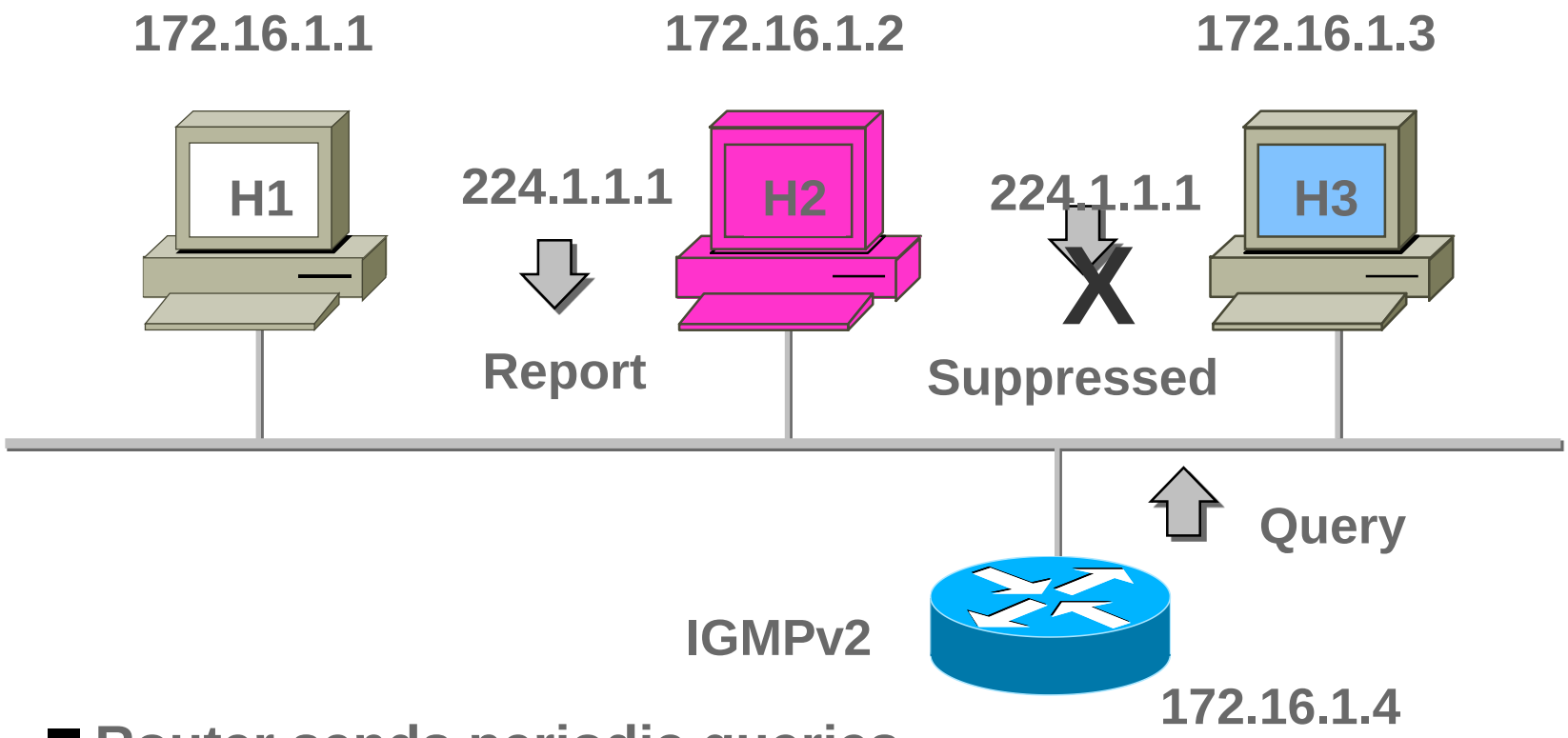
- Initially all routers send out a query
- Router with lowest IP address “elected” querier(DR)
- Other routers become non-queriers

Query router elections

- IGMPv2 USES IP address and universal membership query message to select the query router. The process is as follows:
- every router assumes that it is a query router. When the router starts up, it sends a universal membership query message to all nodes (the destination address is 224.0.0.1).
- The router with its own IP address and IP packet of the source IP address for comparison, t smallest IP address is selected as a query ro
- All non-query router start a query timer, receive the general query message of the query router, the timer reset. If the timer timeout, the selected query router is considered to have failed, go to step after, restart the election. Timers are typically evaluated at twice the query interval.

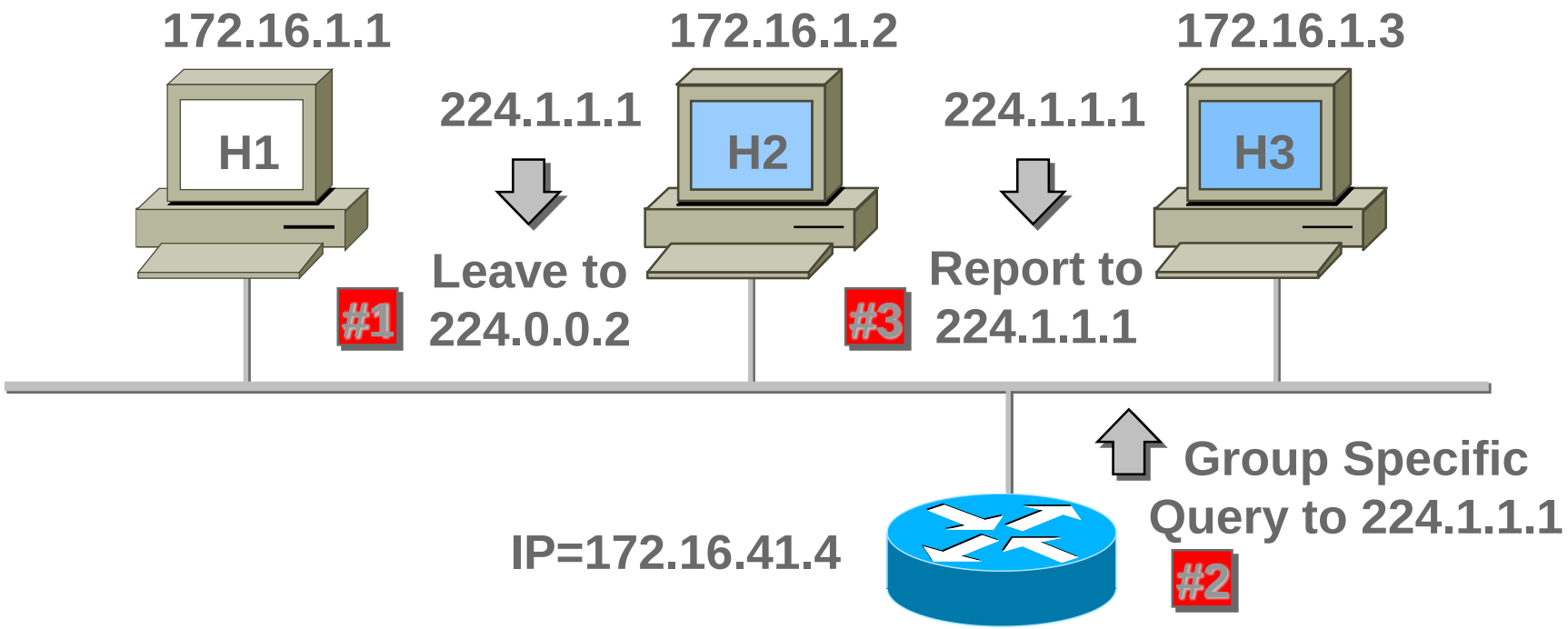
Timer?

IGMPv2—Maintaining a Group



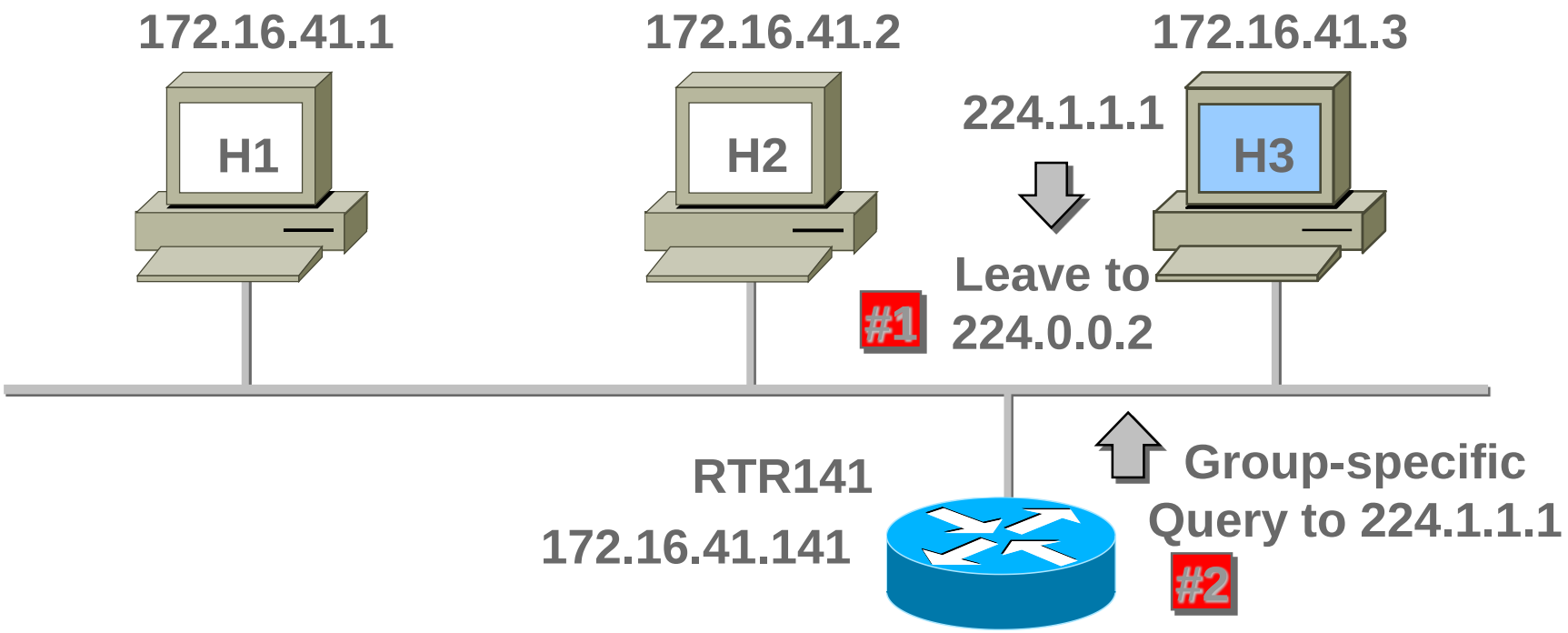
- Router sends periodic queries
- One member per group per subnet report
- Other members suppress reports

IGMPv2—Leaving a Group



- H2 leaves group; sends leave message
- Router sends group-specific query
- A remaining member host sends report; group remains active

IGMPv2—Leaving a Group (Cont.)



#1 Last host leaves group; sends Leave message

#2 Router sends group-specific query;
no report is received, group times out

IGMP v2 - enhancements

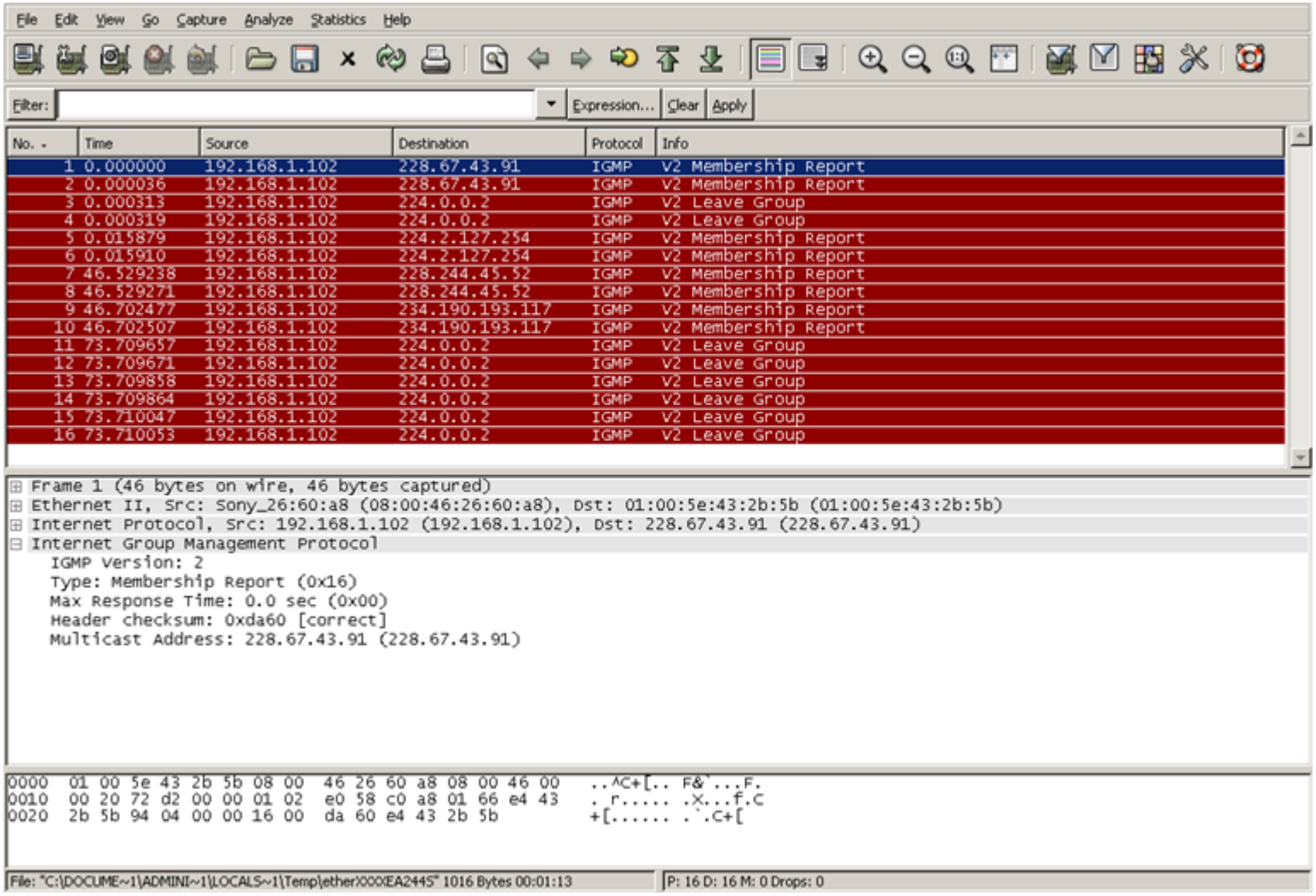
IGMP v2 introduces a procedure for the election of the router querier for each LAN. In the version 1 this was done by different routing policies.

Group-Specific Query – Added to permit queries to check if there's other subscribers for a specific group

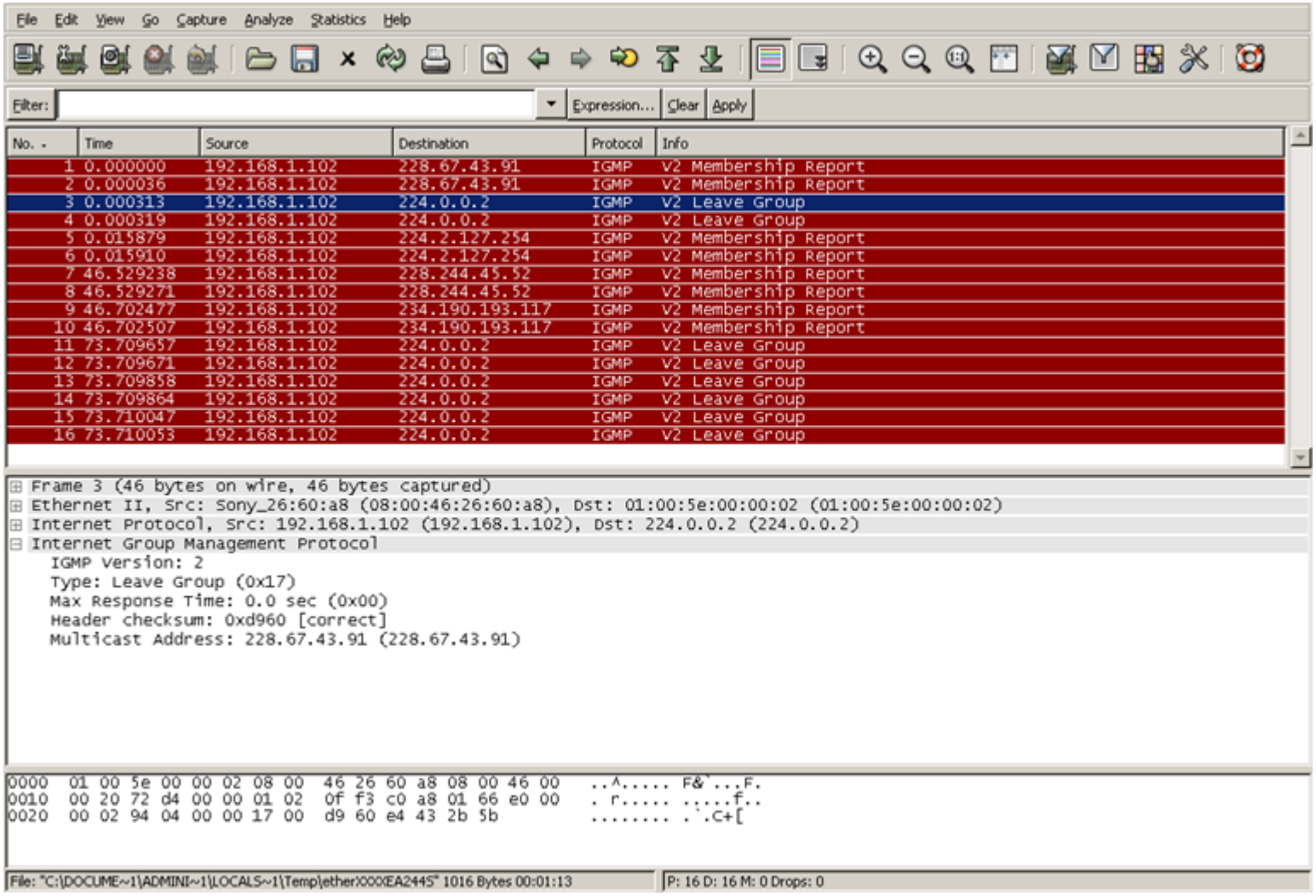
Leave-Group – for a reduction in the time it takes for a multicast router to learn that there are no longer any members of a particular group present on an attached network. Sent to *all-routers* (224.0.0.2)

When a router receives the Leave-Group message, it uses the Group-Specific Query to verify if the sender was the last one in the group.

Ethereal Example



Ethereal Example



IGMPv1 and v2 Compatibility

- There are three situations when the host and router use different versions of IGMP:
- In the first case, the host uses v2 and the router uses v1.
- In the second case, the host uses v1 and the router uses v2.
- In the third case, there are both v1 and v2 routers.

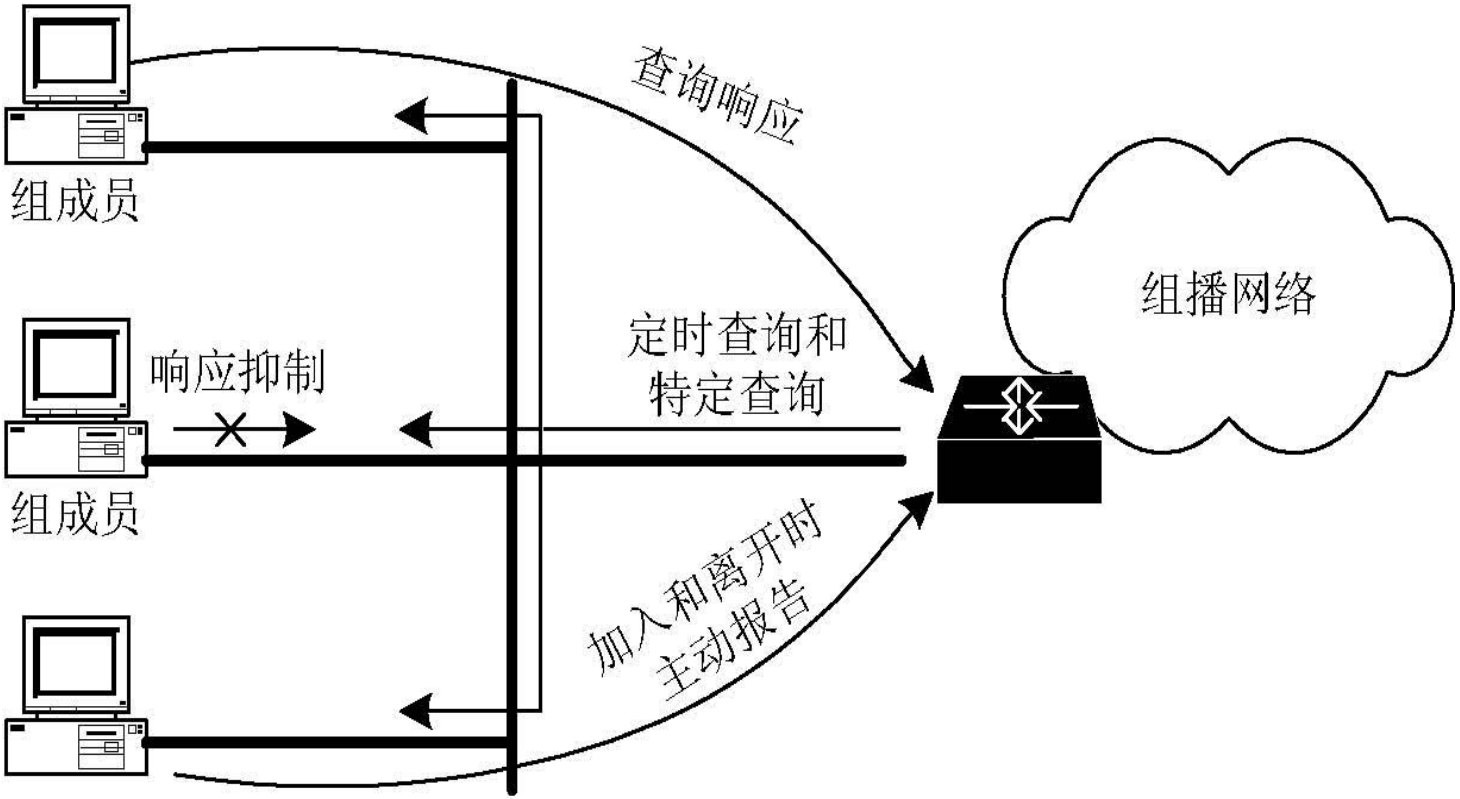
Compatibility Modes v1 &v2

- IGMPv1 router will send General Queries with the Max Response Time set to 0. This must be interpreted as a value of 10s by V2 host.
- Send V1 Report if IGMP querier is version 1
- The V2 host must allow its Membership Report to be suppressed by a Version 1 Membership Report
- If there are version 1 hosts present for a particular group, a router must ignore any Leave Group messages that it receives for that group.

8.3.6 IGMPv2 ‘s operation

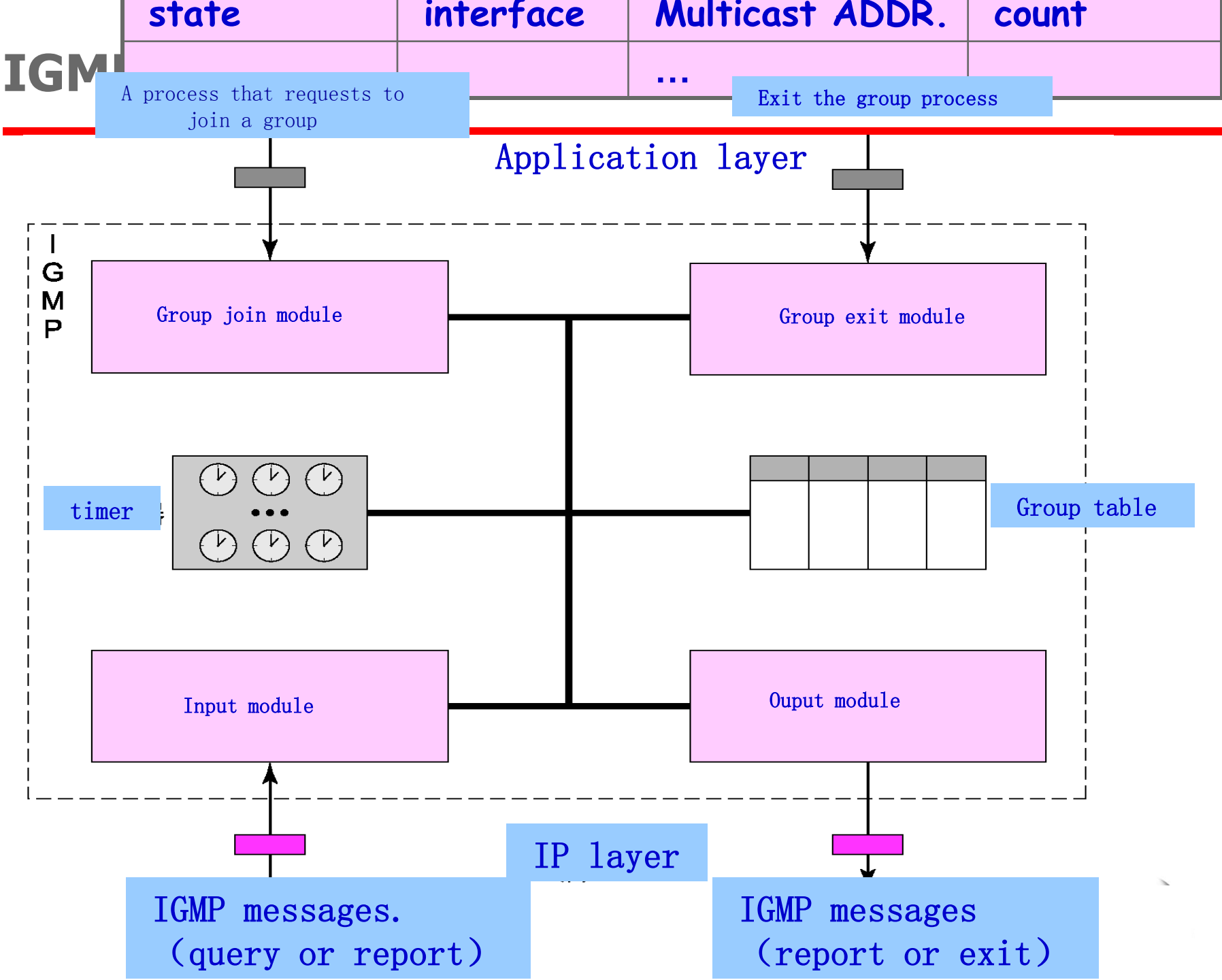
- The query router periodically sends general query messages, queries all multicast group membership, and the host sends membership report messages for response.
- The response suppression technique can be used by the host to send the report message.
- If a new host wants to join a multicast group, can actively send a membership report message.
- When leaving a multicast group, an outgoing group message is sent actively. After receiving the outgoing group message, the query router sends a specific group query message to determine whether all group members of the multicast group have left the group.
- Through these interactions, the router creates table entries in the multicast group address table to record active multicast groups on the network. The router forwards multicast packets based on the multicast group address table.

IGMPv2 's working principle

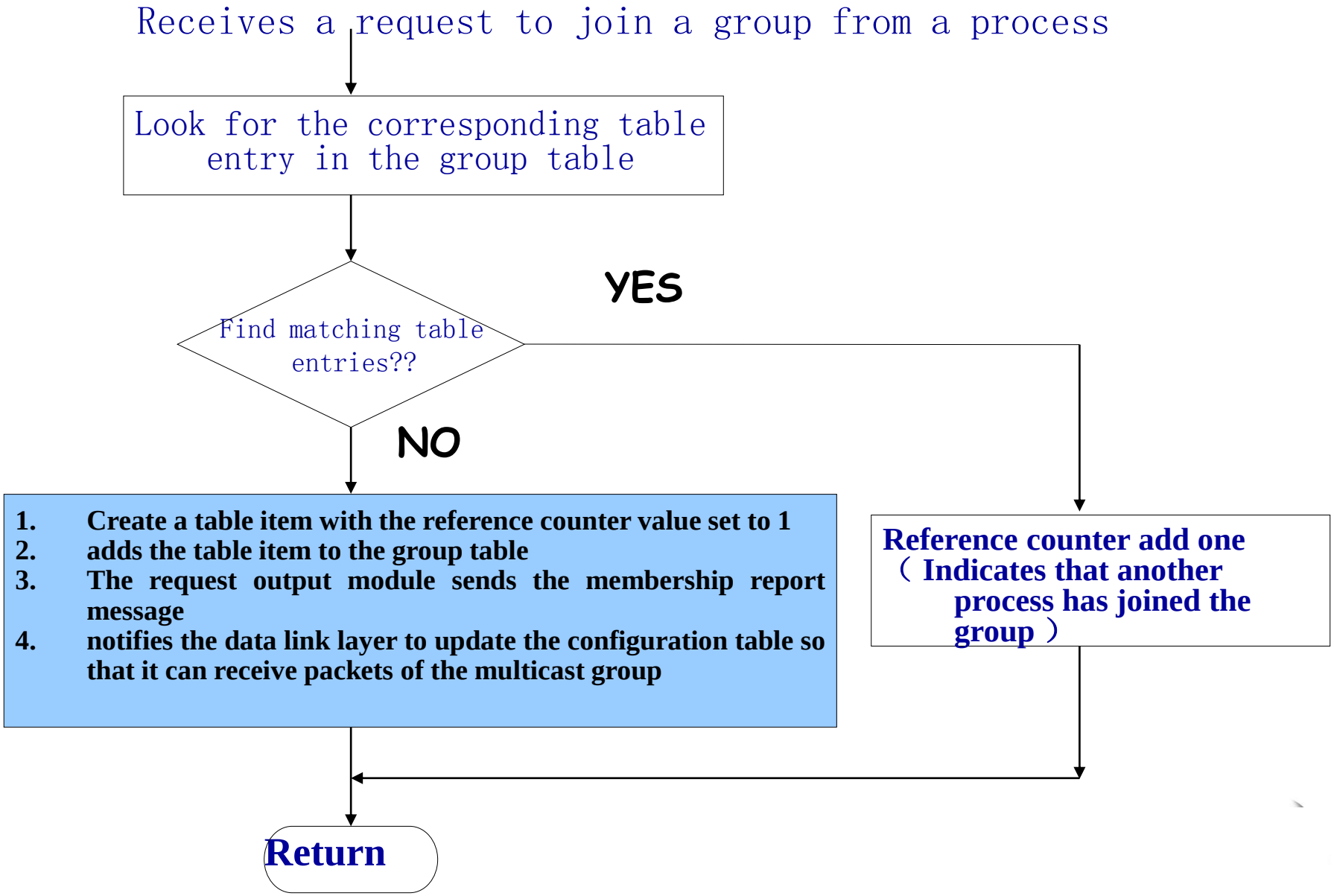


IGMPv2's implementation

- **IGMP software implementation, the implementation of the host as an example. There are 6 components:**
  - A set of tables
  - 1 set of timers
  - Four modules
    - ✓Group to join
    - ✓Set out
    - ✓The input
    - ✓The output


state
interface
Multicast ADDR.
count
...
IGM
A process that requests to join a group
Exit the group process
Application layer
IGMP
Group join module
Group exit module
timer
Group table
Input module
Ouput module
IP layer
IGMP messages.
(query or report)
IGMP messages
(report or exit)

Group join module



Group exit module

A process that wants to exit a group calls this module.

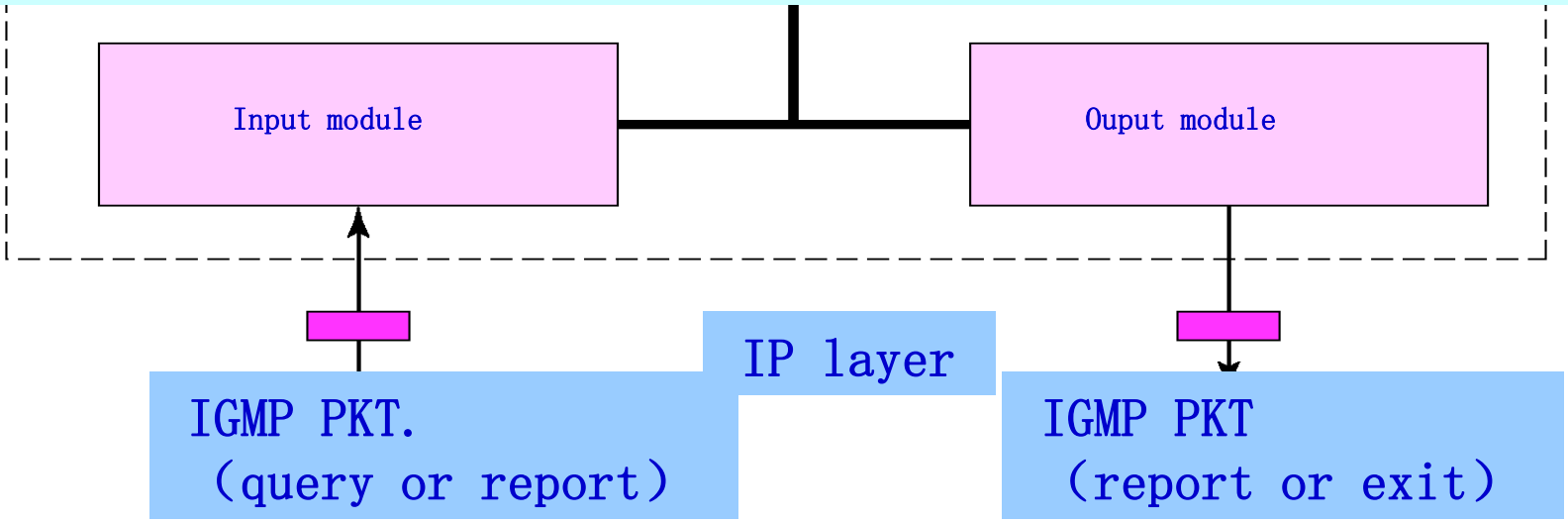
Receive: request from the process exiting the group.

Look for the corresponding table entry in the group table.

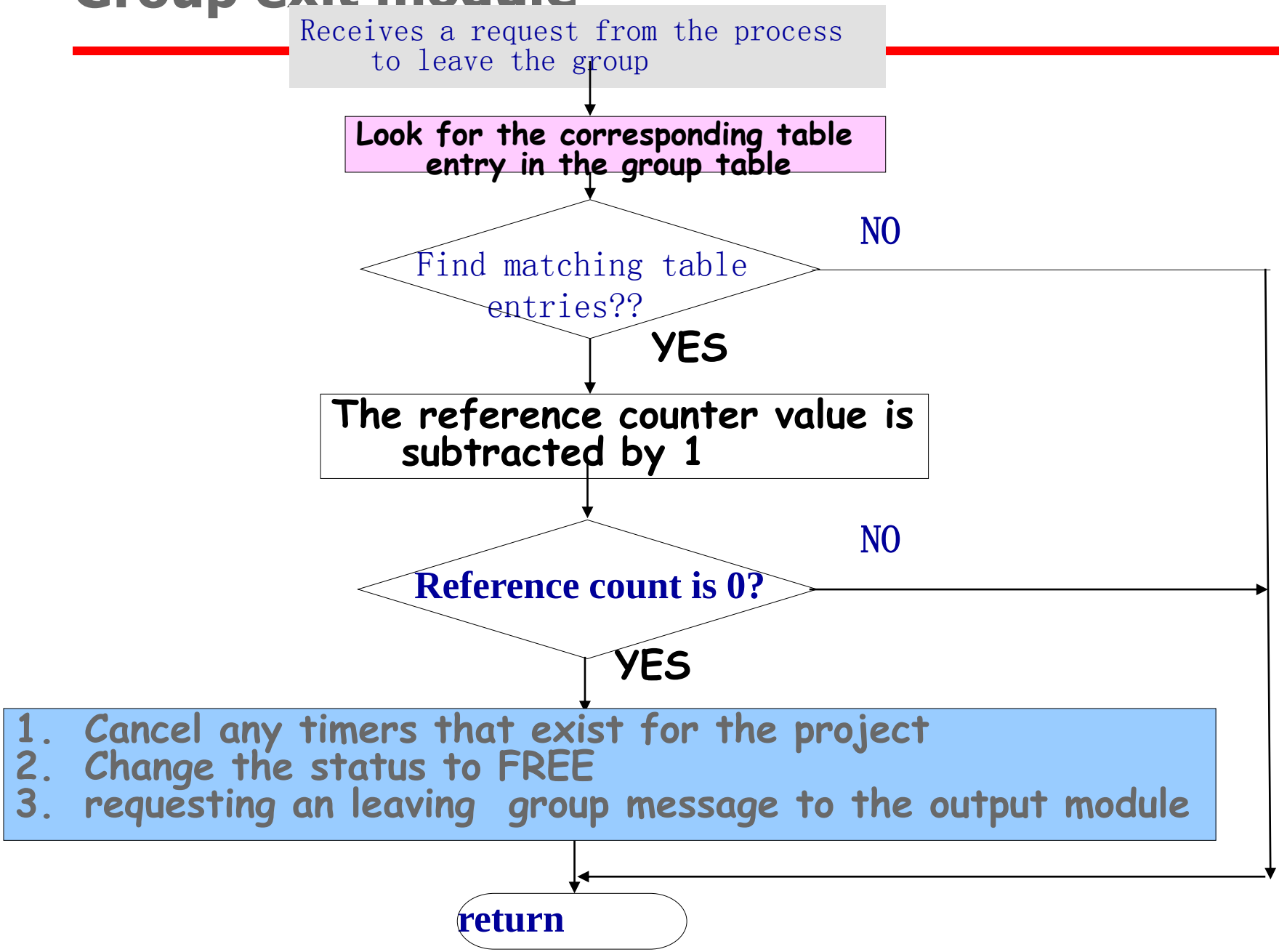
If find

- ✓ Subtract 1 from the value of its reference counter.
- ✓ The essay will have a reference count of 0
  - ➢ If any timers exist for the project, cancel the timer.
  - ➢ Change the state to Free.
  - ➢ The request output module sends an exit report message.

return



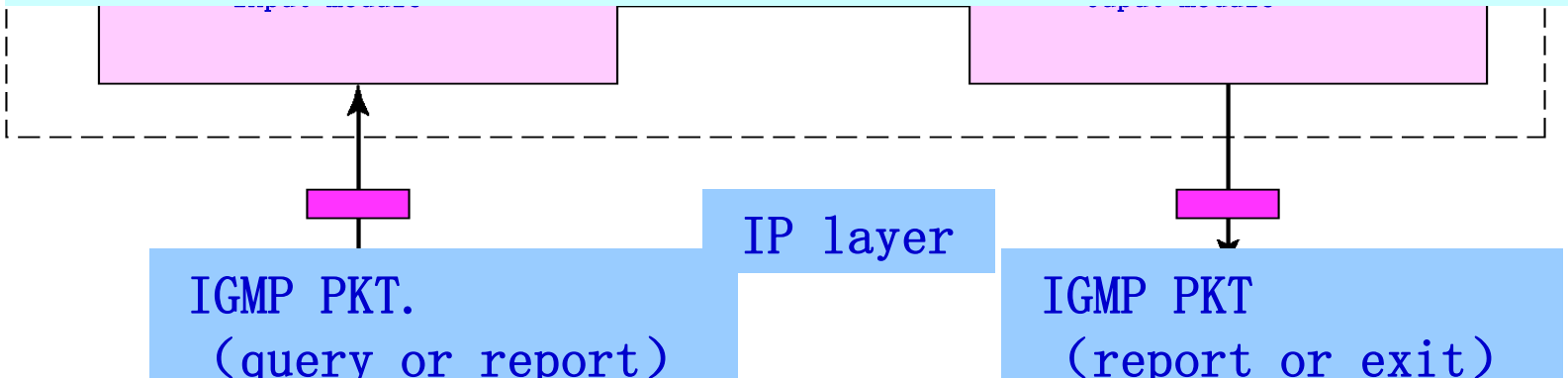
Group exit module



IGM

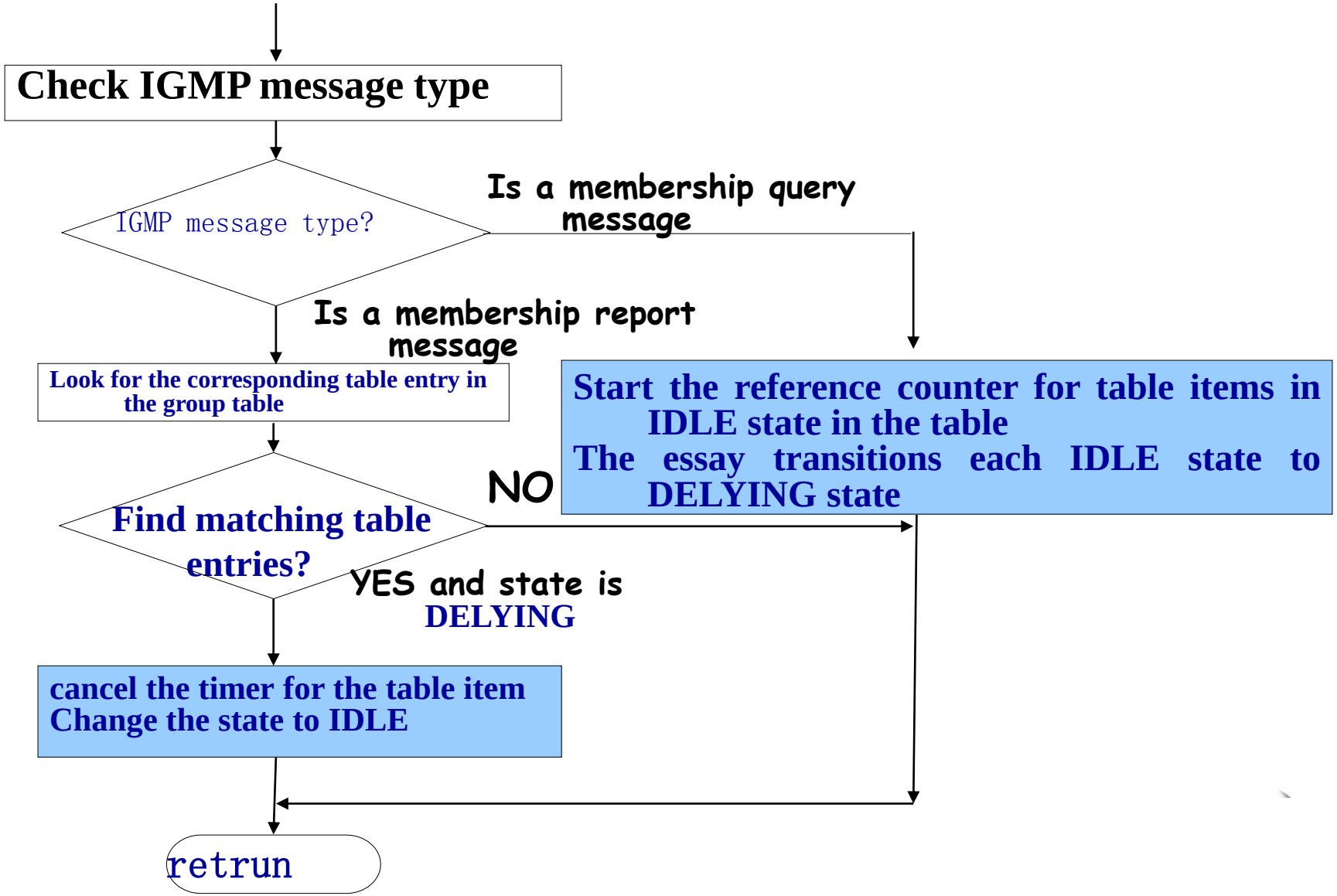
Receive: IGMP messages (only query and report messages are received).

1. Check the message type.
2. If the message is queried
   a) Start the reference counter for table items in Idle state in the table.
   b) every Idle state into a state of Delaying.(report message will be sent at the time of timing)
3. If the membership report message (response suppression)
   a) Look for items in the table.
   b) if find the project, and the status of Delaying (show that another host members sent report message), then
      ✓ Cancel the timer for the project.
      ✓ Change the state to Idle.
4. return



Input module

Receive IGMP message:(only membership query messages and membership report messages are accepted)



6. Output module

Calls from cutoff times to timers, join or exit modules.
Receive: a signal from a timer, or a request to join a module, or a request to group out of a module.

1. If the message comes from a timer
   (1) to find the project, and state for Delaying it
   Create a membership report message.
   Reset the state to Idle.
2. If the message comes from the group, add the module
   Create membership report messages
3. If the message comes from the group exit module
   Create exit messages.
4. Send this message
5. return

IGMP v3 - features

- MUST be interoperable with v1 and v2
- The maximum response time increased from 25.5s to 53s, which is suitable for larger networks.
- report message contains multiple group records, which can effectively reduce network traffic.
- In IGMPv3, response suppression in previous versions was disabled.
- Source-filtering
  - Only from some sources, All but some sources

IGMP v3 - Message format

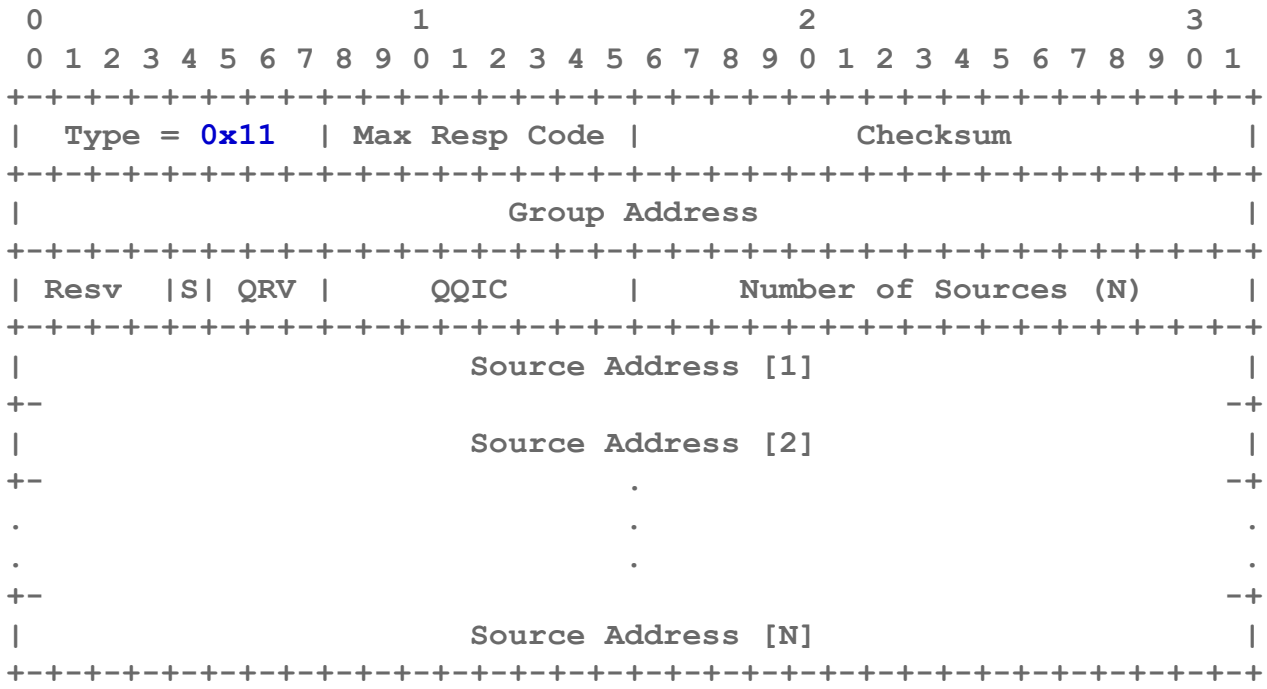
IGMP messages are encapsulated in IPv4 datagrams. Every IGMP message is sent with an IP Time-to-Live of 1, and carries an IP Router Alert option [RFC-2113] in its IP header.

There are two IGMP message types of concern to the IGMPv3 protocol:

Type Number (hex)	Message Name
0x11	Membership Query
0x22	Version 3 Membership Report

IGMP v3 - Message format

Membership Query Message



The **Max Resp Code** field specifies the maximum time allowed before sending a responding report. Allow IGMPv3 routers to tune the "leave latency".

The **Group Address** field is set to zero when sending a General Query, and set to the IP multicast address being queried when sending a Group-Specific Query or Group-and-Source-Specific Query

QRV (Querier's Robustness Variable)

The **Number of Sources (N)** field specifies how many source addresses are present in the Query.

The **Source Address [i]** fields are a vector of n IP unicast addresses, where n is the value in the Number of Sources (N) field.

IGMP v3 - Message format

Membership Query Message

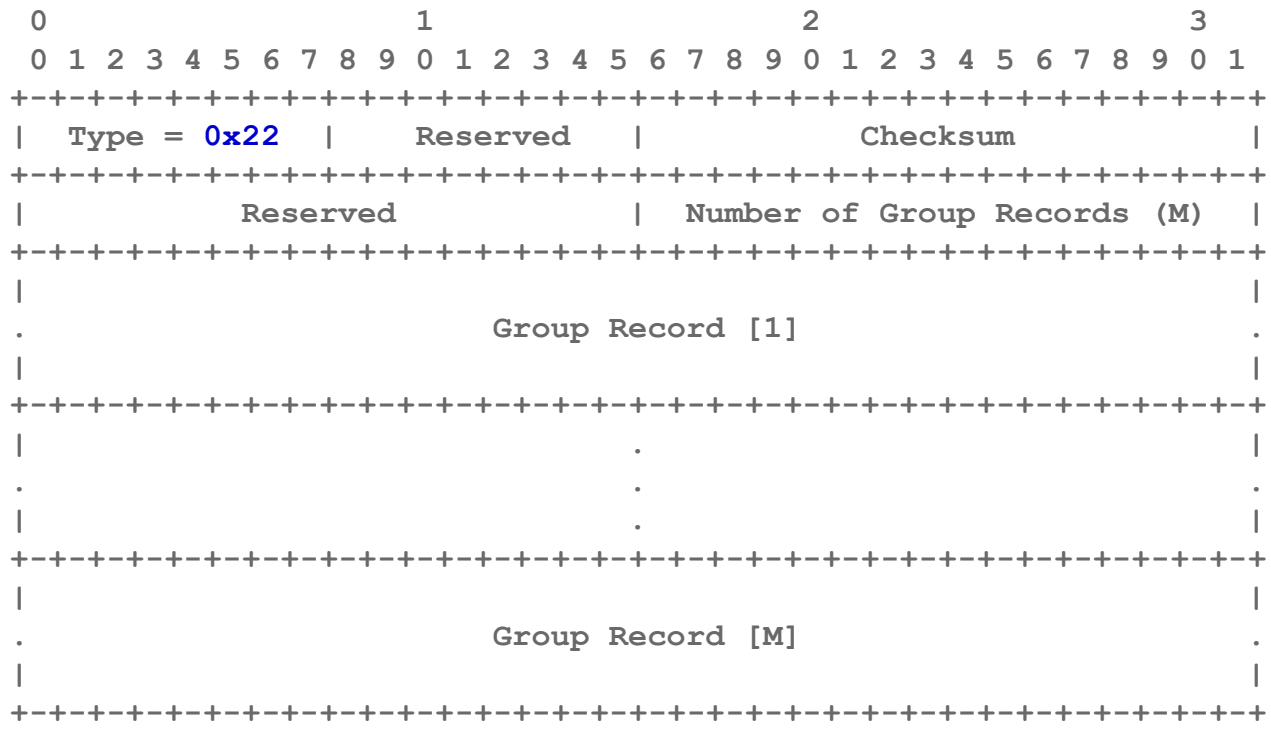
There are three variants of the Query message:

1. A "General Query"
2. A "Group-Specific Query"
3. A "Group-and-Source-Specific Query"

In IGMPv3, General Queries are sent with an IP destination address of 224.0.0.1, the all-systems multicast address. Group-Specific and Group-and-Source-Specific Queries are sent with an IP destination address equal to the multicast address of interest.

IGMP v3 - Message format

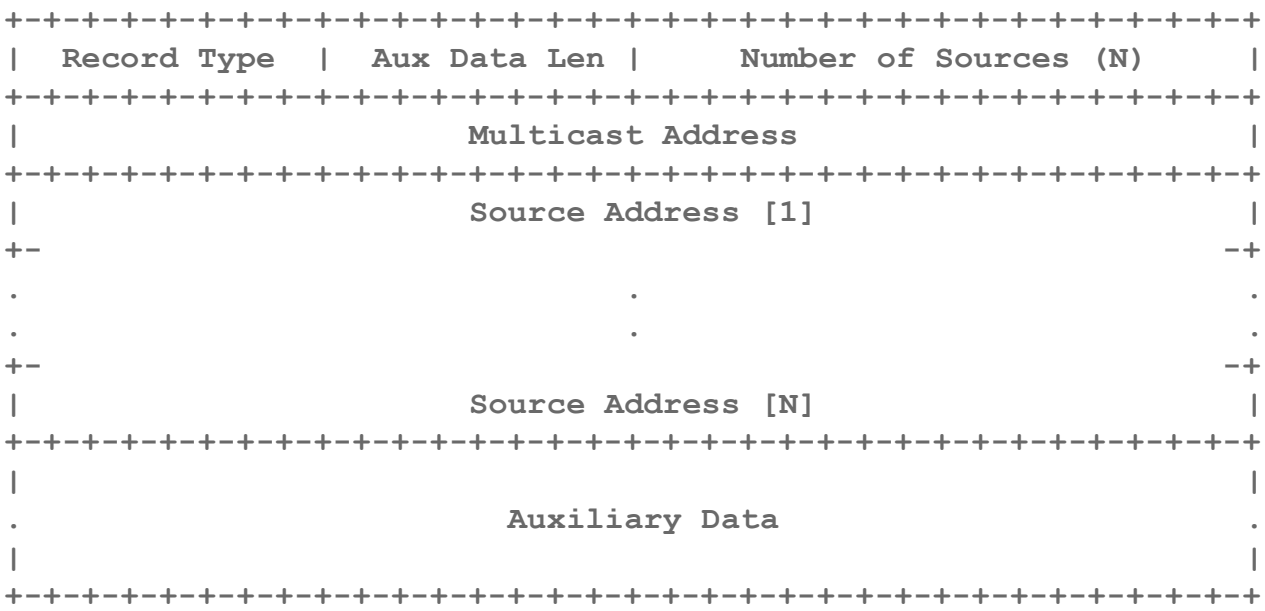
Membership Report Message



IGMP v3 - Message format

Membership Report Message

Each Group Record has the following internal format:



IGMPv1、IGMPv2 and IGMPv3

difference	IGMPv1	IGMPv2	IGMPv3
Query router election	Rely on the upper routing protocol	Self election	Self election
Leaving gourp	Implicit leave	Actively sends outgoing group messages	Actively sends outgoing group messages
Specify group joining	N	Y	Y
Specify source joining	N	N	Y