Chapter 10
Internet Group Management Protocol

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Outline

- Group management
- IGMP messages
- IGMP operation
- Encapsulation
- IGMP package

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Introduction

- Internet Group Management Protocol (IGMP)
  - One-to-many communication
  - One of the necessary, but not sufficient, protocols that is involved in multicasting

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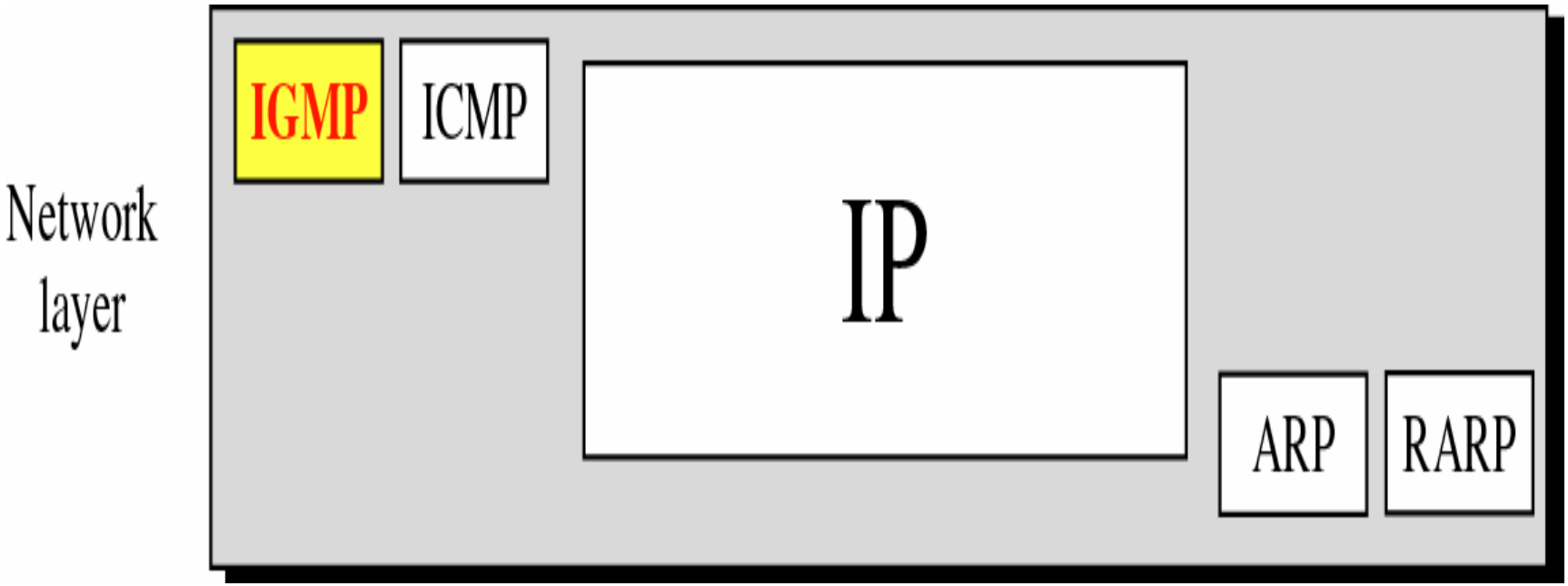
Figure 19.1

Position of IGMP in The Network Layer



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10.1

GROUP MANAGEMENT

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IGMP

- A protocol that manages group membership
- Not a multicasting routing protocol
  - For multicasting, we need routing tables in routers to route multicast packets
  - This is done by the multicasting routing protocols
  - However, IGMP does not address this

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IGMP (Cont.)

- IGMP gives the multicast routers information about the membership status of hosts (routers) connected to the network
  - Help a multicast router *create and update a list of loyal members related to each router interface*

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10.2

IGMP MESSAGES

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IGMP Messages

- IGMP messages
  - Query
    - General and special
  - Membership report
  - Leave report

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Figure 19.2

IGMP Message Types

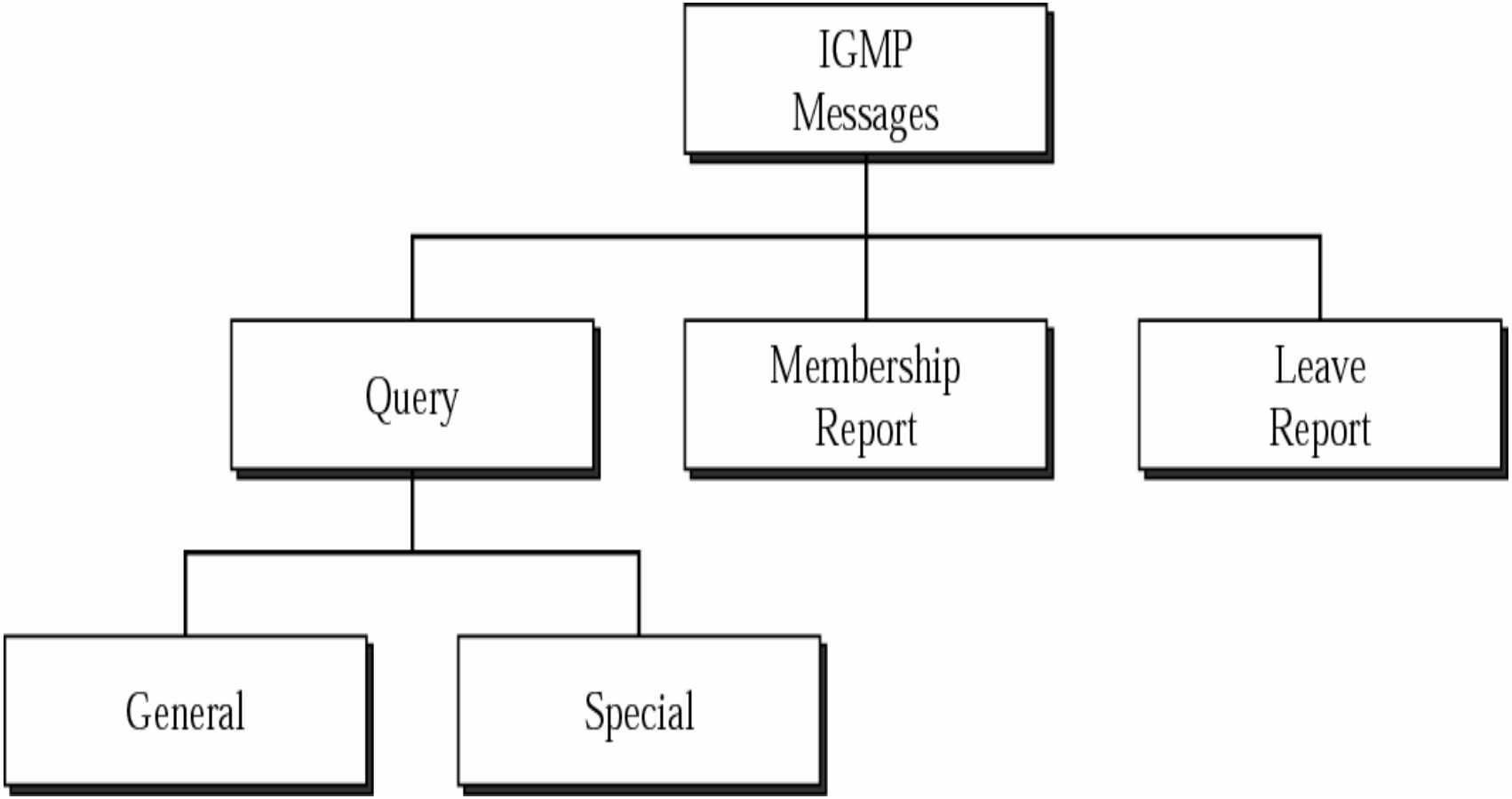

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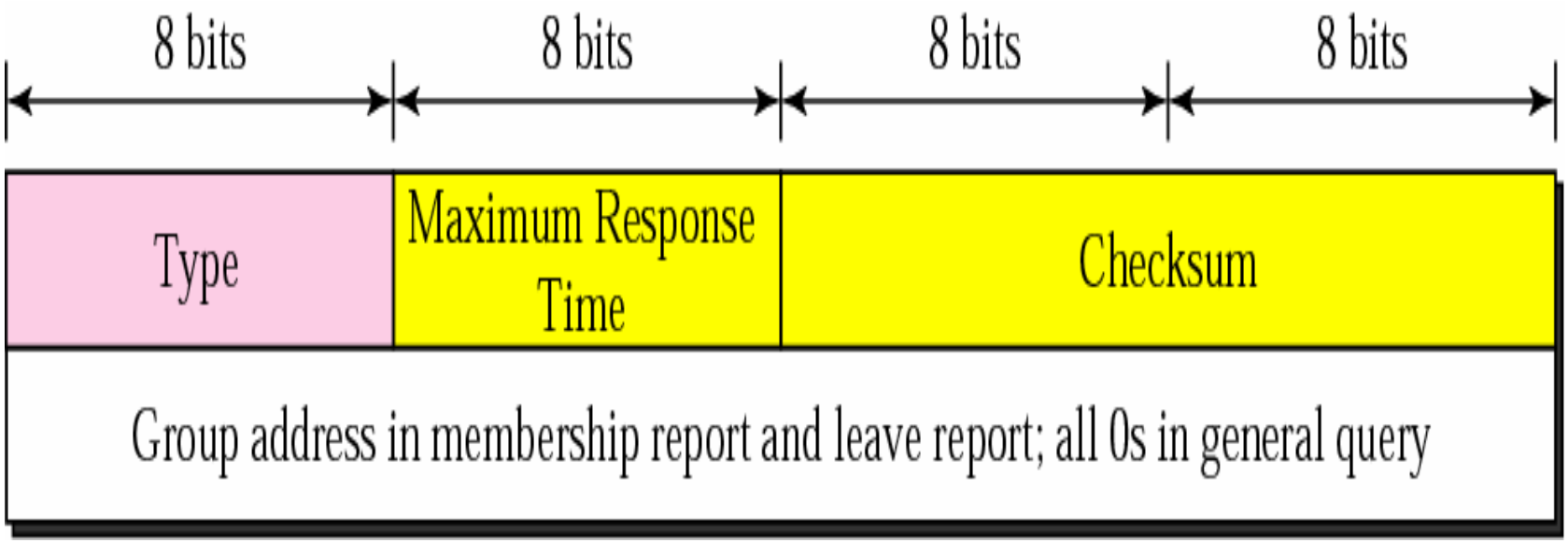
Figure 19.3

IGMP Message Format



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IGMP Message Format

- Type
  - Define the type of message
    - 00010001: general or special query
    - 00010110: membership report
    - 00010111: leave report
- Maximum response time
  - The amount of time a query must be answered
  - In tenths of a second
    - Value = 100 : 10 second

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IGMP Message Format (Cont.)

- Checksum
  - Calculated over the 8-byte message

- Group address
  - 0: for a general query message
  - Groupid (multicast address of the group) : for the special query, the membership report and the leave report messages

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10.3

IGMP OPERATION

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IGMP Operation

- Each multicast router has a list of multicast addresses
  - Each address corresponding to a group
  - Each group must have at least one loyal member in one of the routing's connecting network

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IGMP Operation (Cont.)

- For each group
  - Only one router has the duty of distributing the multicast packets for that group
  - For example, if three routers connected to a network
    - Their list of groupids are *mutually exclusive*

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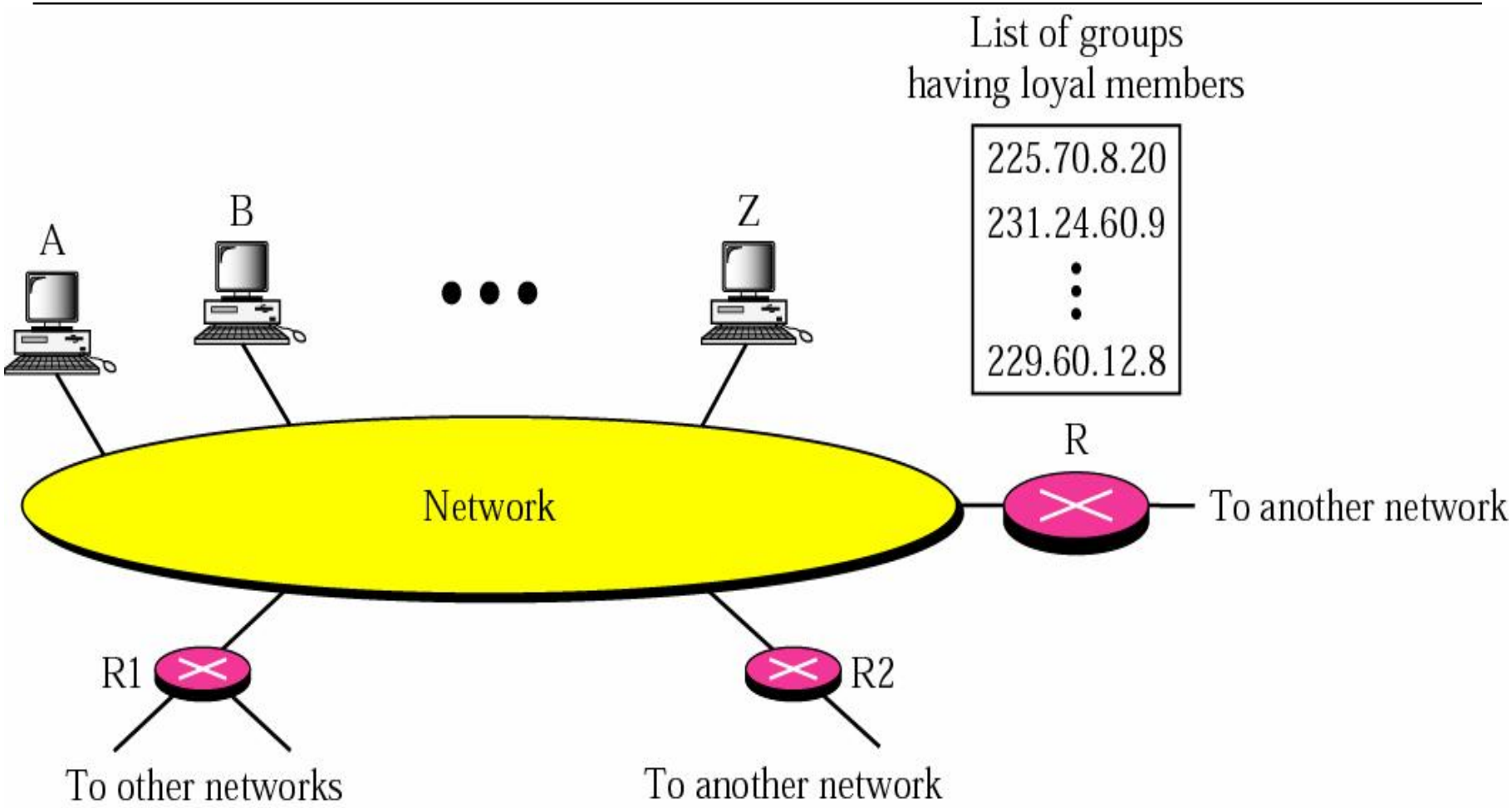
Figure 19.4

IGMP Operation



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IGMP Operation

- Join a group
- Leave a group
- Monitor a group

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Join a Group

- Host: maintain a list of process that have membership in a group
- When a new process wants to join a new group
  - The host adds *the process's name*, *the requested group's name* to its list
  - If this is the first entry for this group
    - Send a membership report message

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Join a Group (Cont.)

- Router can also send membership report
  - If there is a new interest in a group for any of its interface
  - Note that, the membership report is sent out of all interface except the one from which the new interest comes

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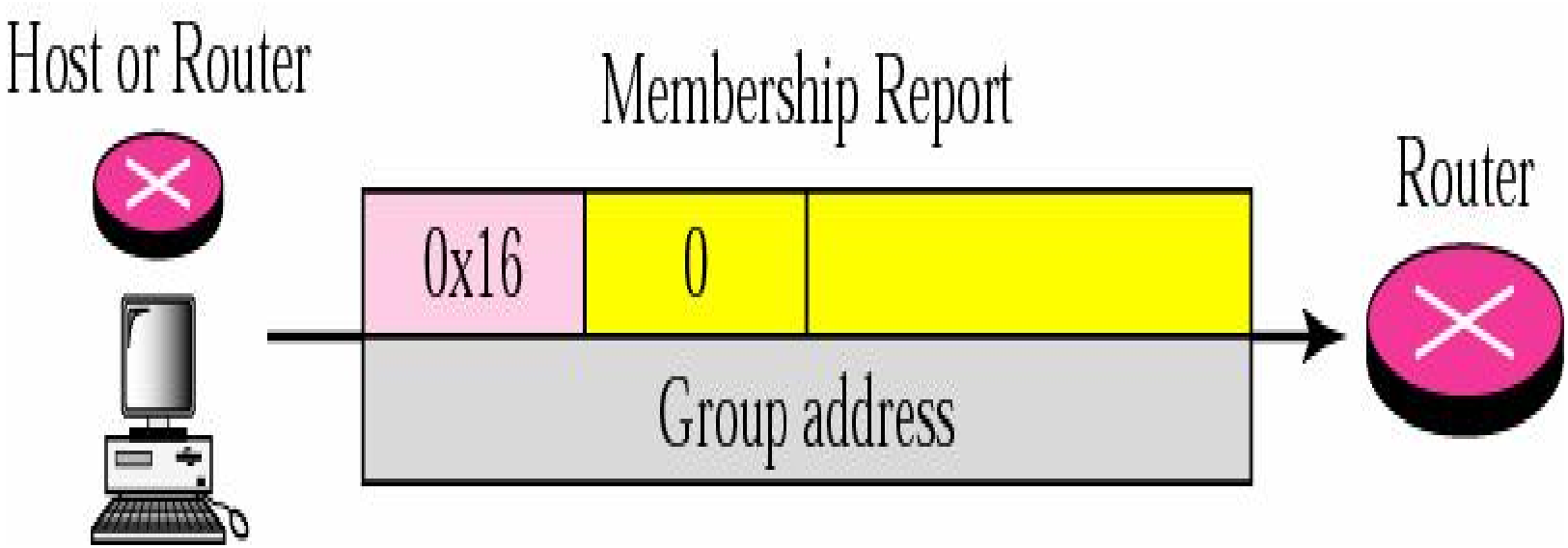
Figure 10.5

Membership Report



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Join a Group (Cont.)

- A membership report be sent twice
  - One after the other within a few moments
  - To prevent the first one is lost or damaged

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Note

In IGMP, a membership report is sent twice, one after the other.

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Leave a Group

- Occurrence
  - When a host sees that no process is interested in a specific group
  - When a router sees that none of the networks connected to its interface is interested in a specific group
- In above both cases, send a *leave report*

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Leave a Group (Cont.)

- However, when a multicast router receives a leave report
  - It cannot immediately purge that group from its list
  - Because the report comes from just one host or a router
  - There may be other hosts or routers that are still interested in that group

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Leave a Group (Cont.)

- Thus, the router sends a special query message and waits for a specified response time
  - If no interest is received during the time
    - No one is interested in that group in its network
    - Purge the group from its list

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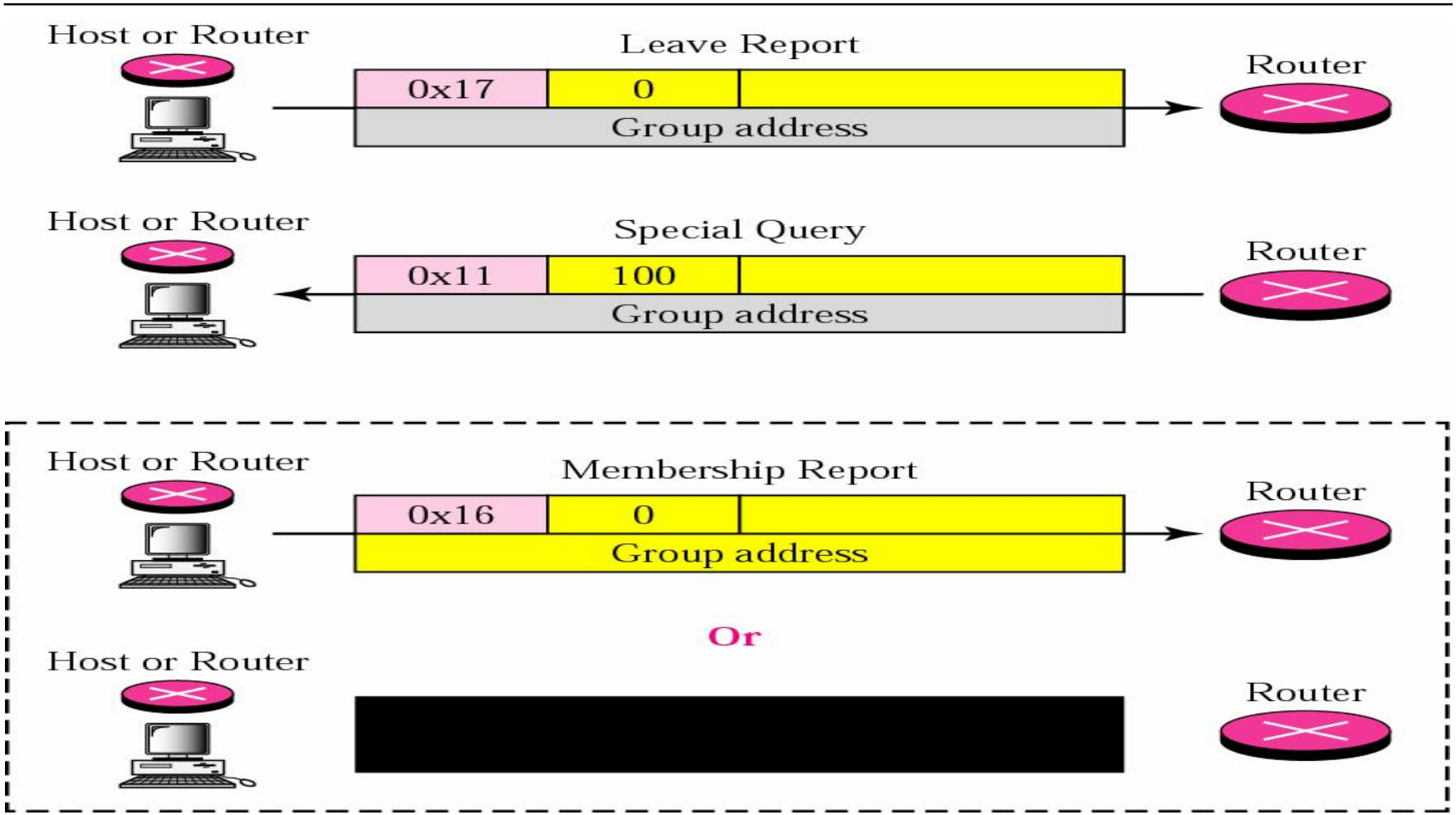
Figure 10-6

Leave Report



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Monitor Membership

- Although we have membership report message and leave report message
  - But this is not enough
  - A host may be shut down or removed accidentally
- Thus, the multicast router must monitor all of the hosts or routers' group membership

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Monitor Membership (Cont.)

- The router *periodically* sends a *general query message*
  - By default, 255 seconds
  - Group address field is set to *0.0.0.0*
    - Does not define a particular group
  - Has a maximum response time of 10 seconds
- When receives, a host or router sends a membership response if it is still interested in a group

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Note

The general query message does not define a particular group.

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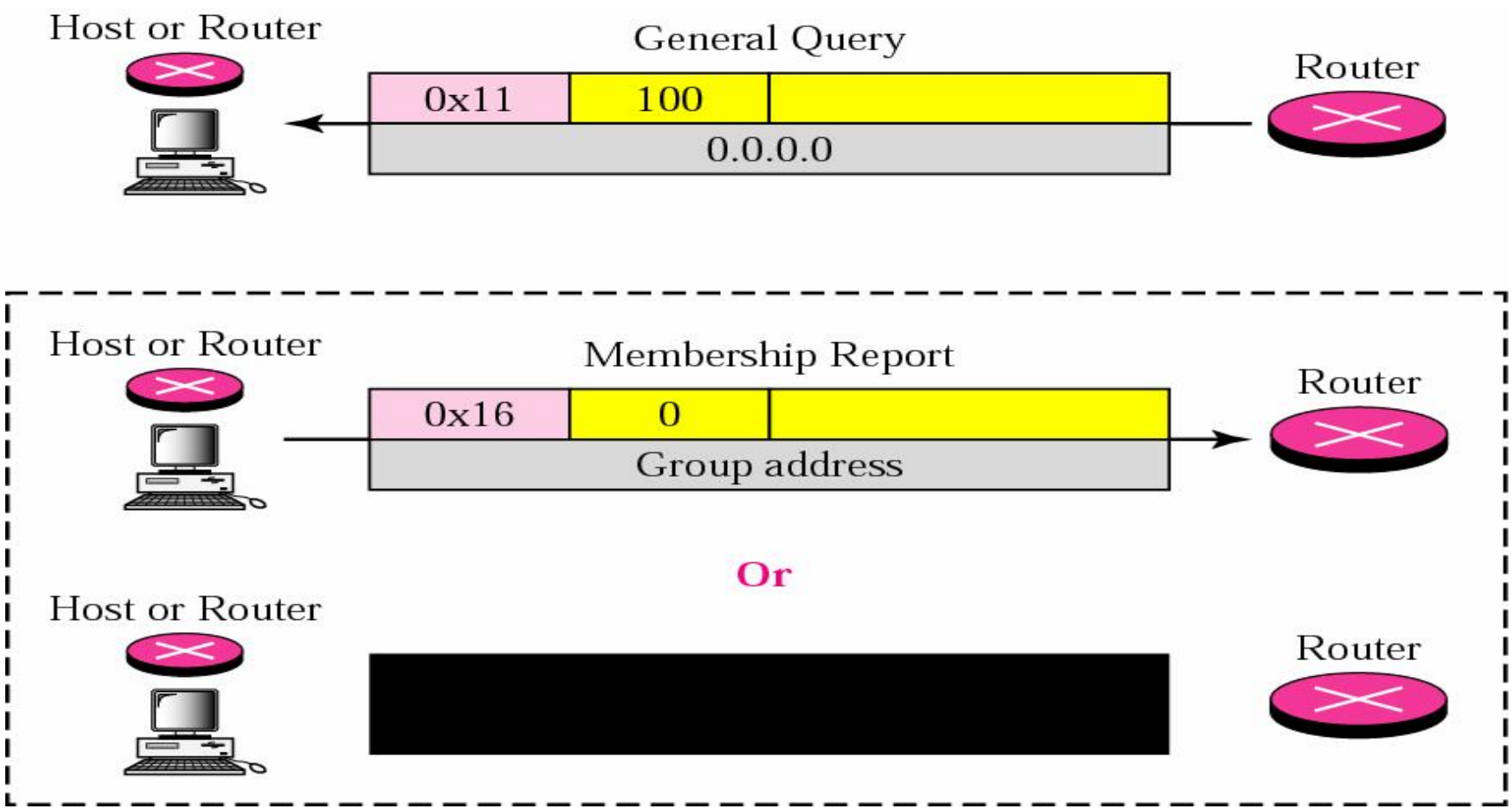
Figure 10.7

General Query Message



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Delayed Response

- However, there may be many hosts/routers interested in the same group
  - Each would send its report message
  - Flooding

- Solution: delayed response
  - Only one response is sent for a group

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Delayed Response (Cont.)

- When a host or router receives a query message
  - It does not respond immediately and delay for a while
- Each host or router uses a random number to create a timer
  - Expire between 1 to 10 seconds
- Once a waiting host or router receives a report
  - It does not send the report again

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Example 1

Imagine there are three hosts in a network as shown in Figure 10.8 (next slide).

A query message was received at time 0; the random delay time (in tenths of seconds) for each group is shown next to the group address. Show the sequence of report messages.

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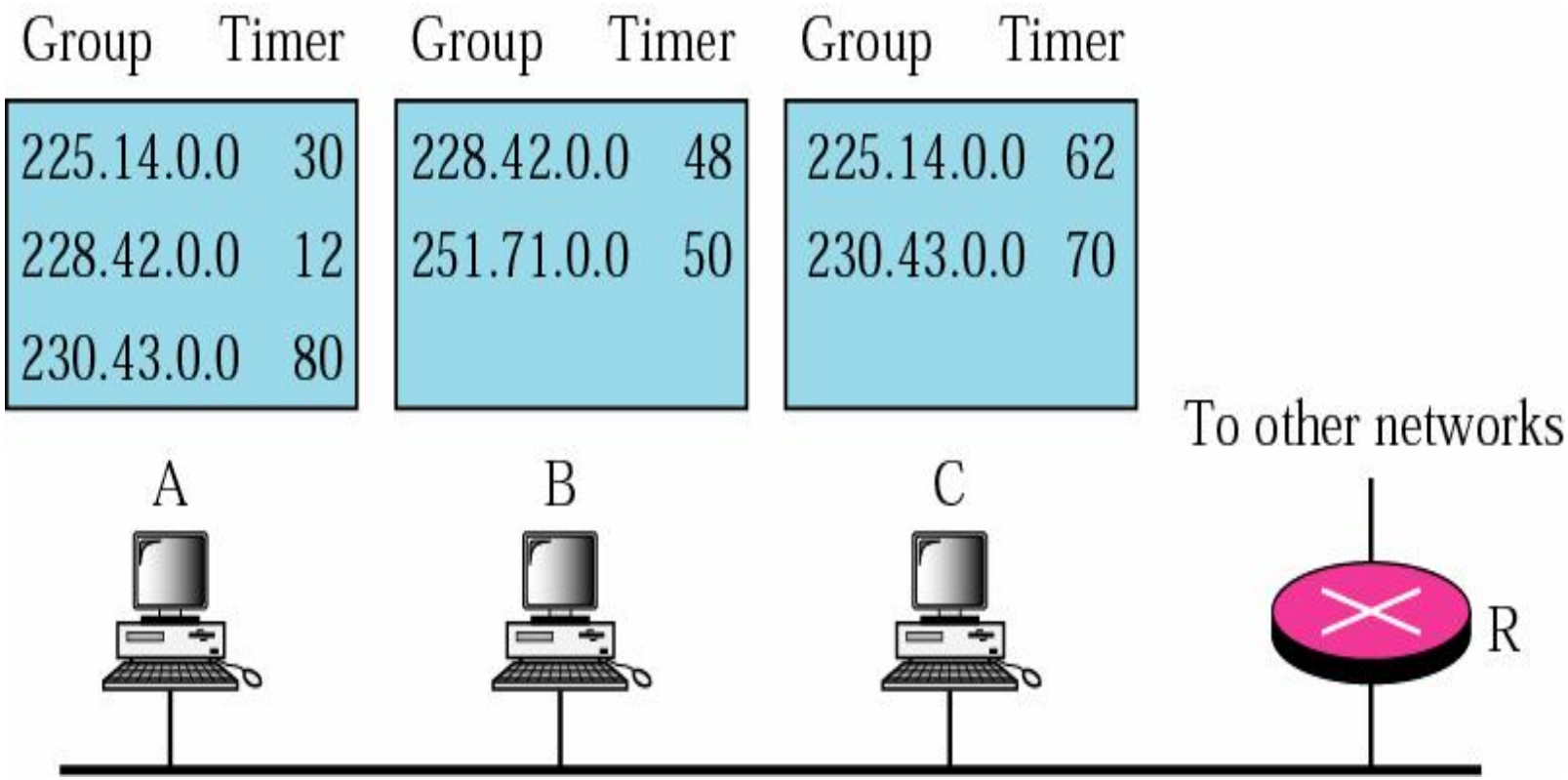
Figure 19.8

Example 1



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Solution

The events occur in this sequence:

Time 12: The timer for 228.42.0.0 in host A expires and a membership report is sent, which is received by the router and every host including host B which cancels its timer for 228.42.0.0.

Time 30: The timer for 225.14.0.0 in host A expires and a membership report is sent, which is received by the router and every host including host C which cancels its timer for 225.14.0.0.

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Solution (Continued)

Time 50: The timer for 251.70.0.0 in host C expires and a membership report is sent, which is received by the router and every host.

Time 70: The timer for 230.43.0.0 in host A expires and a membership report is sent, which is received by the router and every host including host A which cancels its timer for 230.43.0.0.

Note that if each host had sent a report for every group in its list, there would have been *seven* reports; with this strategy only *four* reports are sent.

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Query Router

- Query message may create a lot of response
- To prevent unnecessary traffic
  - IGMP designates one router as the query router for each network
- Only the query router sends the query message
  - The other routers are passive

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10.4

ENCAPSULATION

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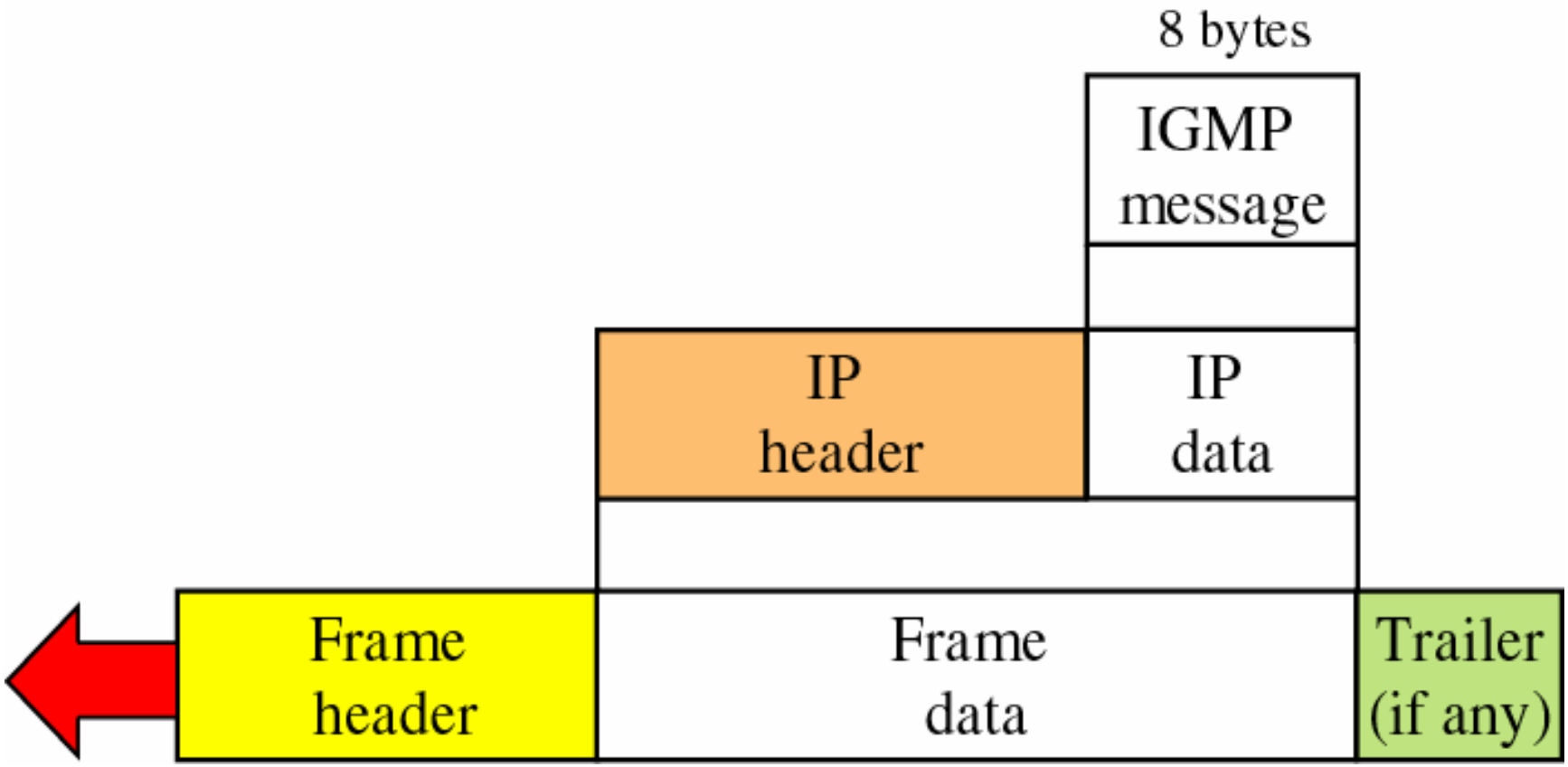
Figure 19.8

Encapsulation of IGMP Packet



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IP Layer

- At the IP level: three fields are of concern
  - Protocol field: 2
  - TTL field: one
    - IGMP's domain is LAN, no IGMP message should travel beyond the LAN
  - Destination IP address
    - Query: 224.0.0.1: all systems on this subnet
      - All routers and all hosts will receive this packet
    - Membership report: the multicast address of the group
    - Leave report: 224.0.0.2: all routers on this subnet
      - Routers receives this packet while hosts receive and disregard it

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Note

The IP packet that carries an IGMP packet has a value of 2 in its protocol field.

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Note

The IP packet that carries an IGMP packet has a value of 1 in its TTL field.

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Data Link Layer

- IGMP is encapsulated in an IP packet
  - IP packet will have a multicast IP address
- ARP protocol cannot find the corresponding MAC address
- Solution
  - Depends on whether the underlying data link layer support physical multicast address or not

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Physical Multicast Support

- Most LANs support physical multicast address
  - Ethernet is one of them
- If the first 25 bits in an Ethernet address are
  - 00000001000000000010111100: physical multicast address
  - The remaining 23 bits is used to define a group

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Physical Multicast Support (Cont.)

- To convert an IP multicast address into an Ethernet address, the multicast router
  - Extract the least significant 23 bits of a class D IP address
  - Then insert into a multicast Ethernet address
  - Note, class D defines multicast addresses

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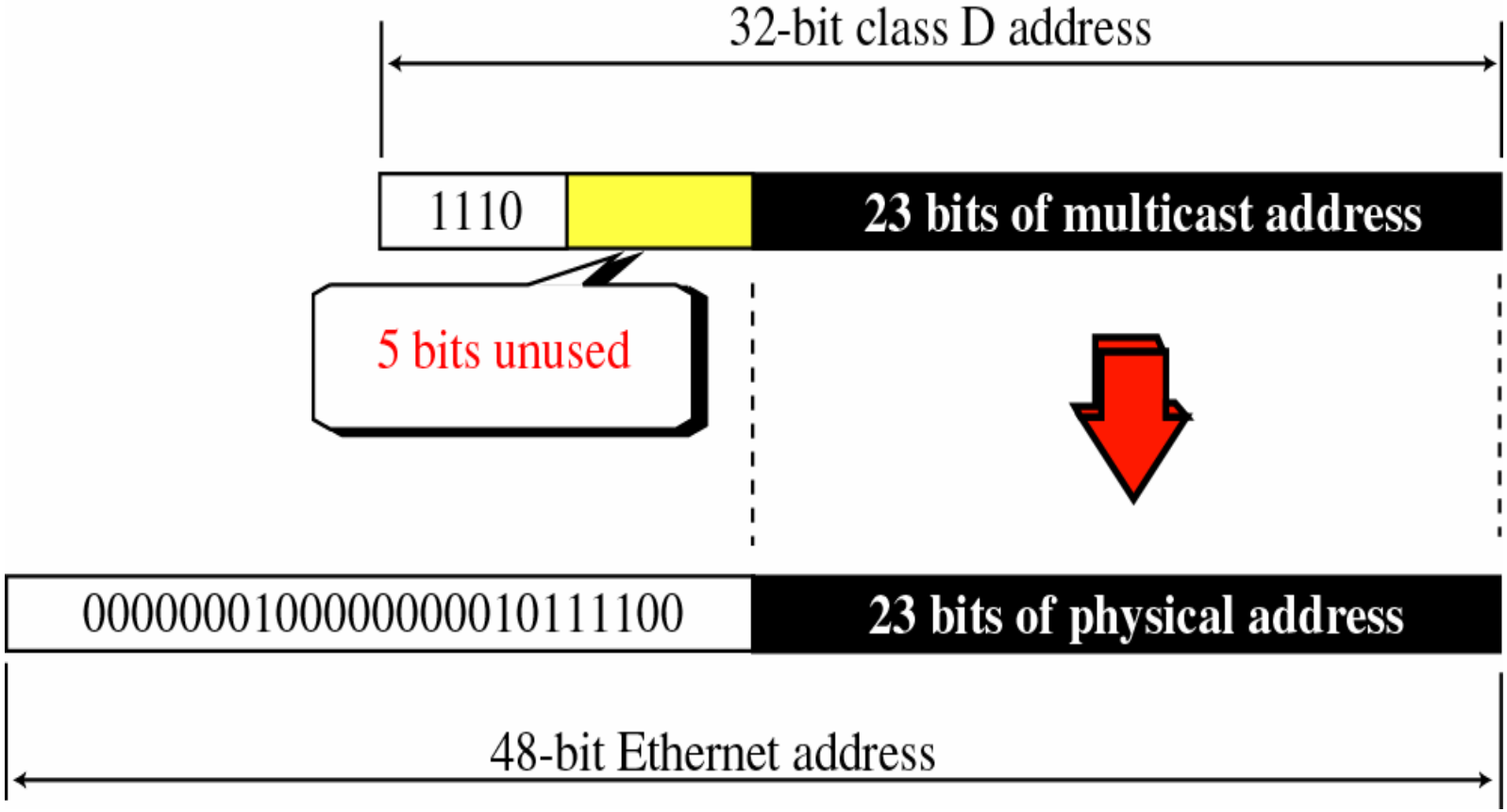
Mapping Class D to Ethernet Physical Address



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The Classes of IP Address

	First byte	Second byte	Third byte	Fourth byte
Class A	**0**			
Class B	**10**			
Class C	**110**			
Class D	**1110**			
Class E	**1111**			

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Physical Multicast Support (Cont.)

- However, the group identifier of a class D IP address is 28 (32-4) bits
  - Thus, 5 (28-23) bits are not used
  - 32 (2^5) multicast addresses at the IP level are mapped to a single multicast address
  - Many-to-one mapping
- Thus, a host may receive multicast packets not belong to it
  - Host must check the IP address since MAC address is not completely accurate

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No Physical Multicast Support

- Most WANs do not support physical multicast addressing
- To send a multicast packet through these networks
  - Use the ***tunneling*** technique
- Tunneling
  - The multicast packet is encapsulated in a unicast packet and send through the network
  - Then, it emerges from the other side as a multicast packet

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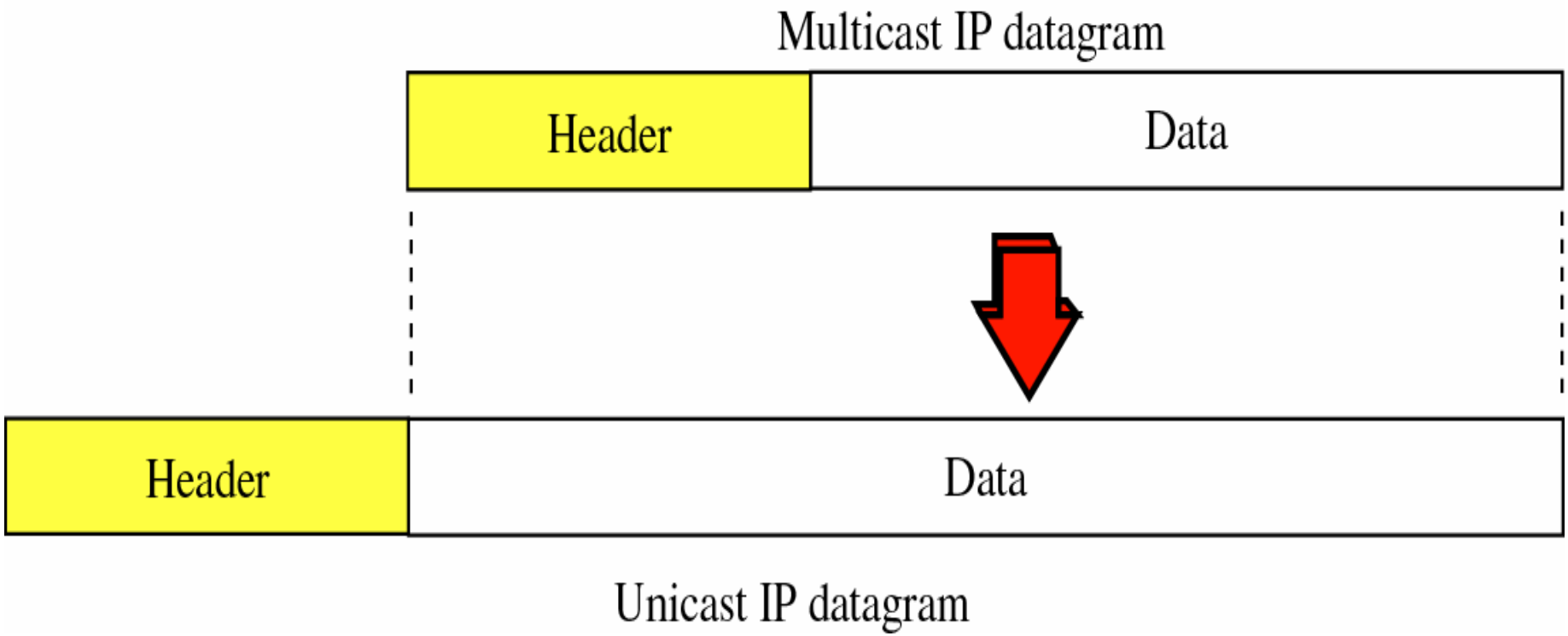
Figure 19.11

Tunneling



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10.5

IGMP PACKAGE

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IGMP Package

- Show ony the modules used in an IGMP host
- A group table
- A set of timers
- Four software modules
  - A group-joining module
  - A group-leaving module
  - An input module
  - An output module

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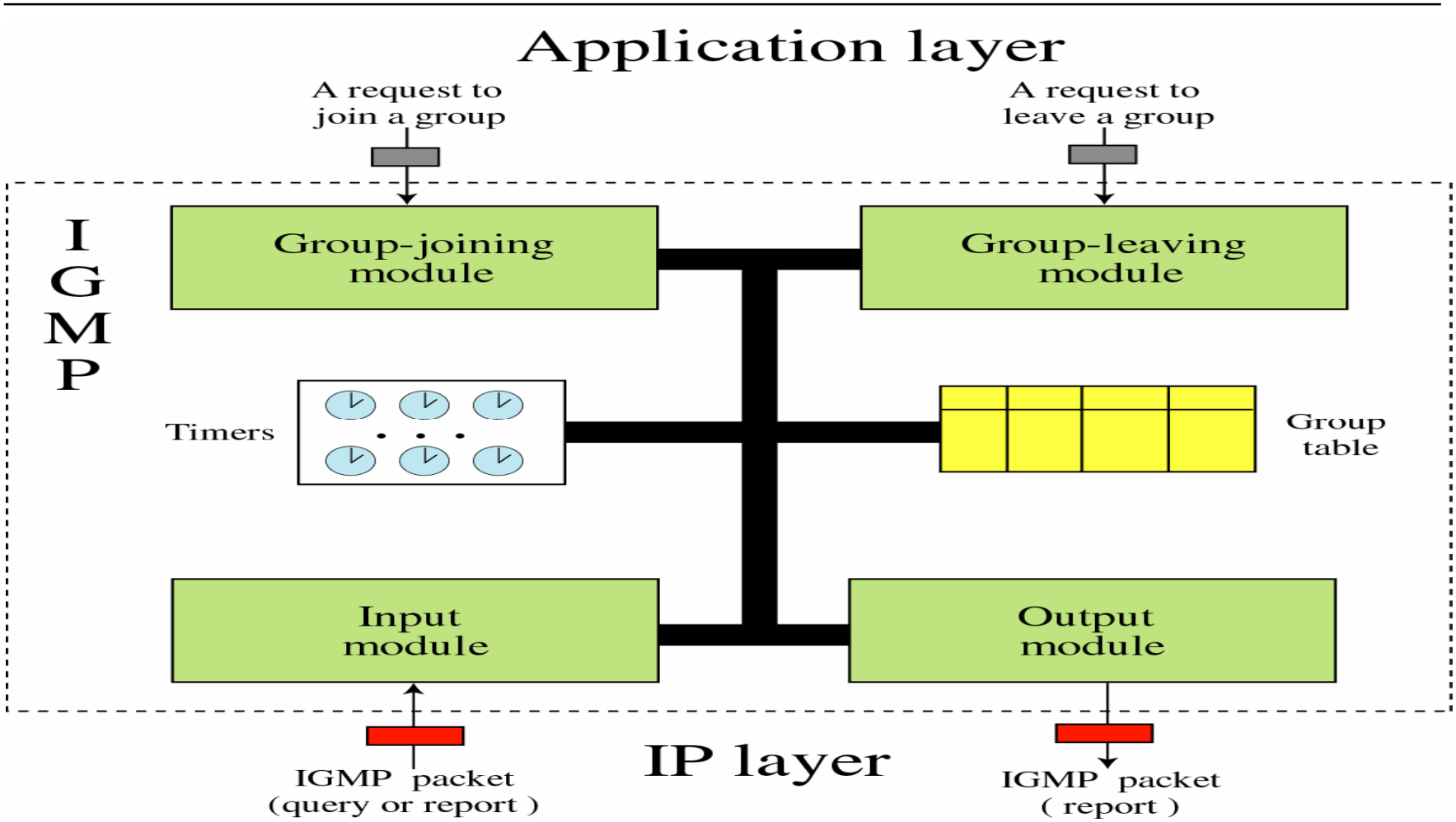
Figure 10-12

IGMP Package



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Group Table

- Group table shows whether processes in this host belonging to this group or not
- State: defines the state of the entry
  - FREE: no processes left in the group
  - DELAYING: a report must be sent for this entry when the timers matures
  - IDLE: no timer running for this entry

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Group Table (Cont.)

- Interface number
  - The interface through which the multicast packet is sent or received
- Group address: the multicast address
- Reference count
  - The number of processes interested in the group
  - When a process joins a group: + 1
  - When a process leave a group: -1
  - When zero: state = FREE

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Group Table

State	Interface No.	Group Address	Reference Count
.....	.....	.....	.....
.....	.....	.....	.....
.....	.....	.....	.....

State: Free, Delaying, Idle

Reference Count: Number of processes interested

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Timers

- Each entry in the DELAYING state has a timer to govern the sending of reports

- Select a random value and if expires
  - Send a signal to the output module to generate a report

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Group-Joining Module

- Receive: a request from a process to join a group
- If found
  - Increment the reference count
- Else
  - Create an entry with reference count set to one
  - Add the entry to the table
  - Request a membership report from the output module
  - Inform the data link layer to update its configuration table
    - Then this type of multicast packet can be received

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Group-Leaving Module

- Receive: a request from a process to leave a group
- Look for the corresponding entry in the table
- If found
  - Decrement the reference count
  - If (reference count is zero)
    - If (any timer for this entry):
      - Cancel the timer
    - Change the state to FREE
    - Request a leave report from the output module
- Return

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Input Module

- Receive: an IGMP message
- Check the message type
- If (query)
  - Start a timer for each entry in the table with the state IDLE
  - Change each IDLE state to DELAYING state
  - Return
- If (membership report)
  - Look for the corresponding entry in the table
  - If (found and state is DELAYING)
    - Cancel the timer for this entry
    - Change the state to IDLE
- Return

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Input Module

- Hosts do not receive leave report
- Thus, the previous slide does not show this

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Output Module

- Receive: a signal from a matured timer or a request from joining or leaving module
- If the message comes from a timer
  - If (found and state is DELAYING)
    - Create a membership report
    - Reset the state to IDLE
- If the message comes from the group-joining module
  - Create a membership report
- If the message comes from the group-leaving module
  - Create a leave report
- Send the message and return

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