Lecture 4.3

Network Layer

Multicasting-IGMP

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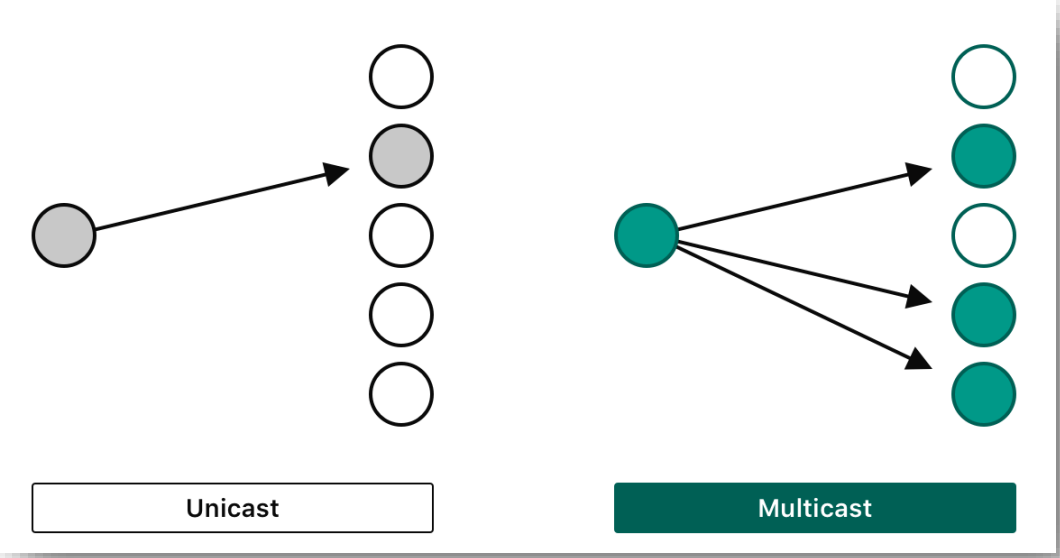
Introduction

- The **IP protocol** can be involved in **two types** of **communication**:
  - ***Unicasting***
  - ***Multicasting***
- **Unicasting** is the **communication** between **one sender and one receiver**.
- It is a **one-to-one communication.**
- However, some **processes** sometimes need to **send** the same **message** to a **large number of receivers simultaneously.**
- This is called **multicasting**, which is a **one-to-many communication.**

Introduction



Multicasting

- **Multicasting** has many **applications.**
- **For example**,
  - **Multiple stockbrokers** can **simultaneously be informed** of **changes** in a **stock price.**
  - **Multiple travel agents** can **be informed** of a **plane cancellation**.
  - Some other applications include **distance learning** and **video-on-demand**.
- The **Internet Group Management Protocol (IGMP)** is one of the **necessary**, but **not sufficient** protocol that is involved in **Multicasting.**
- For **multicasting** in the **Internet** we need **routers** that are **able** to **route multicast packets.**
- The **routing tables** of these **routers** must be **updated** by using one of the **Multicasting routing protocols**.

Group Management

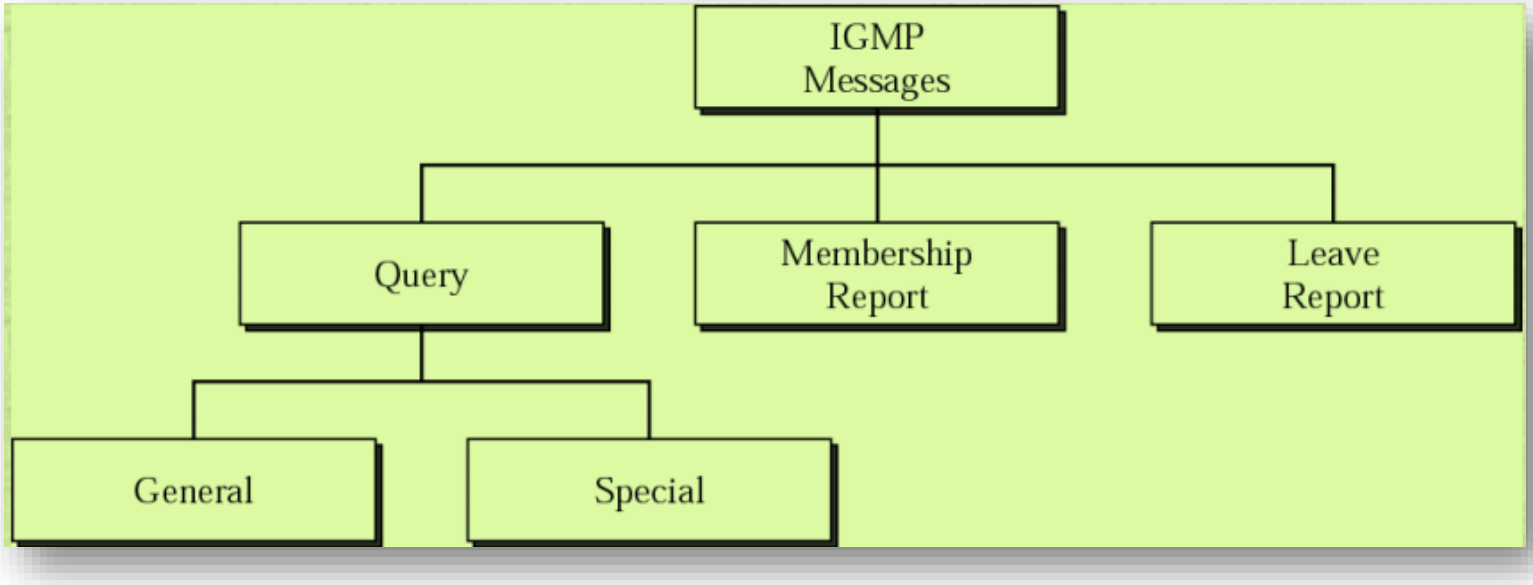
- **IGMP** is a **companion** to the **IP protocol** which **manages group membership.**
- In any **network**, there are **one** or **more** **multicast routers** that **distribute** **multicast packets** to **hosts** or other **routers.**
- The **IGMP protocol** informs the **multicast routers** about the **membership status** **of hosts (routers)** connected to the **network.**
- If a **router** has **no knowledge about the membership status** of the **hosts**, it must **broadcast** **all these packets**.
- This creates a **lot of traffic** and **consumes bandwidth**.

Group Management

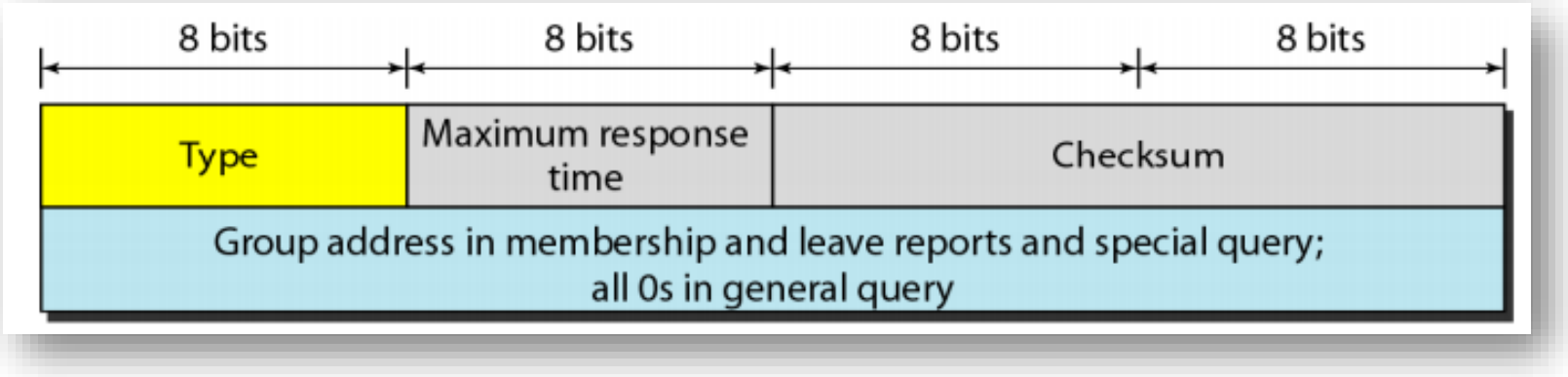
- **Loyal Member**
- In **multicasting**, those **user** that still want to **receive multicast messages** from **one network** are called **loyal members** for that network.
- Each **multicast router** keeps a **list of groups** in the **network** for which there is **at least one loyal member.**
- **IGMP** helps the **multicast router** to **create** and **update** this **list**.

IGMP Messages

- **IGMP** has gone through **three versions**: **IGMPv1**, **IGMPv2**, the current version **IGMPv3.**
- **IGMPv2** has **three types** of **messages**:



Message Format



- **Type**. This **8-bit field** defines the **type of message**, as shown in **Table** below.
- The **value** of the **type** is shown in both **hexadecimal** and **binary notation.**

Type	*Value*
General or special query	0x11 or 00010001
Membership report	0x16 or 00010110
Leave report	0x17 or 00010111

Message Format

Maximum Response Time

- This **8-bit field** defines the **amount of time** in which a **query** must be **answered**.
- The **default** value is **10 s.**
- The **value** is **nonzero** in the **query message**; it is **set to zero** in the **other two message types.**

Checksum

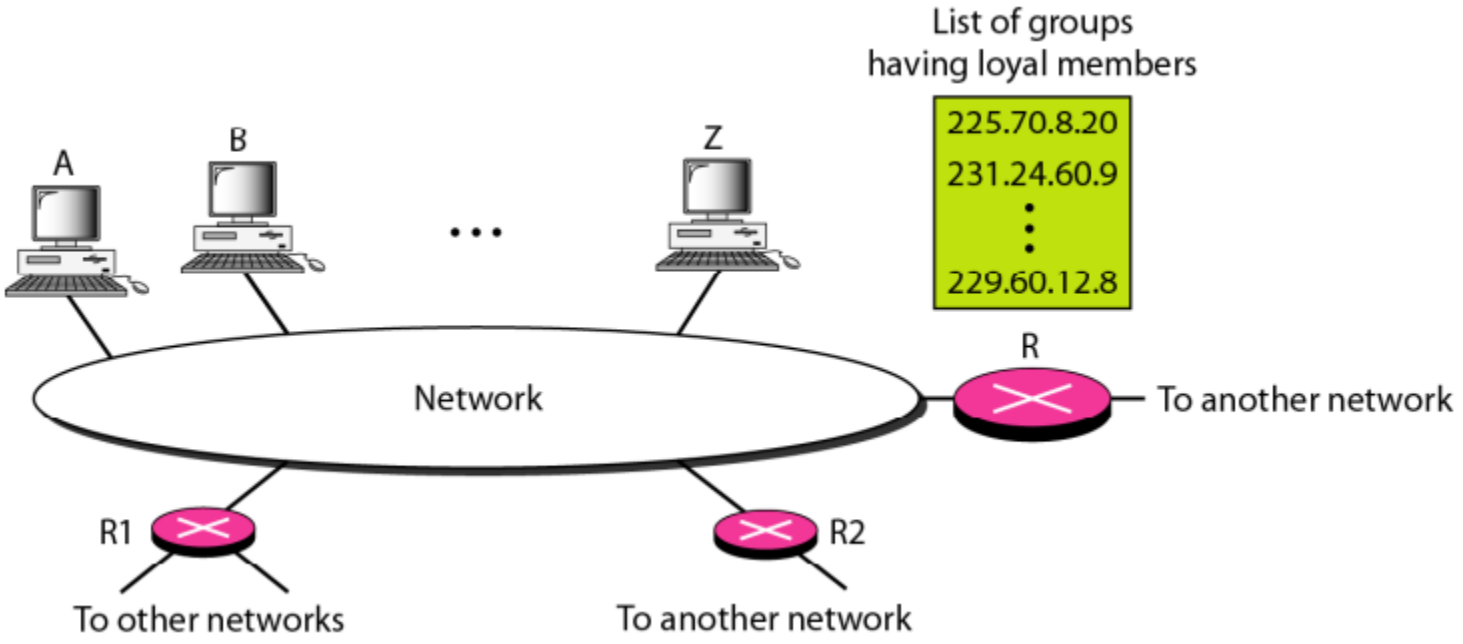
- This is a **16-bit field** carrying the **checksum.**

Group address

- The **value** of this field is **0** for a **general query message**.
- The **value** defines the **group id (multicast address** of the **group)** in the **special query**, the **membership report**, and the **leave report messages.**

IGMP Operation

- **IGMP** operates **locally.**
- A **multicast router** connected to a **network** has a **list** of **multicast addresses of the groups with at least one loyal member** in that **network.**



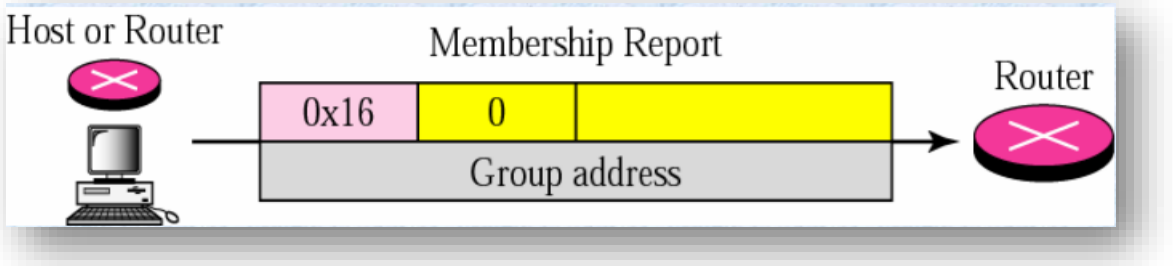
IGMP Operation

- For **each group**, there is **one router** that has the **duty** of **distributing** the **multicast packets** destined for that **group.**
- If **multiple Multicast Routers** exist in **one network**, then their **Group Lists** are **mutually exclusive**.
- A **host** or **multicast router** can have **membership in a group**.
- When a **host** has **membership**, it means that one of its **processes** (an application program) **receives multicast packets** from **some group.**
- When a **router** has **membership in** a **group**, it means that a **network** connected to one of its other **interfaces receives** these **multicast packets.**
- *In **both cases**, the **host** and the **router** **keep** a **list of** group ids.*

Joining a Group

- A **host** or a **router** can **join** a **group.**
- A **host** maintains a **list of processes** that have **membership** in a **group**.
- When a **process** **wants** to **join a new group**, it **sends** **its** **request** to the **host**.
- The **host** adds the name of the **process** and the **name** of the **requested group** to its **list.**
- If this is the **first entry** for this **particular group**, the **host** sends a **membership report message** to the **multicast router.**
- The **protocol** requires that the **membership report** be **sent twice**, one after the other within a few moments.
- In this way, if the **first one** is **lost** or **damaged**, the **second** one replaces it.

Joining a Group using Membership Report

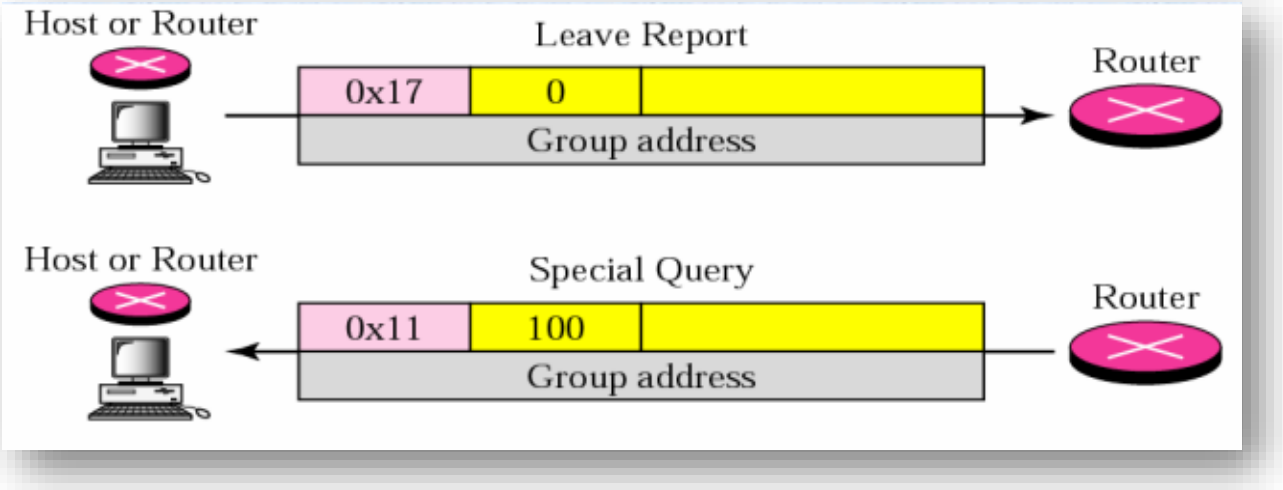


Leaving a Group

- When a **host** sees that **no process is interested** in a **specific group**, it **sends** a **leave report.**
- Similarly, when a **router** sees that **none** of the **networks connected** to its **interfaces** is **interested** in a **specific group**, it **sends** a **leave report** about that **group.**
- 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 **router**; there may be **other hosts** or **routers** that are **still interested** in that **group.**
- To make sure, the **router** sends a **special query message** and **inserts** the **group id,** or **multicast address**, related to the **group.**

Leaving a Group

- The **router** allows a **specified time** for **any host** or **router** to **respond** the **special query message.**
- If, during this **time, no interest** (**membership report**) is **received,** the **router** assumes that there are **no loyal members** in the **network** and **purges** the **group from its list.**



Monitoring Membership using General Query message

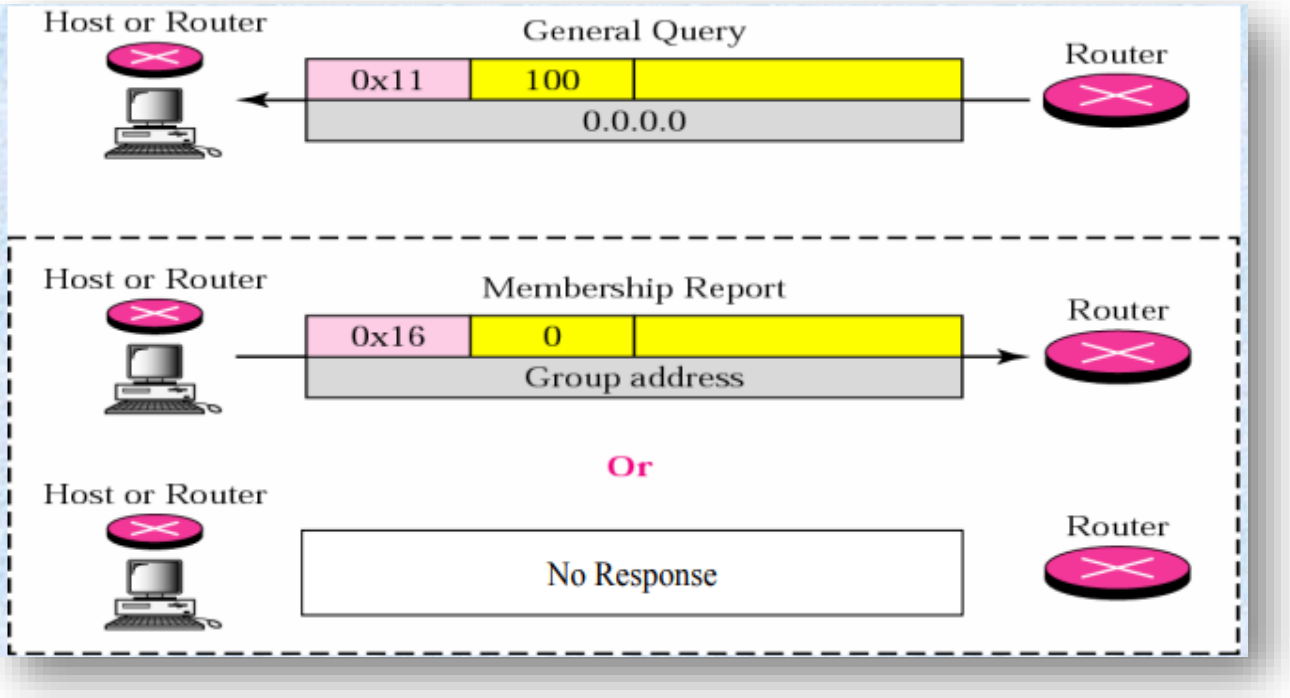
- A **host** or **router** can **join a group** by **sending** a **membership report message**.
- It can **leave a group** by **sending** a **leave report message**.
- However, **sending** these **two types** of **reports** is **not enough.**
- Consider the **situation** in which there is **only one host interested** in **a group**, but the **host** is **shut down** or **removed** from the **system.**
- The **multicast router** will **never receive** a **leave report.**
- The **multicast router** is **responsible** for **monitoring** all the **hosts** or **routers** in a **LAN** to see if they want to continue their **membership** in a group.
- The **router periodically** (by default, every 125 s) sends a **general query message**.
- In this message, the **group address field** is set to **0.0.0.0.**

Monitoring Membership using General Query message

- The **router expects** an **answer** for **each group** in its **group list**; even **new groups** may **respond.**
- The **query message** has a **maximum response time** of **10 s.**
- When a **host** or **router** receives the **general query message**, it **responds** with a **membership report** if it is **interested** in a **group**.
- However, if there is a **common interest** (two hosts, for example, are interested in the same group), **only one response** is **sent** for that **group** to **prevent unnecessary traffic.**
- To **prevent unnecessary traffic**, **IGMP** uses a **delayed response strategy**.
- When a **host** or **router receives** a **query message**, it **does not respond immediately**; it **delays** the **response.**

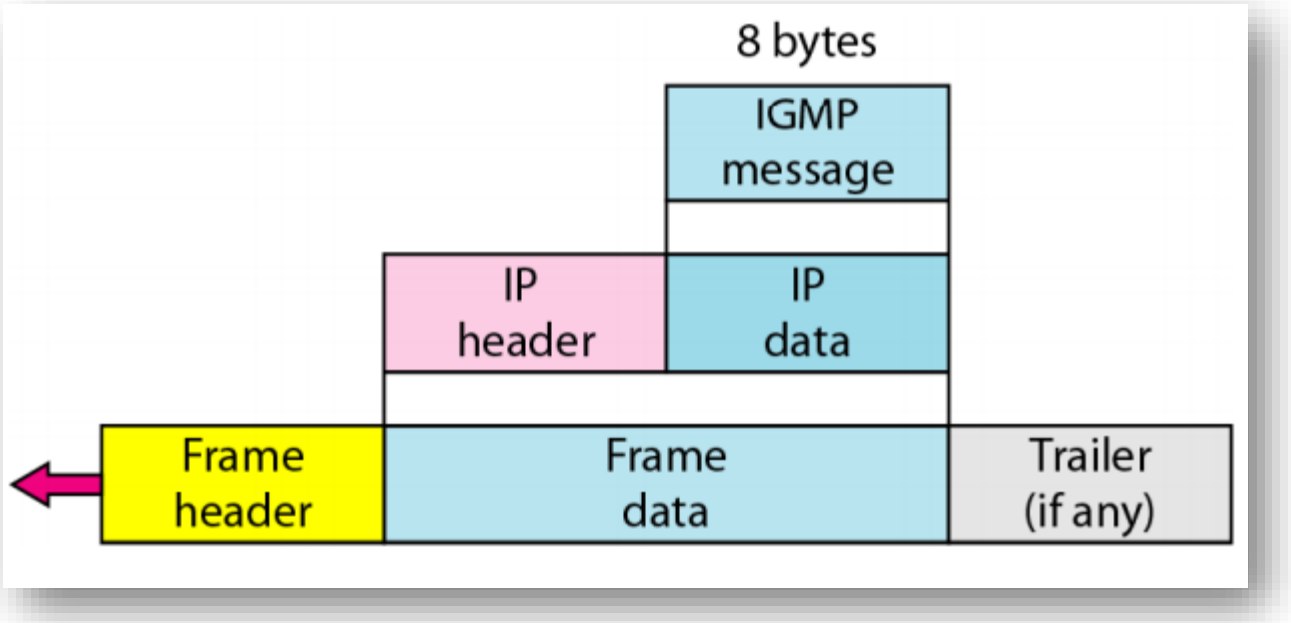
Monitoring Membership using General Query message

- Note that the **query message** must be **sent** by **only one router** (normally called the **query router**), also to **prevent unnecessary traffic.**



Encapsulation

- The **IGMP message** is **encapsulated** in an **IP datagram**, which is itself **encapsulated in a frame.**



Encapsulation at Network Layer

- The **value** of the **protocol field** is **2** for the **IGMP protocol.**
- Every **IP packet** carrying this **value** in its **protocol field** has data delivered to the **IGMP protocol.**
- When the **message** is **encapsulated** in the **IP datagram**, the value of **TTL** must be **1**.
- This is required because the **domain of IGMP** is the **LAN**.
- No **IGMP message** must travel **beyond** the **LAN.**
- A **TTL value** of 1 **guarantees** that the **message** does **not leave** the **LAN** since this **value** is **decremented** to **0** by the **next router** and, consequently, the **packet** is **discarded.**

Encapsulation at Network Layer

Type	*IP Destination Address*
Query	224.0.0.1 All systems on this subnet
Membership report	The multicast address of the group
Leave report	224.0.0.2 All routers on this subnet

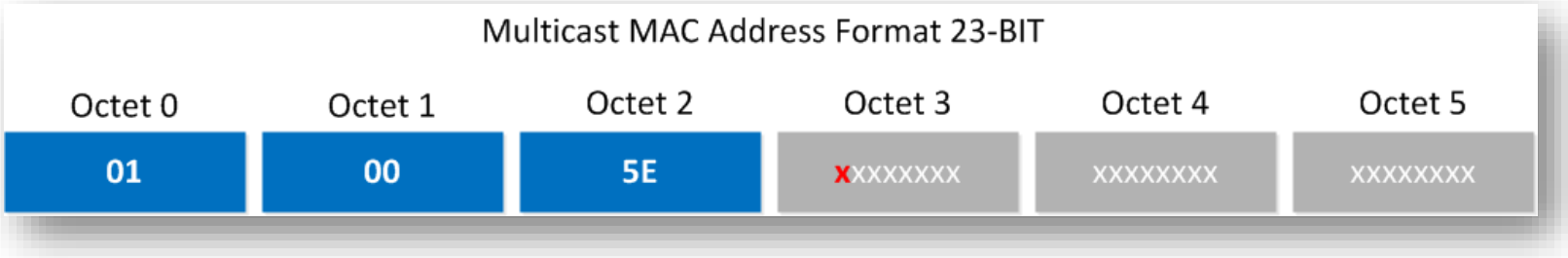
- A **Query message** is **multicast** by using the **multicast address 224.0.0.1**
- **All hosts** and **all routers** will **receive** the **message.**
- A **Membership report** is **multicast** using a **destination address** equal to the **multicast address** being reported (**groupid**).
- **Every station** (host or router) that **receives** the **packet** can immediately **determine** (from the header) the **group** for which a **report** has been **sent.**
- A **Leave report message** is **multicast** using the **multicast address 224.0.0.2** (**all routers on this subnet)** so that **routers receive** this type of **message.**
- **Note: Multicast IP address range: 224.0.0.0 – 239.255.255.255**

Encapsulation at Data Link Layer

- At the **network layer**, the **IGMP message** is **encapsulated** in an **IP packet** and is treated as an **IP packet.**
- However, because the **IP packet** has a **multicast IP address**, the **ARP** protocol **cannot find the corresponding MAC** (physical) **address** to **forward** the **packet** at the **data link layer.**
- What happens next depends on whether the underlying **data link layer supports physical multicast addresses**.
- Most **LANs** support **physical multicast addressing**, **Ethernet** is one of them.

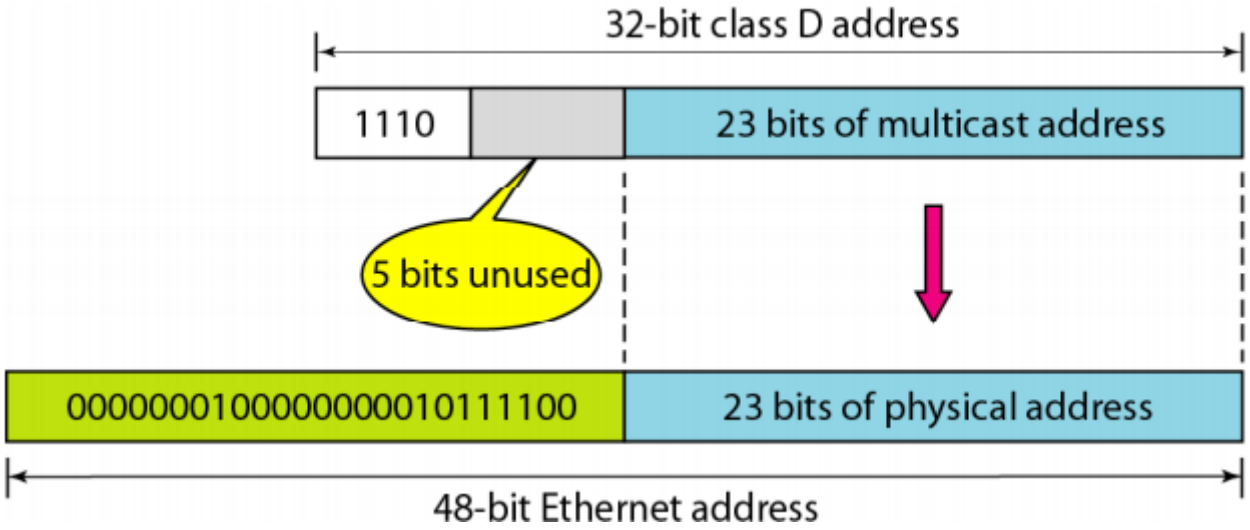
Physical Multicast Support

- An **Ethernet physical address (MAC address)** is **six octets** (**48 bits**) long.
- If the **first 25 bits** in an **Ethernet address** are **00000001000000000010111100** or if **hexadecimal prefix** is **01-00-5E**, this identifies a **physical multicast address** for the **TCP/IP protocol.**
- The remaining **23 bits** can be used to **define a group**.



- To convert an **IP multicast address** into an **Ethernet address**, the **multicast router** extracts the **least significant 23 bits** of a **class D IP address** and inserts them into a **multicast Ethernet physical address**.

Physical Multicast Support



Example 1

Question: Change the **multicast IP address 230.43.14.7** to an Ethernet **multicast physical address.**

Solution

- We write the rightmost **23 bits** of the **IP address** in **hexadecimal.**
- This can be done by changing the **rightmost 3 bytes** to **hexadecimal** and then **subtracting 8** from the **leftmost digit** if it is **greater than or equal to 8**.
- In this example, the result is **2B:0E:07.**
- We add the result of part a to the starting Ethernet multicast address, which is **01:00:5E:**00:00:00.
- The result is **01:00:5E**:**2B:0E:07**

Example 2

Question 2: Change the **multicast IP address** **238.212.24.9** to an **Ethernet multicast address.**

Solution

- The **rightmost 3 bytes** in hexadecimal is **D4: 18:09.**
- We need to **subtract 8** from the leftmost digit, resulting in **54:18:09.**
- We add the result of part a to the **Ethernet multicast** starting address.
- The result is **01:00:5E:54: 18:09**

No Physical Multicast Support

- Most **WANs do not support physical multicast addressing.**
- To **send** a **multicast packet** through **these networks**, a **process** called ***tunneling*** *is* ***used.***
- In **tunneling**, the **multicast packet** is **encapsulated in a unicast packet** and **sent** through the **network,** where it **emerges** from the **other side** as a **multicast packet.**