NETWORK PROTOCOLS

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BASICS OF NETWORKING

LECTURE 2

2204 - 2025

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Outline

In this lecture will talk about:

- **Basics of Networking**
  - Review layered network models
  - Addressing

Layered Network Models

- The intercommunication between hosts in any computer network, be it a large-scale or a small-scale one is **built upon the premise** of various task-specific **layers**.

✓ يعتمد الاتصال المتبادل بين المضيفين في أي شبكة كمبيوتر، سواء كانت واسعة النطاق أو صغيرة النطاق، على فرضية وجود طبقات مختلفة خاصة بالمهام.

- Most **commonly** accepted and used **traditional** layered network models.
  - open systems interconnection (**OSI**) 7-layer model developed by the International Organization of Standardization (ISO).
  - Internet protocol suite (**TCP/IP**) 4-layer model.

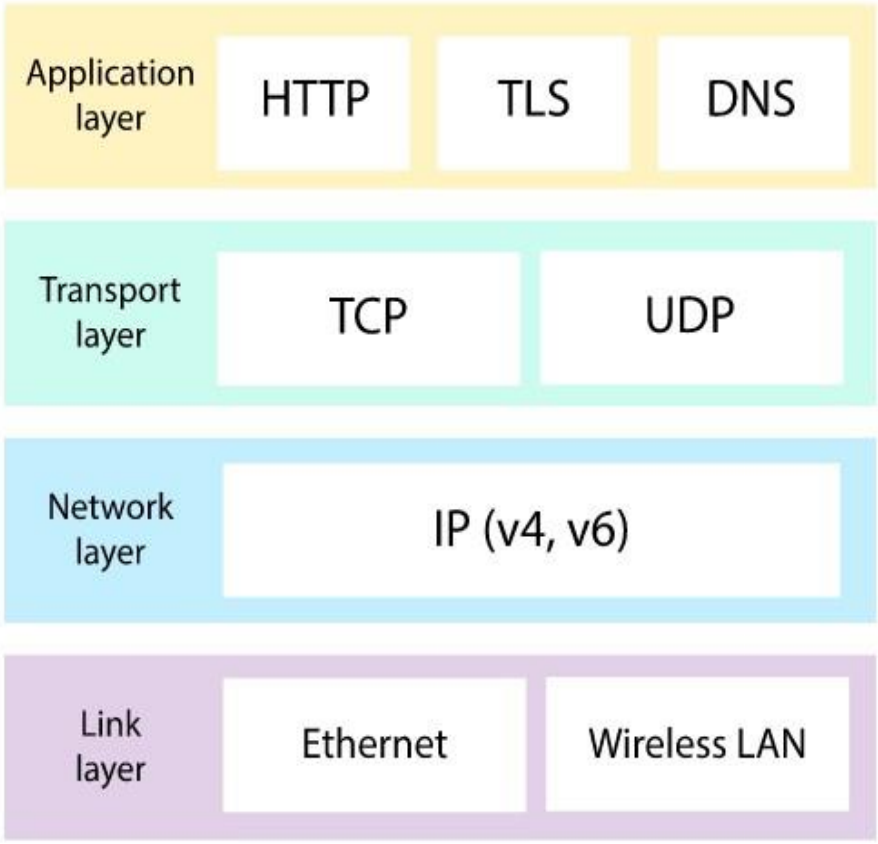
Layered Network Models

- **(ISO-OSI) reference model:**

1) **Application Layer**
2) **Presentation Layer**
3) **Session Layer**
4) **Transport Layer**
5) **Network Layer**
6) **Data Link Layer**
7) **Physical Layer**

Layered Network Models

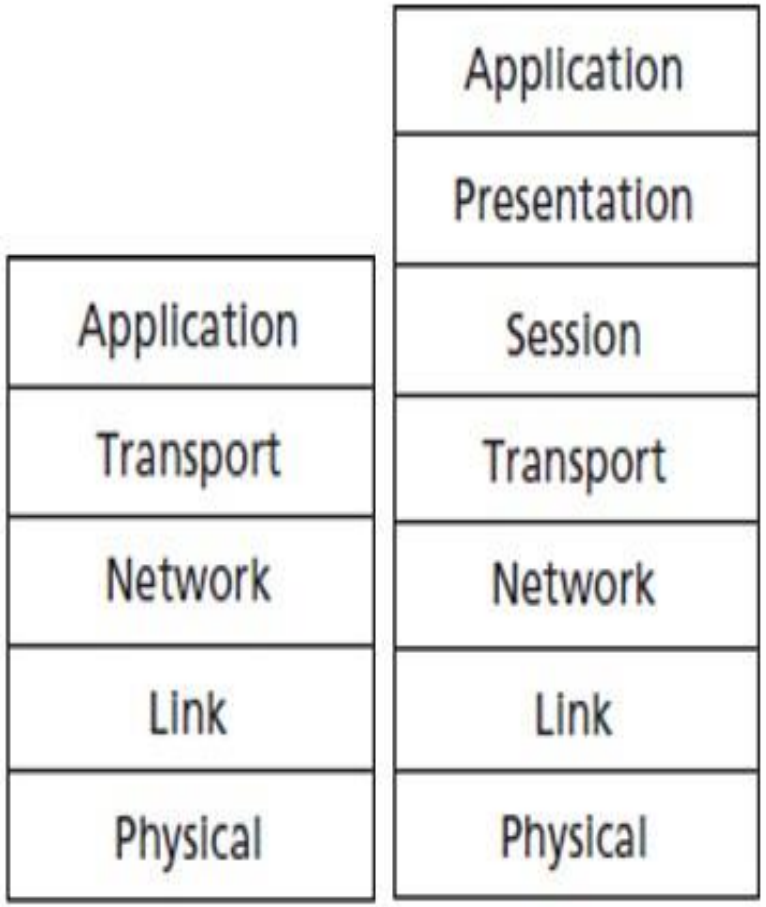
- Internet protocol suite, transmission control protocol (TCP) and Internet protocol (IP), (**TCP/IP**).



Layered Network Models

- **Internet protocol suite (TCP/IP)**

1) **Application layer**
2) **Transport layer**
3) **Internet layer**
4) **Link layer.**
   - Data link layer
   - Physical layer



- **(ISO-OSI) reference model:**

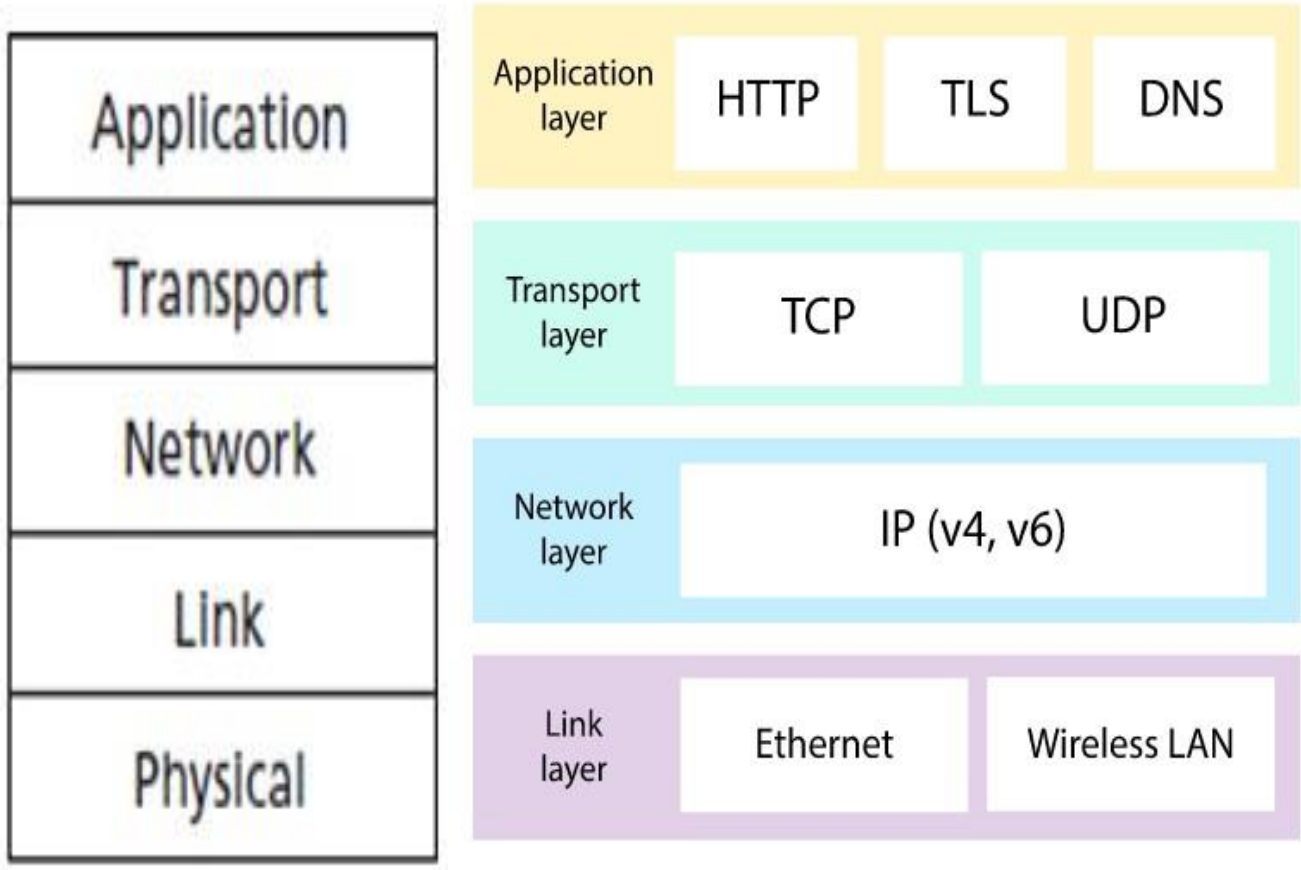
1) **Application Layer**
2) **Presentation Layer**
3) **Session Layer**
4) **Transport Layer**
5) **Network Layer**
6) **Data Link Layer**
7) **Physical Layer**

Layered Network Models

- **Internet protocol suite (TCP/IP)**

1) Application layer:

- **layer 1**, of the TCP/IP protocol suite equivalent with the collective functionalities of the OSI model's session, presentation, and application layers.
- This layer enables an end-user to access the services.
- Hypertext transfer protocol (HTTP), file transfer protocol (FTP), simple mail transfer protocol (SMTP), domain name system (DNS).

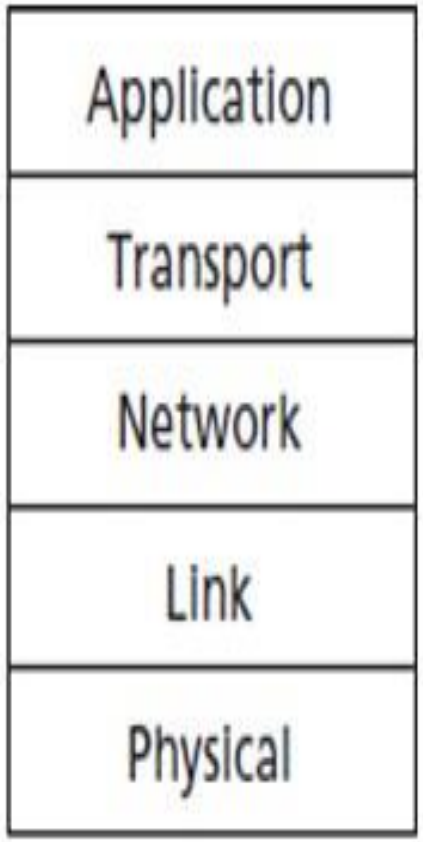


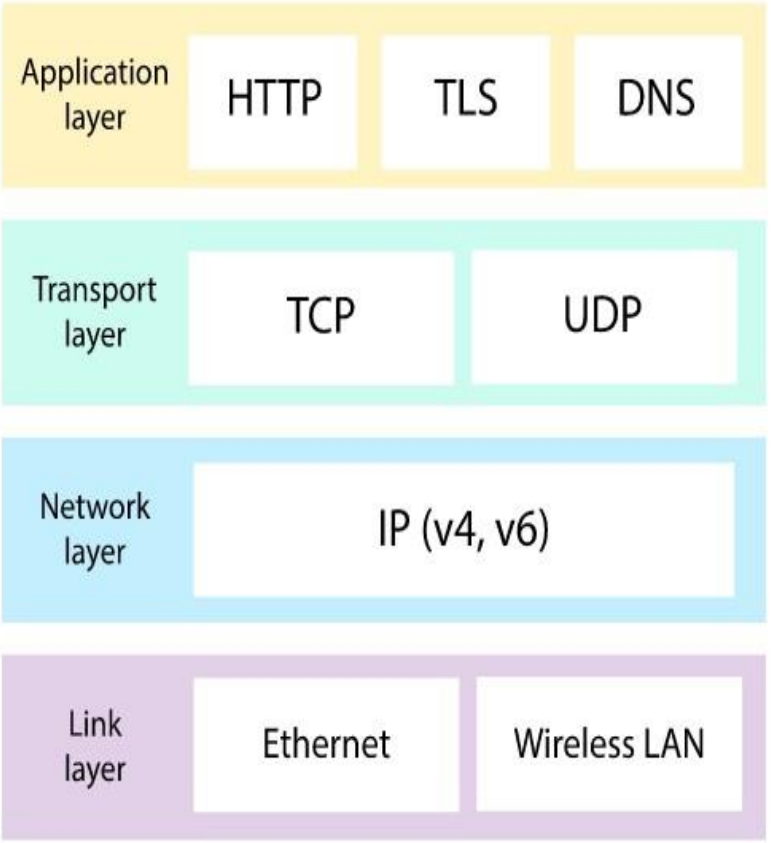
Layered Network Models

- **Internet protocol suite (TCP/IP)**

2) Transport layer:

- **Layer 2** of the TCP/IP protocol suite is functionally equivalent with the transport layer of the OSI model.
- **Tasked with** the functions of error control, flow control, congestion control, segmentation, and addressing in an **end-to-end manner**.
- Transmission control protocol (**TCP**) and user datagram protocol (**UDP**) are the core protocols.
- providing connection-oriented or connectionless services between two or more hosts or networked devices.



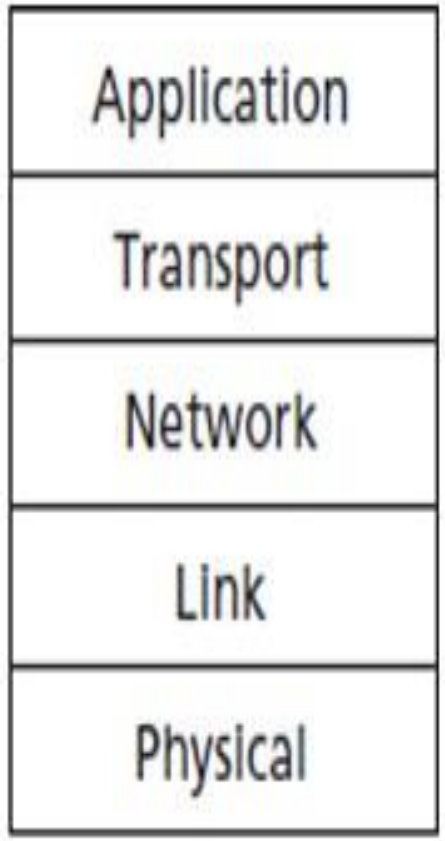


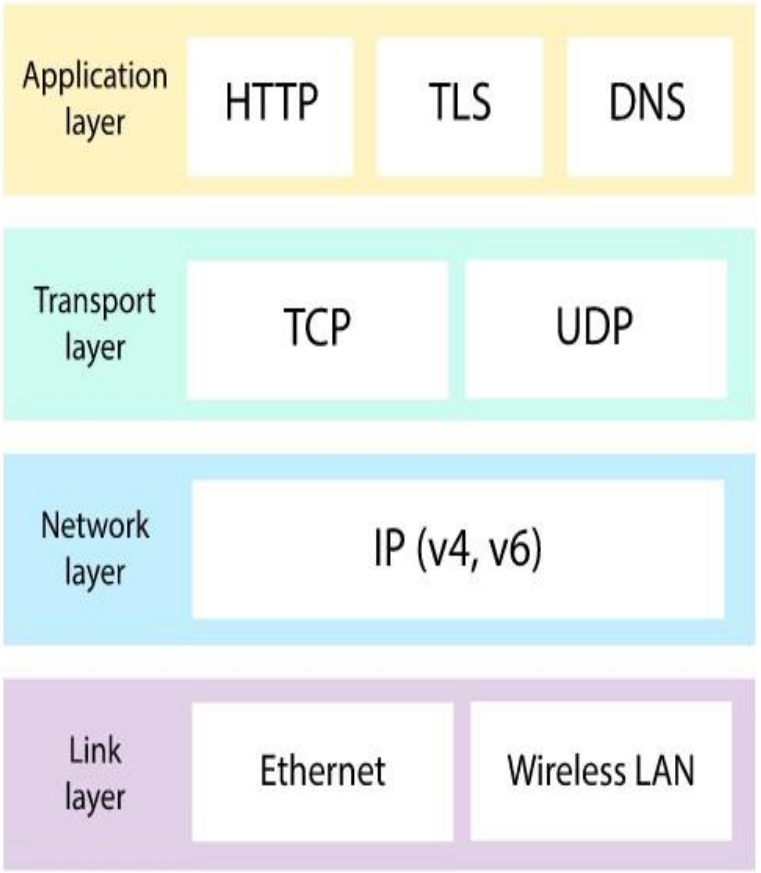
Layered Network Models

- **Internet protocol suite (TCP/IP)**

3) Internet layer:

- **Layer 3** of the TCP/IP protocol suite is somewhat equivalent to the network layer of the OSI model.
- It is responsible for addressing, address translation, data packaging, routing, and packet delivery tracking operations.
- Address resolution protocol (ARP), Internet protocol (IP), Internet control message protocol (ICMP), and Internet group management protocol (IGMP).



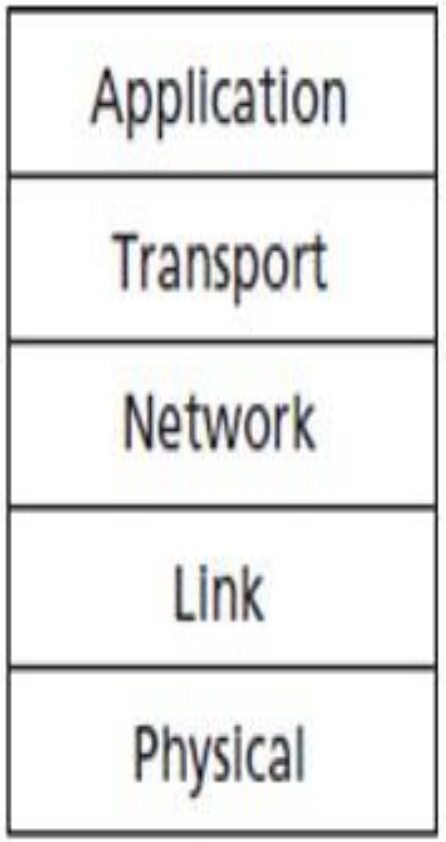


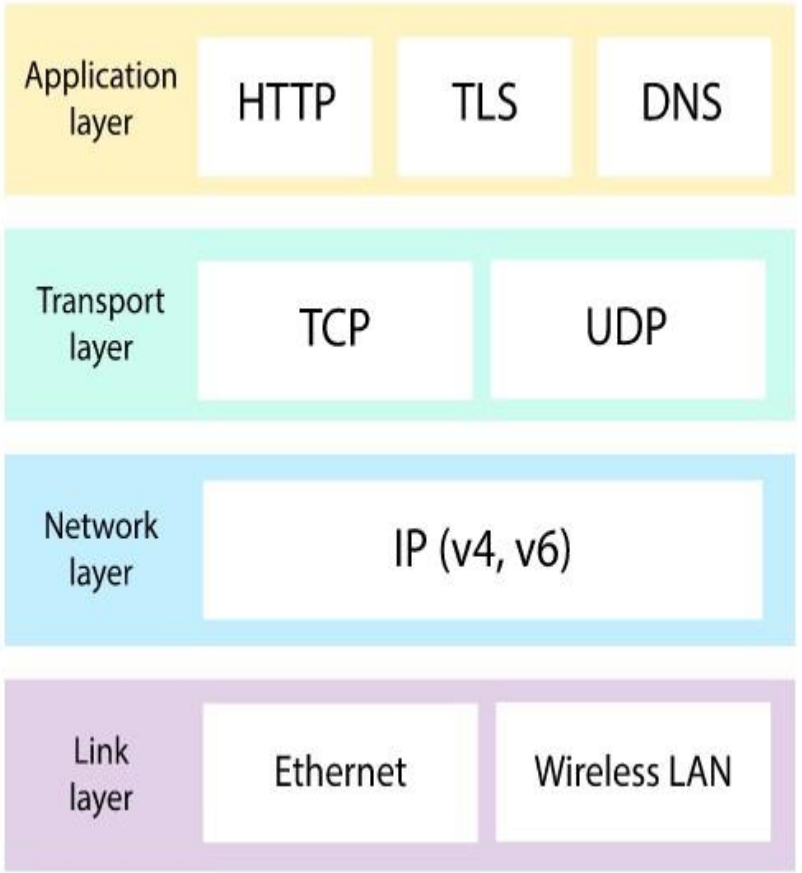
Layered Network Models

- **Internet protocol suite (TCP/IP)**

4) Link layer.

- This layer is equivalent to the collective physical and data link layer of the OSI model.
- It enables the transmission of TCP/IP packets over the physical medium.
- Link layer is independent of the medium in use, frame format, and network access.
- Ethernet, wireless LAN, and the asynchronous transfer mode (ATM).





Addressing / Overview

- **Addressing:** is the mechanism by which *devices on a network identify and communicate with each other*.
- ***Importance:*** Effective addressing **ensures** data packets are **sent** to the **correct** destination, facilitating seamless "سلس" communication. It also aids in resource management and network organization.
- Just as a postal address helps deliver mail to the right location, network addresses **enable data transfer across interconnected devices**.
- Addressing **mechanisms** can be divided into **two** parts:

I. one focusing on **data link layer** address.

II. other focuses on **network layer** addressing.

Addressing / Types of Addresses

I. **Physical** Addresses (**MAC** Addresses):

- ✓ **Data link layer**

II. **Logical** Addresses (**IP** Addresses):

- ✓ **Network layer**

Types of Addresses/ Physical Addresses

I. **Physical** Addresses (**MAC** Addresses):

- ✓ **Data link layer**

. ***Definition***:

A **MAC** (*Media Access Control*) address is a **hardware address** that **uniquely identifies each device** on a local network. It is **burned into the NIC** (Network Interface Card) and cannot be changed.

Types of Addresses/ Physical Addresses

- ***Structure*:**
  - **MAC** addresses are **48 bits** long, typically displayed in **six pairs of hexadecimal digits**, separated by **colons or hyphens** (e.g., 00:1A:2B:3C:4D:5E).
  - The ***first half*** (24 bits) is the **OUI** (Organizationally Unique Identifier), indicating the manufacturer. The ***second half*** (*24 bits*) is a **unique serial number** assigned by that manufacturer.
- ***Functionality*:**
  - **MAC** addresses are ***used for local network communications***. When data is sent across a network, it is **encapsulated in frames** that include the **source and destination** MAC addresses. Devices **on the same LAN** use these addresses to ensure data reaches the correct destination.

Types of Addresses/ Physical Addresses

- These physical addresses are also known as media access control (MAC) addresses.
- MAC addresses are unique 48-bit hardware addresses provided by the device manufacturers.
- **the first 24** bits are organizational identifiers.
- **the last 24** bits are network interface controller identifiers.

Types of Addresses/ Logical Addresses

II. **Logical** Addresses (**IP** Addresses):

- ✓ **Network layer**

. ***Definition***:

An IP address is a **logical identifier** assigned to devices to ***facilitate communication over networks***.

***Importance*:** **IP** addresses allow devices across different networks to locate and communicate with each other.

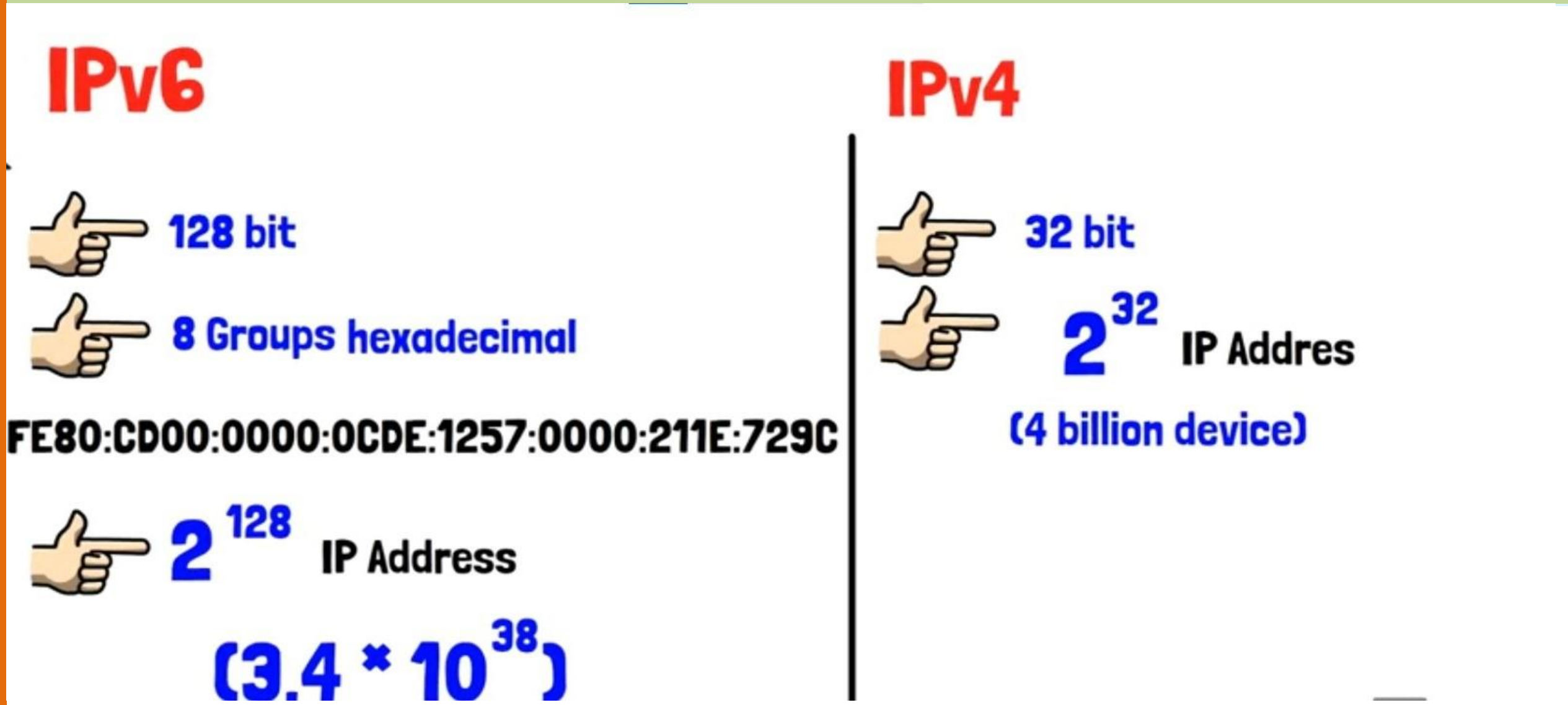
Types of Addresses/ Logical Addresses

- ***Versions*** of IP Addresses:

  - **IPv4**: Utilizes a 32-bit address space, allowing for **approximately 4.3 billion unique addresses**, which have become insufficient for the growing number of devices.

  - **IPv6**: Utilizes a 128-bit address space, allowing for an **astronomical هائل,ضخم number of unique addresses**, ensuring scalability for the future.

Types of Addresses/ Logical Addresses



Types of Addresses/ Logical Addresses

- ***Structure*** of **IPv4** Addresses:
  - **Format**: ***Four*** *decimal numbers* separated by dots (e.g., 192.168.1.1), where each number ranges from 0 to 255.
  - **Network and Host Portions أجزاء** : The **subnet mask** determines **how many bits** represent the **network** and how many represent the **host**.

Types of Addresses/ Logical Addresses

❑ *Structure* of IPv4 Addresses:

VER: 4 bits long and represents the version of IP

HLEN: 4 bits long & length of the IPv4 packet header.

ToS: It is 8 bits long. The first six bits represent the differentiated services code point (DSCP) & last 2 bits give information about the congestion witnessed in the network.

TOTAL LENGTH: It is 16 bits long and identifies the length of the entire IPv4 packet.

IDENTIFIER: It is 16 bits long

FLAGS: It is a 3-bit field,fragmen

FRAGMENT OFFSET: identifies the exact offset or fragment position of the original IP packet and is 13 bits long.

TTL: It is 8 bits long

PROTOCOL: It is 8 bits long.

HEADER CHECKSUM: It is 16 bits long and used for identifying whether a packet is error-free or not.

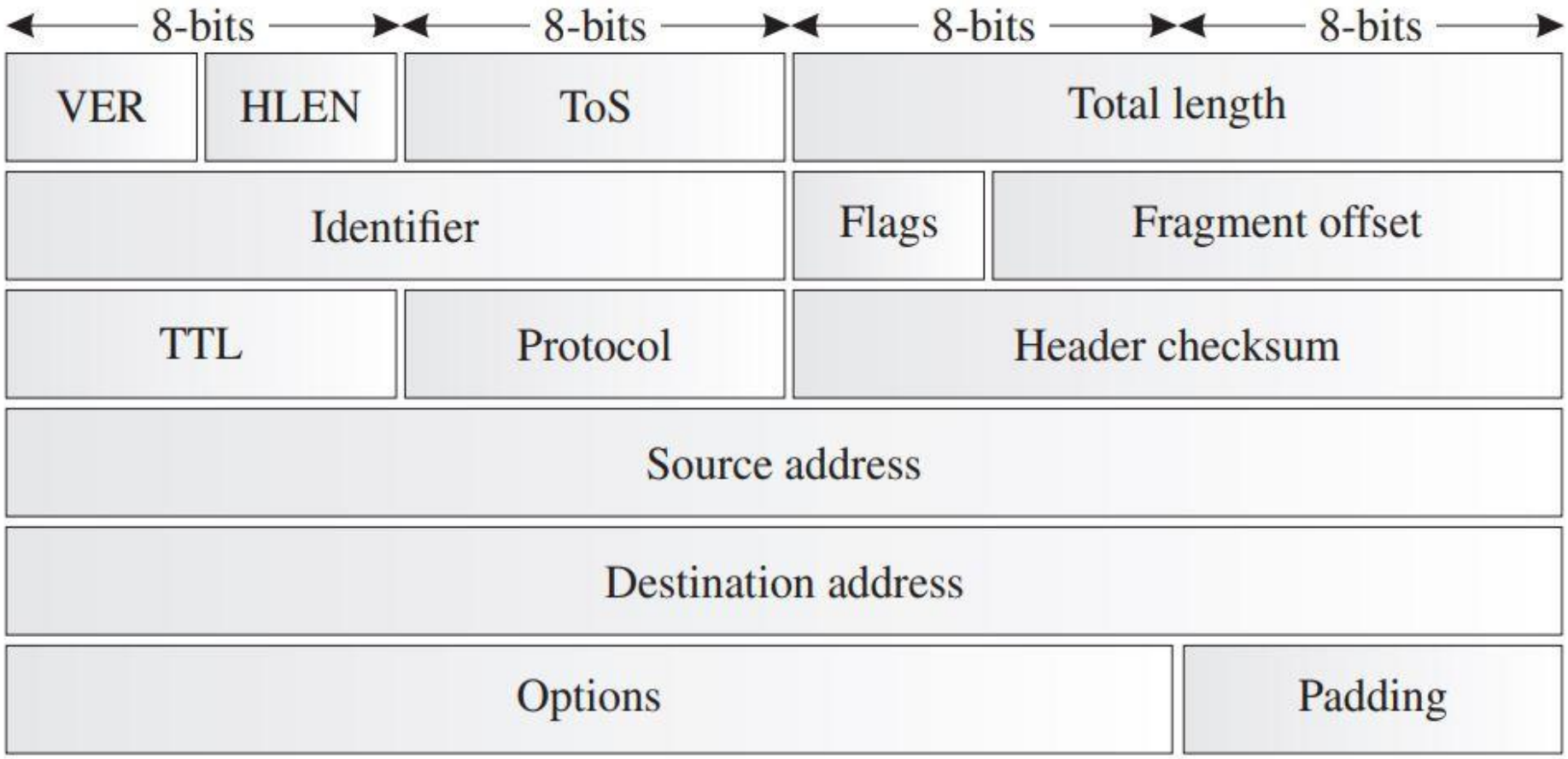
SOURCE ADDRESS: It indicates the origin address of the packet and is 32 bits long.

DESTINATION ADDRESS: It indicates the destination address of the packet and is 32 bits long.

OPTIONS and PADDING: It is an optional field, which may carry values for security, time stamps, route records, and others.

Types of Addresses/ Logical Addresses

- ***Structure*** of IPv4 Addresses:



Types of Addresses/ Logical Addresses

- ***Structure*** of IPv6 Addresses:
  - **Format:** Eight groups of four hexadecimal digits:

    (e.g., 2001:0db8:85a3:0000:0000:8a2e:0370:7334)

Types of Addresses/ Logical Addresses

II. Network layer addressing: **IPv6**

VER: It is 4 bits long and represents the version of IP.

TRAFFIC CLASS: It is 8 bits long. The first six most significant bits represent the type of service to be provided to this packet (by the routers); explicit congestion notification (ECN) is handled by the last 2 bits.

FLOW LABEL: It is 20 bits long and designed for streaming media or real-time data. The FLOW LABEL allows for information flow ordering; it also avoids packet resequencing.

PAYLOAD LENGTH: It is 16 bits long and provides a router with information about a packet's payload length or the amount of data contained in the packet's payload.

NEXT HEADER: It is 8 bits long and informs the router about the type of extension header the packet is carrying. Some of the extension headers and their corresponding values are as follows: Hop-by-hop options header (0), routing header (43), fragment header (44), destination options header (60), authentication header (51), and encapsulating security payload header (50). In case an extension header is absent, it represents the upper layer protocol data units (PDUs).

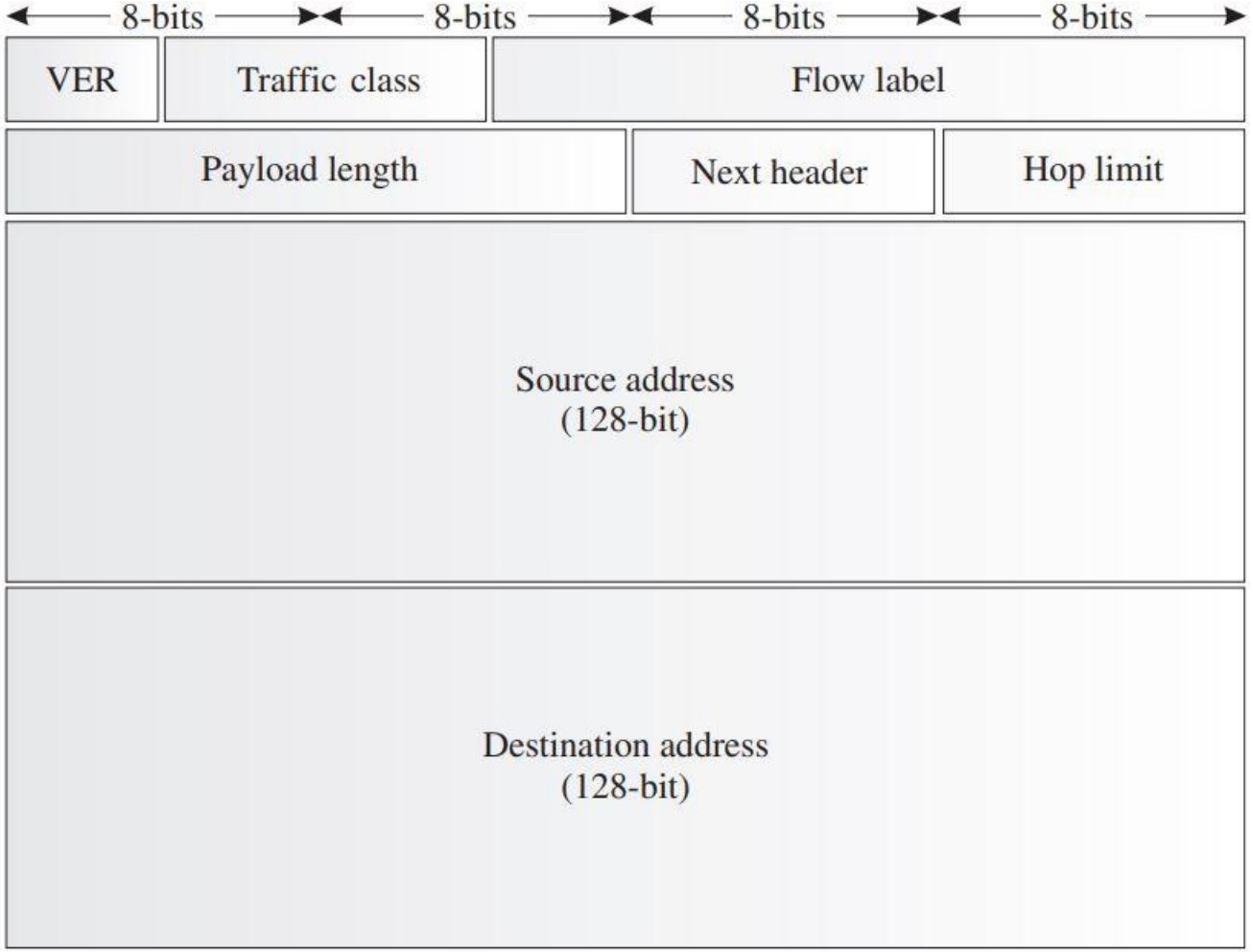
HOP LIMIT: It is 8 bits long and prevents a packet from looping infinitely in the network. As it completes a link, the limit's value is decremented by one.

SOURCE ADDRESS: It is 128 bits long and indicates the origin address of the packet.

DESTINATION ADDRESS: It is 128 bits long and indicates the destination address of the packet.

Types of Addresses/ Logical Addresses

II. Network layer addressing: IPv6



Addressing / Subnetting

❑ Introduction

- After discussing IP addressing, however, we'll need to say a few words about, **how hosts and routers are connected into the Internet.**

- **A host** typically has only a single link into the network; when IP in the host wants to send a datagram, it does so over this link.

- **The boundary** between the **host** and the **physical link** is called an **interface**. Now consider a router and its **interfaces**.

Addressing / Subnetting

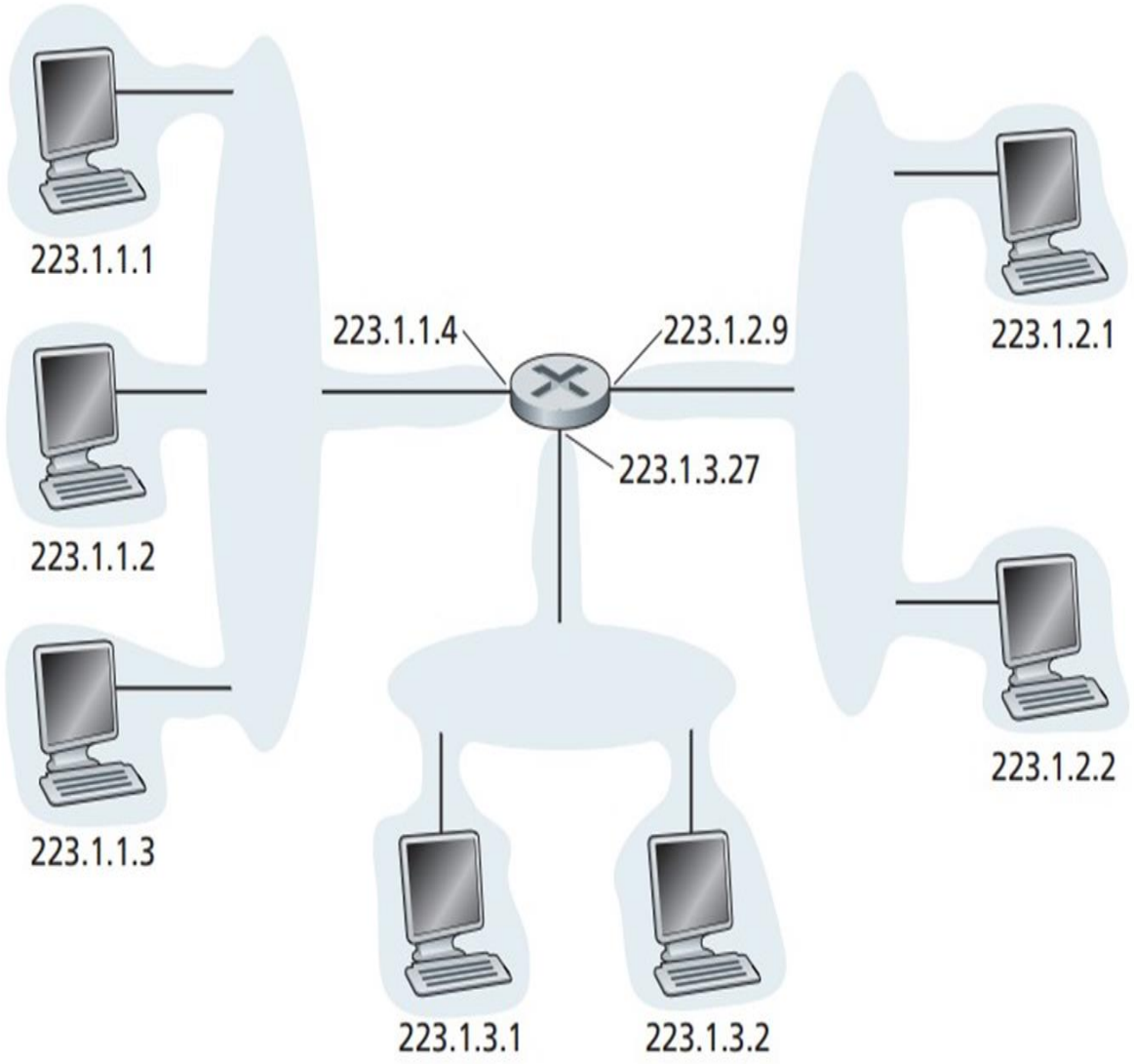
❑ Introduction

- Because a **router's job** is to **receive** a datagram **on one link** and **forward** the datagram on some **other link**, a router necessarily **has two or more links** to which it is connected.
- The **boundary** between the **router** and **any one of its links** is also called an **interface**.
- A **router** thus has multiple interfaces, one for each of its links.
- Because every host and router is capable of sending and receiving IP datagrams, IP requires **each host and router interface to have its own IP address**.
- Thus, an **IP address** is technically **associated يرتبط** with an interface, **rather than** بدلا من with the host or router containing that **interface**.
- **Each interface** on every **host** and **router** in the global Internet **must have an IP address** that is globally unique.
- These addresses cannot be chosen in a willy-nilly manner, however. **A portion of** جزء من **an interface's IP address** will be determined by the **subnet** to which it is connected.
- ومع ذلك، لا يمكن اختيار هذه العناوين بشكل عشوائي. **حيث يتم تحديد جزء من عنوان IPالخاص بالواجهة بواسطة الشبكة الفرعية التي تتصل بها.**

Addressing / Subnetting

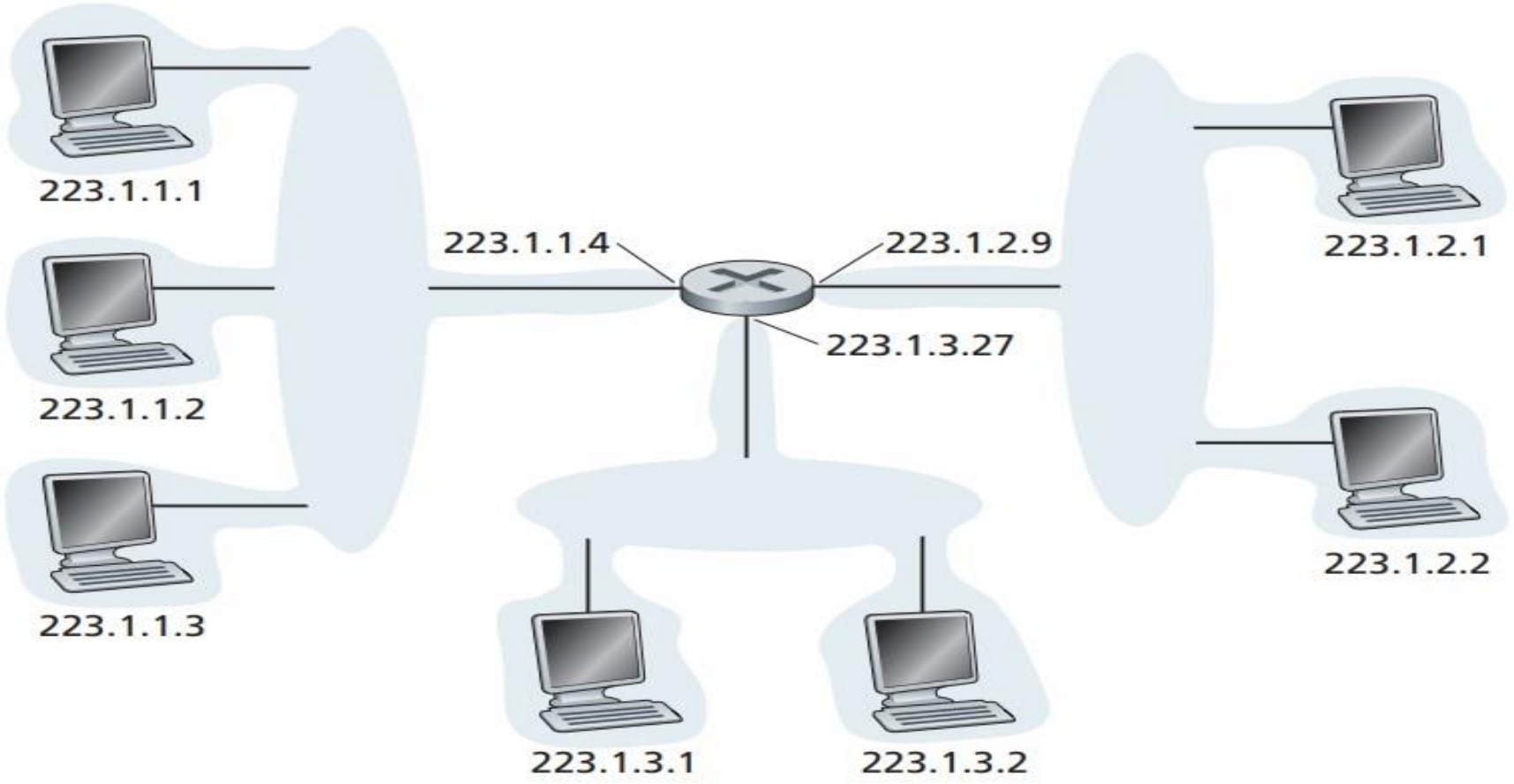
❑ Introduction

- **The Figure A** in the next slide provides an **example** of IP addressing and interfaces.
- In this figure, **one** router (with **three** interfaces) is used to interconnect **seven hosts**.
- Take a close look at the **IP addresses** assigned to the **host** and **router** interfaces, as there are several things to notice.
- The **three hosts** in the upper-left portion of the Figure, and the **router interface** to which they are connected, all have an **IP address** of the form 223.1.1.xxx.
- That is, they all have the same leftmost 24 bits in their IP address.
- these **four interfaces** are also interconnected to each other by a network that contains **no routers**.



Addressing / Subnetting

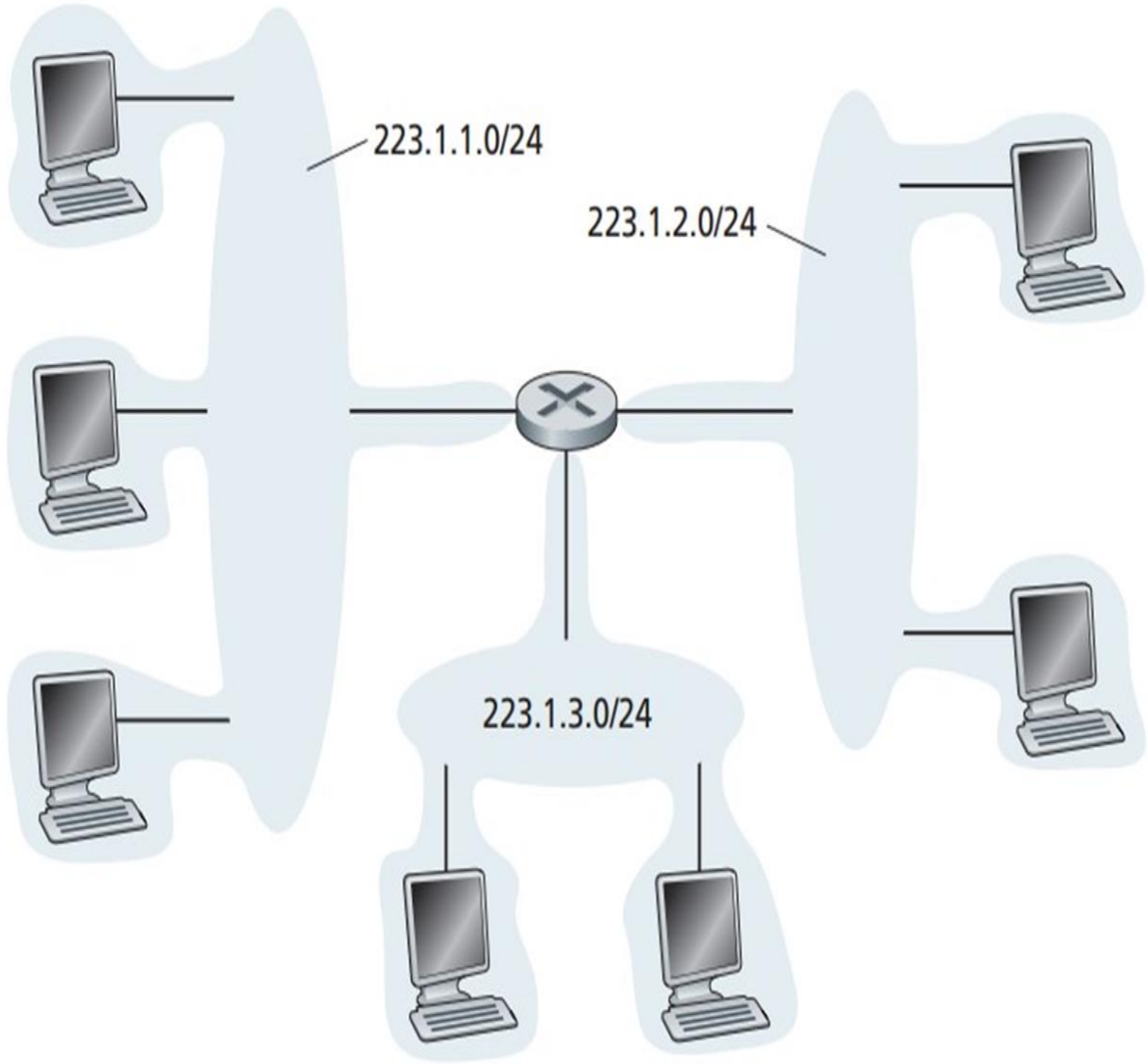
✓ **figure A: illustrates Interface addresses and subnets.**



Addressing / Subnetting

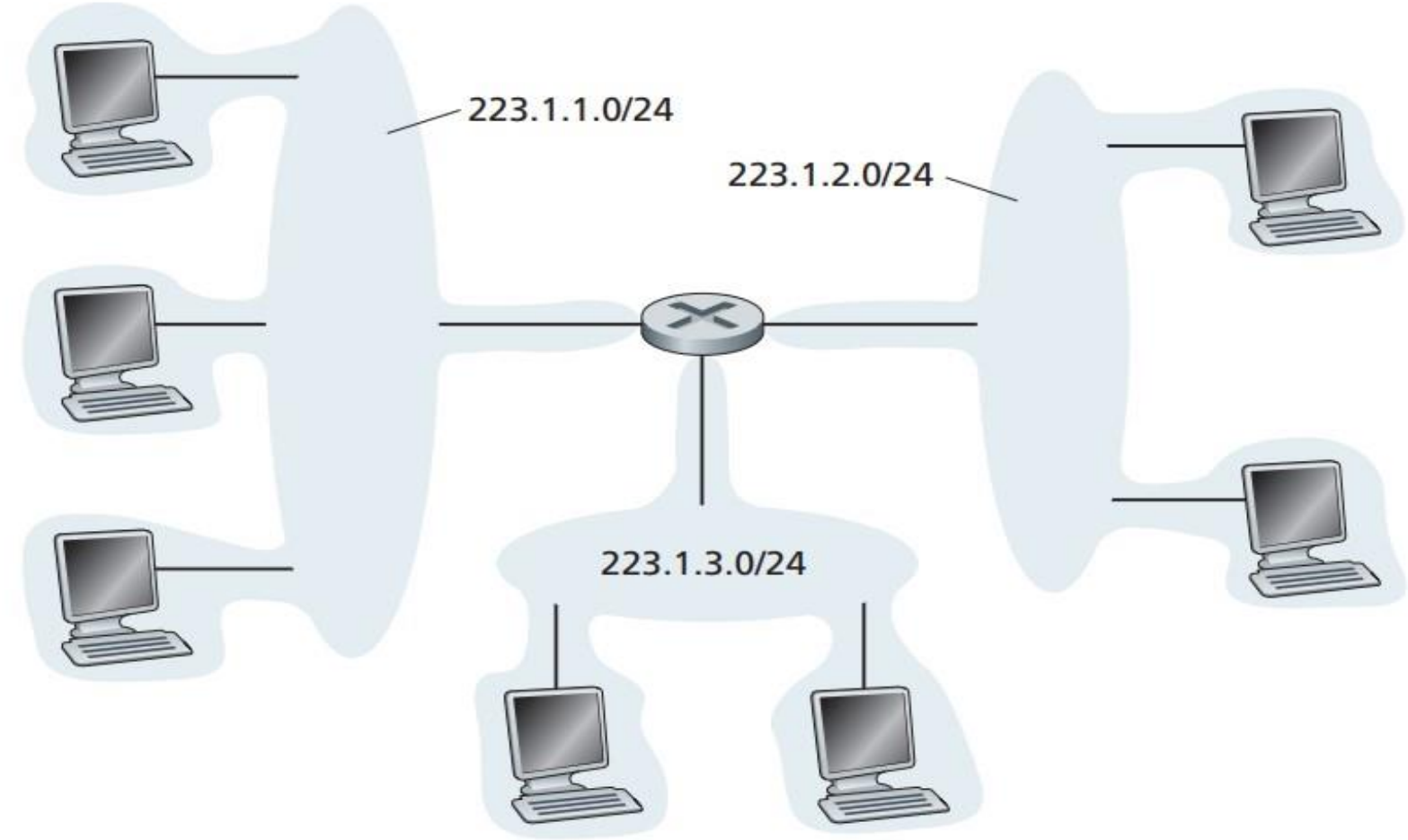
❑ Introduction

- **In IP terms**, this network interconnecting **three host interfaces** and **one router interface** forms تشكل a subnet.
- IP addressing **assigns** an address to this subnet: 223.1.1.0/24, where the **/24** (“slash-24”) notation, sometimes known as a **subnet mask**, indicates that the leftmost 24 bits of the 32-bit quantity define **the subnet address**.
- The 223.1.1.0/24 subnet thus consists of the **three host interfaces** (223.1.1.1, 223.1.1.2, and 223.1.1.3) and **one router interface** (223.1.1.4).
- Any **additional hosts** attached to the 223.1.1.0/24 **subnet** would be required to have an address of the form **223.1.1.xxx**.
- There are two additional subnets shown in **Figure A**: the 223.1.2.0/24 network and the 223.1.3.0/24 subnet. **Figure B** illustrates the three IP subnets present in **Figure A**.



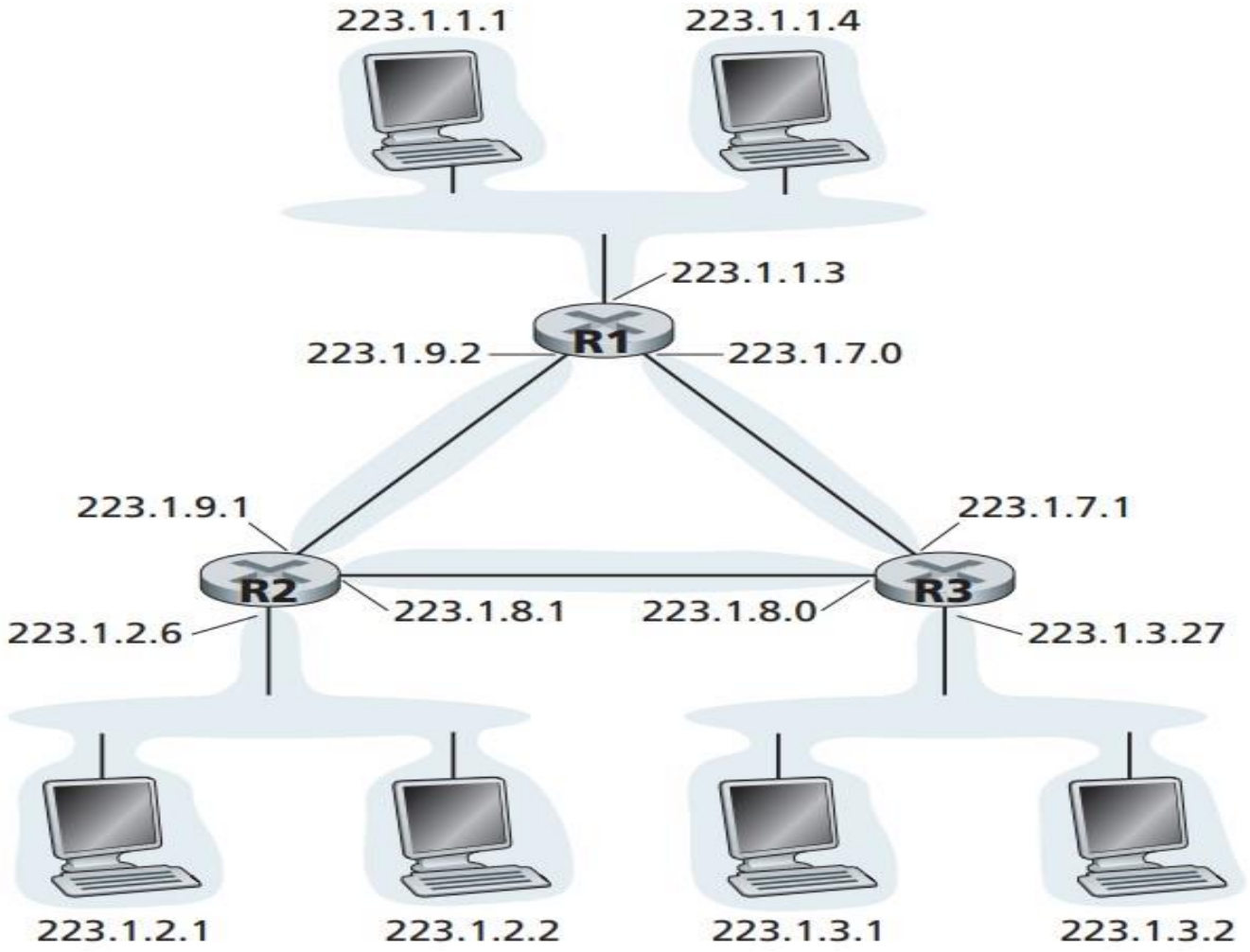
Addressing / Subnetting

✓ **figure B: illustrates Subnet addresses.**



Addressing / Subnetting

- To determine the subnets, detach each interface from its **host** or **router**, creating islands of isolated networks, with interfaces terminating the endpoints of the isolated networks. Each of these isolated networks is called a subnet. If we apply this procedure to the interconnected system in **Figure C**, we get six islands or subnets.



✓ **figure C: illustrates Three routers interconnecting six subnets.**

Addressing / Subnetting

- **Definition:** The **practice** of **dividing** a larger network into smaller, more manageable sub-networks (subnets).

- **Benefits:** Helps in organizing networks, **reducing broadcast traffic**, **improving security**, and **making efficient use of IP addresses**.

Addressing / Subnetting

- **Purpose of Subnetting**

- **Performance Optimization:** By creating smaller subnets, the amount of broadcast traffic is **reduced**, leading to **improved** performance.

- **Improved Security:** Different subnets can have distinct متميز security policies, allowing for better isolation عزل of sensitive data.

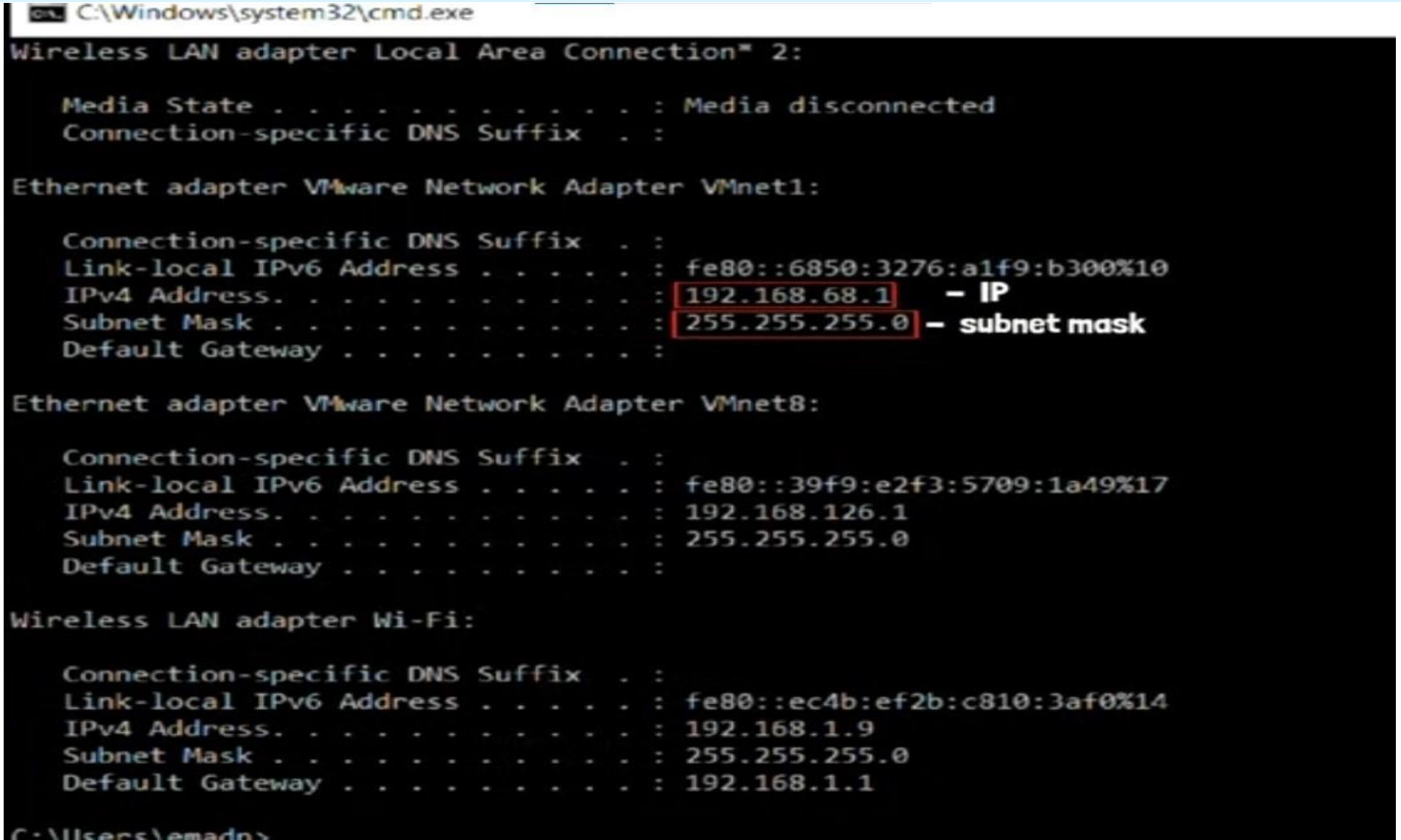
Addressing / Subnet Masks

- **Definition:** A subnet mask is used to divide an IP address into **network** and **host** portions.

- **Example:** A subnet mask of 255.255.255.0 indicates that the **first 24** bits are for the **network**.

Addressing / IP addresses & Subnet Masks

Addressing / IP addresses & Subnet Masks



Addressing / Address Resolution Protocol (ARP)

- ***Definition*:**

  ARP is a protocol used to map an **IP** address to its corresponding **MAC** address within a **local network**.

- ***Layer*:**

  Operates at the Data Link Layer (Layer 2).

Address Resolution Protocol (ARP) / ARP Functionality

- **Process:**

1. The device **broadcasts** an ARP request asking, "**Who has IP address X**?"
2. The device with the **IP** responds with its MAC address.

Address Resolution Protocol (ARP) / ARP Cache

- **Definition:**

  - ✓ A temporary storage for resolved IP-to-MAC address mappings.

- ✓ **Purpose:**

  I. Reduces the need for frequent ARP requests.

  II. Enhancing network efficiency.

Addressing / Address Classes

- ***Classful Addressing*:**

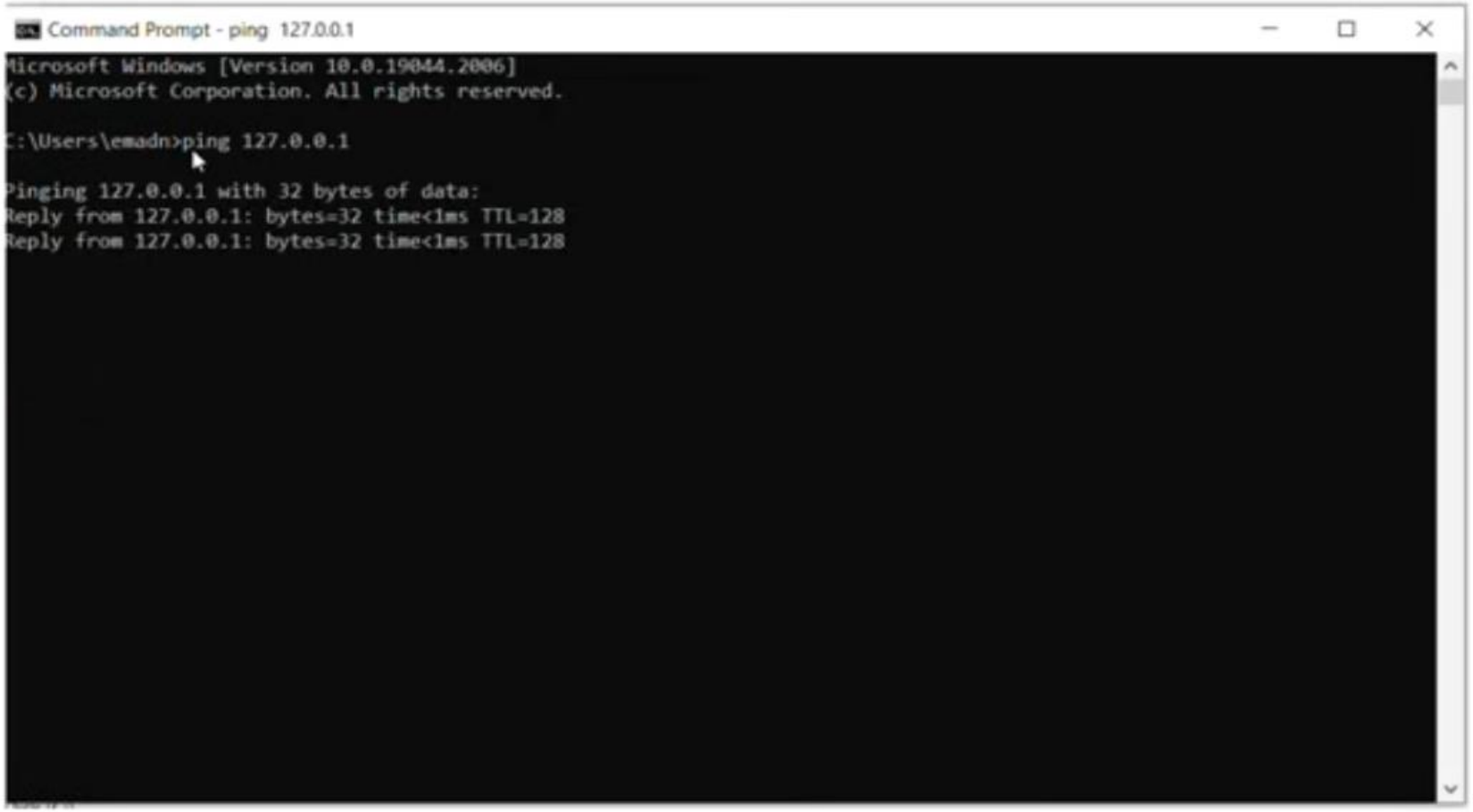
  A **method of categorizing IP** addresses into classes **based on their leading bits**.

  - ***Classes*:**

    - ✓ **Class A:** First octet 1-126 (**large** networks).
    - ✓ **Class B:** First octet 128-191 (**medium** networks).
    - ✓ **Class C:** First octet 192-223 (**small** networks).

Addressing / Address Classes

127 → loopback → loopback Address



Acknowledgment

- **These lecture slides are based on:**

1) **Chapter 4 (P 360-368)** from the book “Computer Networking: A Top-Down Approach, Eighth Edition, Global Edition” by (James F. Kurose and Keith W. Ross’s).

END OF LECTURE (2)

Keep connected with the classroom

lmzcbsf

THANK YOU FOR YOUR ATTENTION