

# Chapter 1

## Fundamental concepts of computer networks.

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# Chapter 1

## **Fundamental concepts of computer networks.**

### Lecture 1

# 1-1 DATA COMMUNICATIONS

*The term **telecommunication** means communication at a distance. The word **data** refers to information presented in whatever form is agreed upon by the parties creating and using the data.* **data : information presented in whatever form**

**telecommunication : communication at a distance** الاتصالات عبر المسافات

***Data communications** are the exchange of data between two devices via some form of transmission medium such as a wire cable or wireless.*

**DATA COMMUNICATIONS** مالمذي يوتر على ال

1. *Delivery* → *Correct destination*
2. *Accuracy* → *Accurate data* بيانات دقيقة
3. *Timelines* → *Real-time transmission*
4. *Jitter* تقطيع → *Uneven delay*

### Topics discussed in this section:

Components

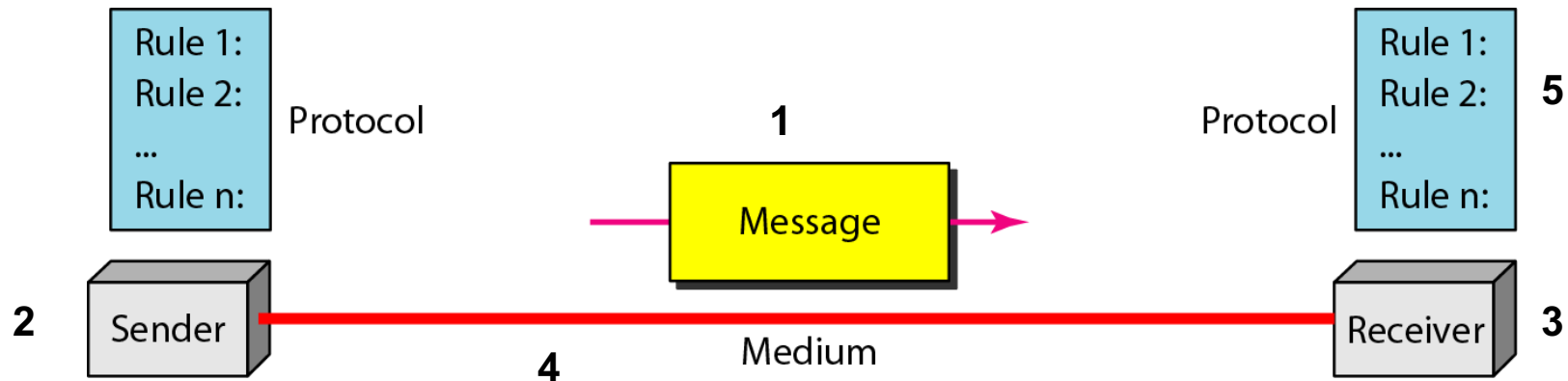
Data Representation

Data Flow

- 1- message
- 2- Sender
- 3- Receiver
- 4- Medium
- 5- Protocol

## Components

**Figure 1.1** *Five components of data communication*

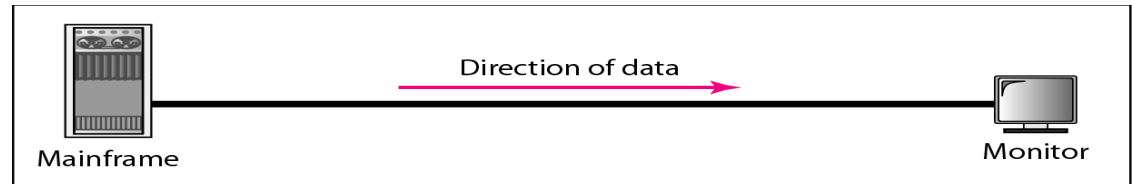


# Data Representation

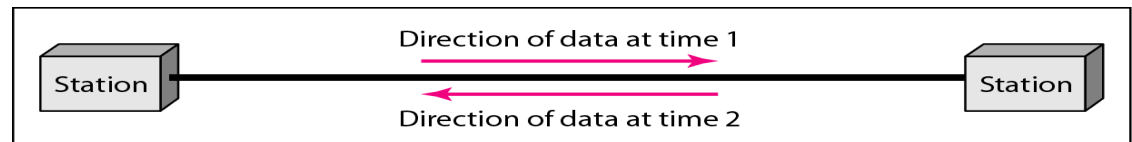
1. *Text*
2. *Numbers*
3. *Images*
4. *Audio*
5. *Video*

## Data flow

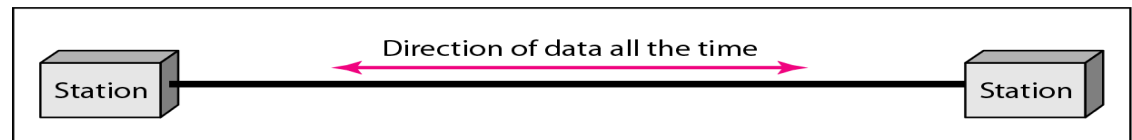
- *Simplex*
- *Half-duplex*
- *Full-duplex*



a. Simplex



b. Half-duplex



c. Full-duplex

# 1-2 NETWORKS

it is a set of nodes connected by communication links

*A **network** is a set of devices (**nodes**) connected by communication **links**. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.*

node : it can be computer or printer ... etc

## *Topics discussed in this section:*

Distributed Processing

Network Criteria (performance, reliability, and security)

Physical Structures ( type of connections and topologies)

Network Models

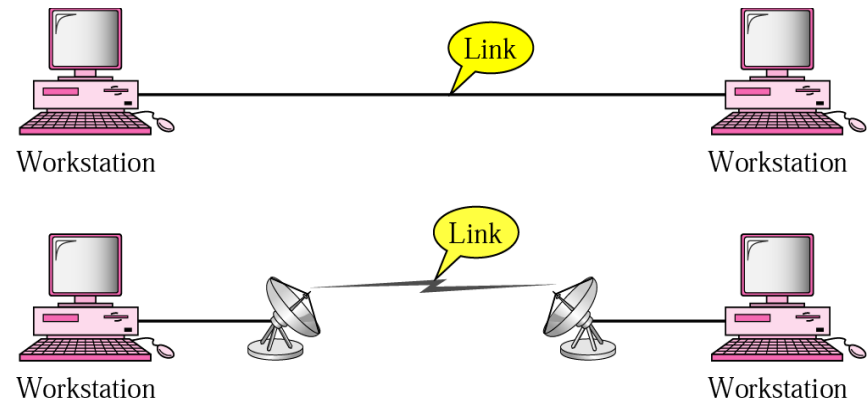
Categories of Networks ( LAN, MAN and WAN)

Interconnection of Networks: Internet

# Types of connections

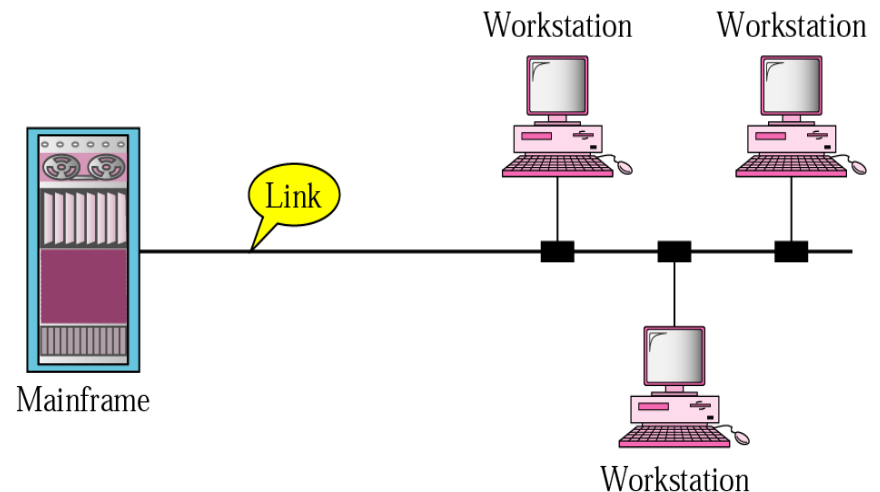
- **Point to point**

- A dedicated link is provided between two devices



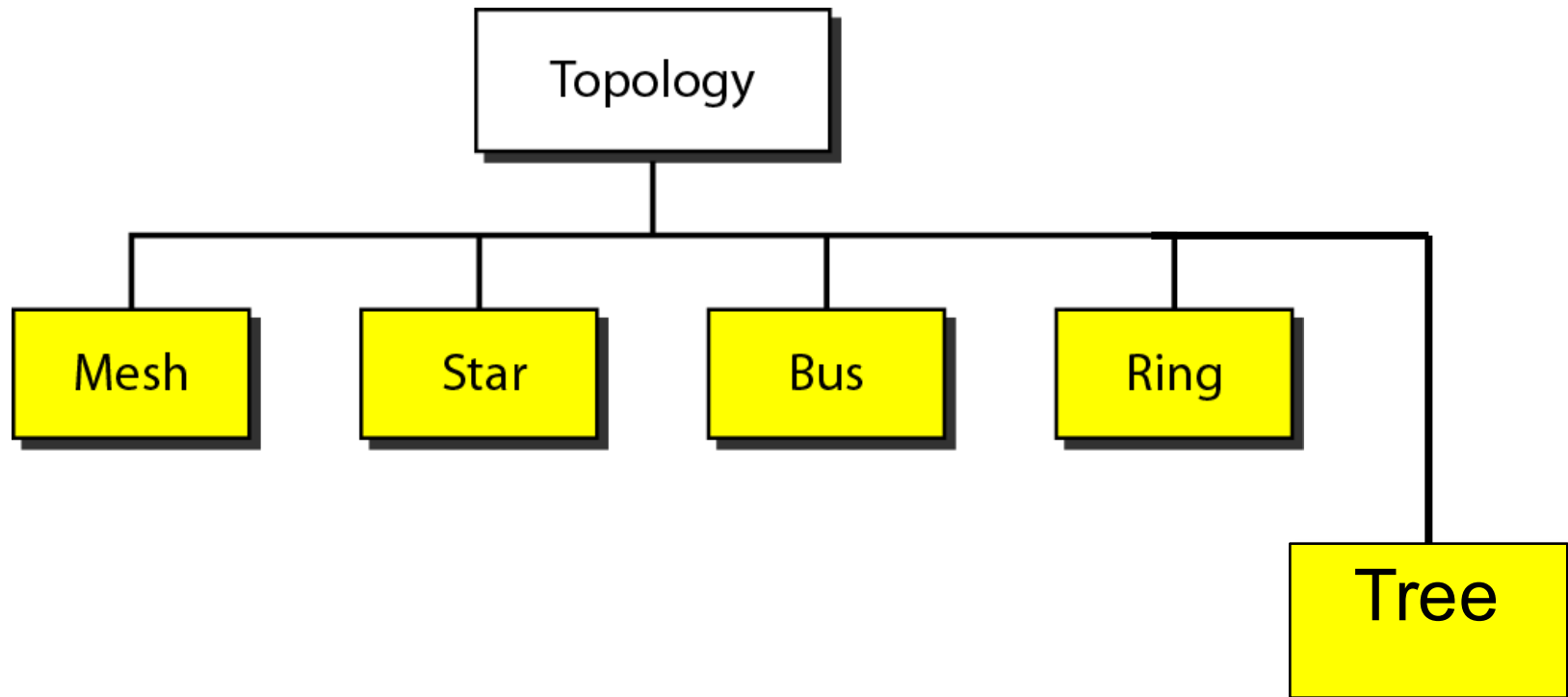
- **Multipoint**

- More than two specific devices share a single link



# *Physical Topology*

How to connect devices together ?





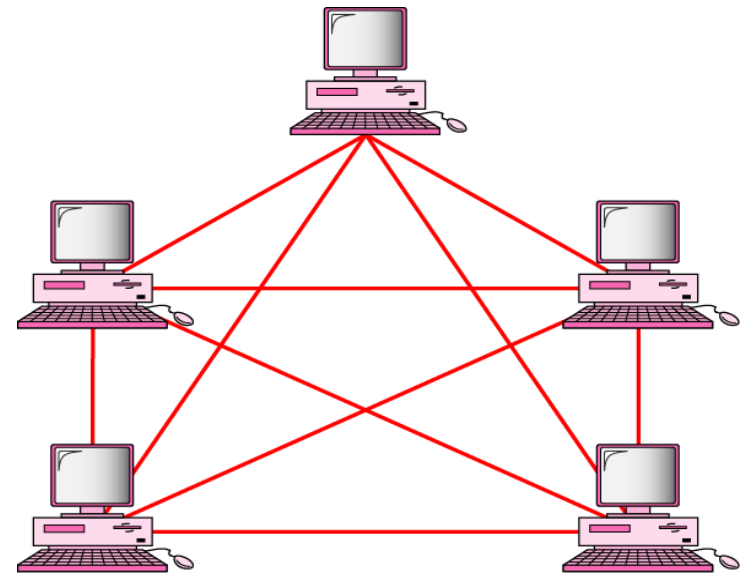
# MESH Topology

هنا كل جهاز مربوط بالجهاز الثاني بشكل مباشر

مخصصة

- Every device has a dedicated point-to-point link to every other devices
- Dedicated
  - Link carries traffic only between the two devices it connects
  - A fully connected mesh network has  $n(n-1)/2$  physical channels to link  $n$  devices
  - Every device on the network must have  $n-1$  input/output (I/O) ports
- Advantage
  - Less traffic, **قوي**, robust, secure, easy to maintain
- Disadvantage
  - Need more resource (cable and ports), expensive

ومشاكلتها انك تحتاج كيبلات ومخارج كثيرة و غالية



$n(n-1)/2$  physical duplex links

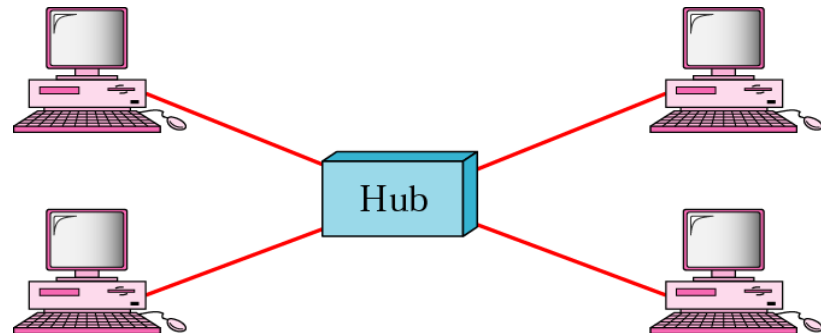
$$5(4)/2 = 10 \text{ links}$$

Every device here must have 4 input/output (  $n-1$  )

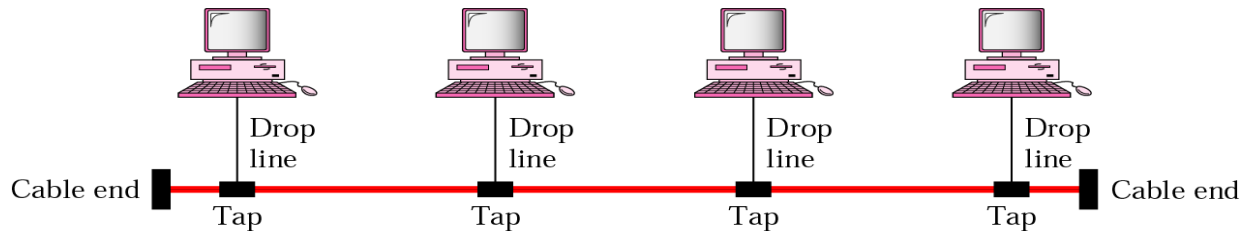
# STAR Topology

وحدة تحكم مركزية

- Each device has a dedicated point-to-point link only to a central controller, usually called a hub.
- No direct traffic and link between devices
- Advantages
  - Less expensive
  - Easy to install and reconfigure
  - Robustness متانة
- Disadvantage
  - Single point of failure

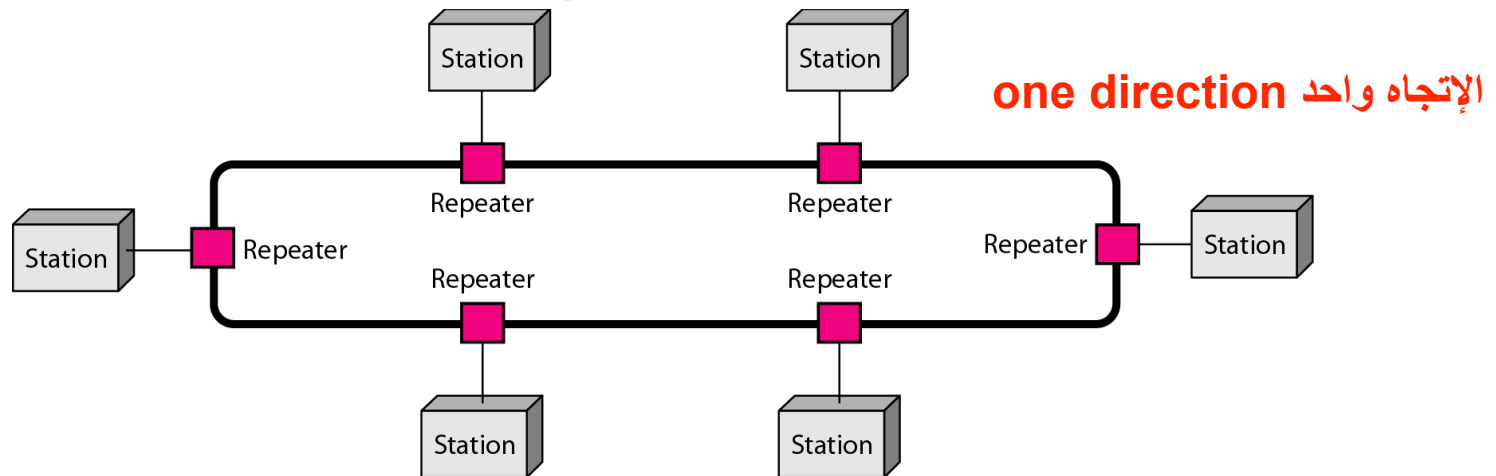


# BUS Topology



- A multipoint topology
- All devices are linked through a backbone cable
- Nodes are connected to the bus cable by drop lines and taps.
  - Drop line
    - A connection running between the device and the main cable
  - Tap
    - A connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core
- Advantage:
  - Ease of installation
- **Disadvantages:**
  - Difficult reconnection and fault isolation
  - Broken or fault of the bus cable stops all transmission

# RING Topology

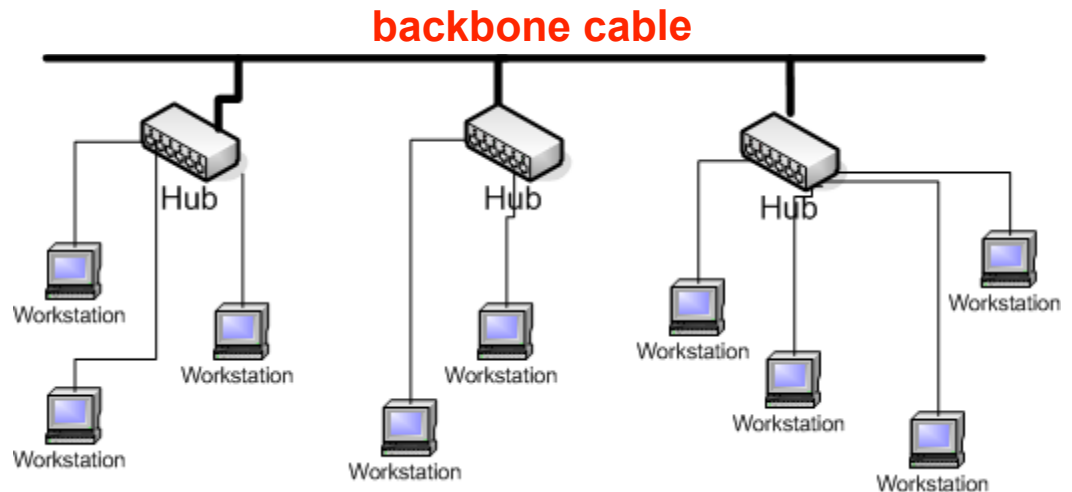


- Each device is dedicated point-to-point connection **only with the two devices** on either side of it
- A signal is passed along the ring in the direction, from device to device, until it reaches its destination
- Each device in the ring **incorporates a repeater**
- Advantages
  - Relatively easy to install and reconfigure
  - Fault isolation is simplified
- Disadvantage
  - **Unidirectional traffic**

# Tree Topology

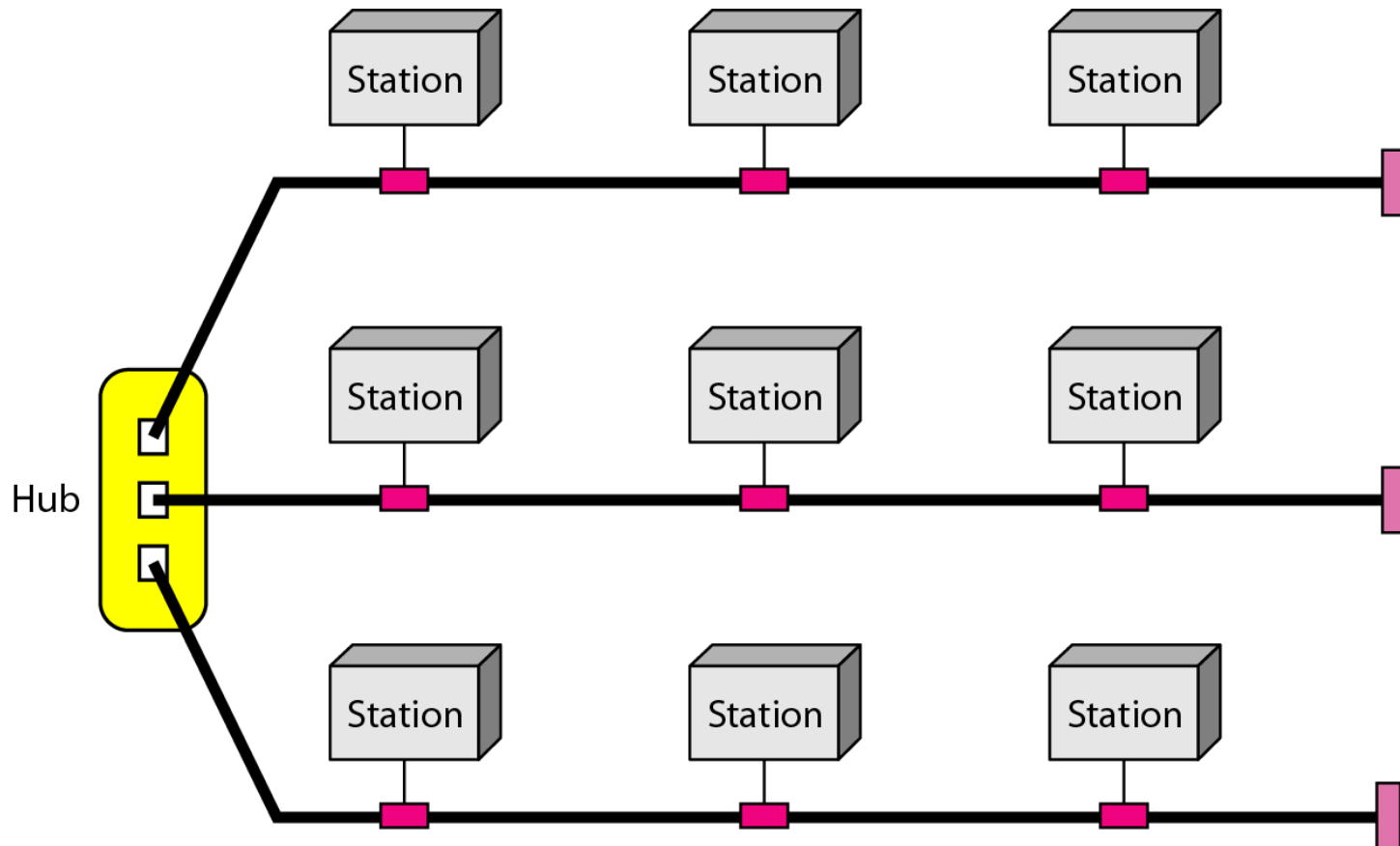
Tree topologies integrate multiple topologies together

Example: Tree topology integrates multiple star topologies together onto a bus



- Advantages:
  - Point-to-point wiring for individual segments.
  - Supported by several hardware and software vendors.
- Disadvantages:
  - Overall length of each segment **backbone cable is** is limited by the type of cabling used.
  - If the backbone line breaks, the entire segment goes down.
  - More difficult to configure and wire than other topologies.

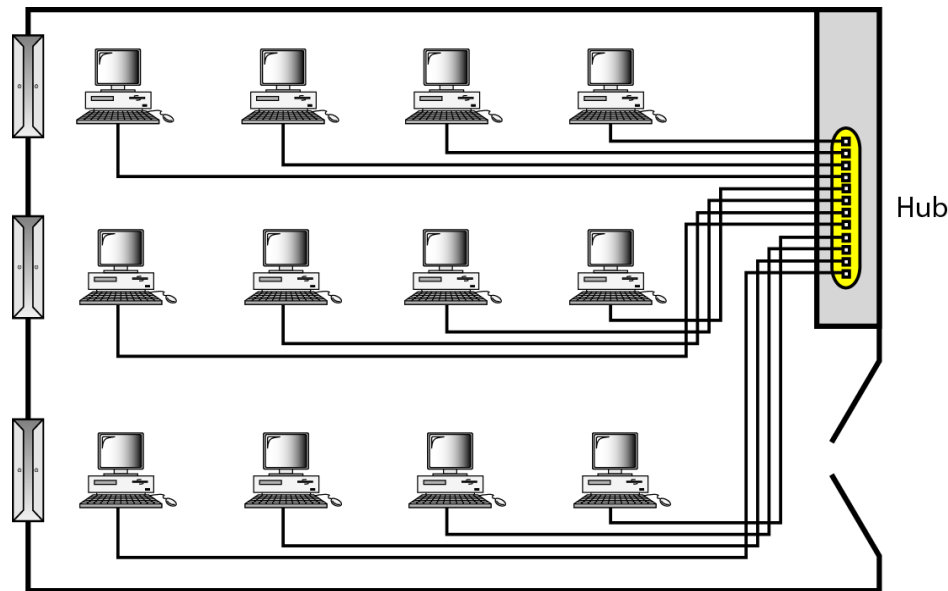
## *A hybrid topology: a star backbone with three bus networks*



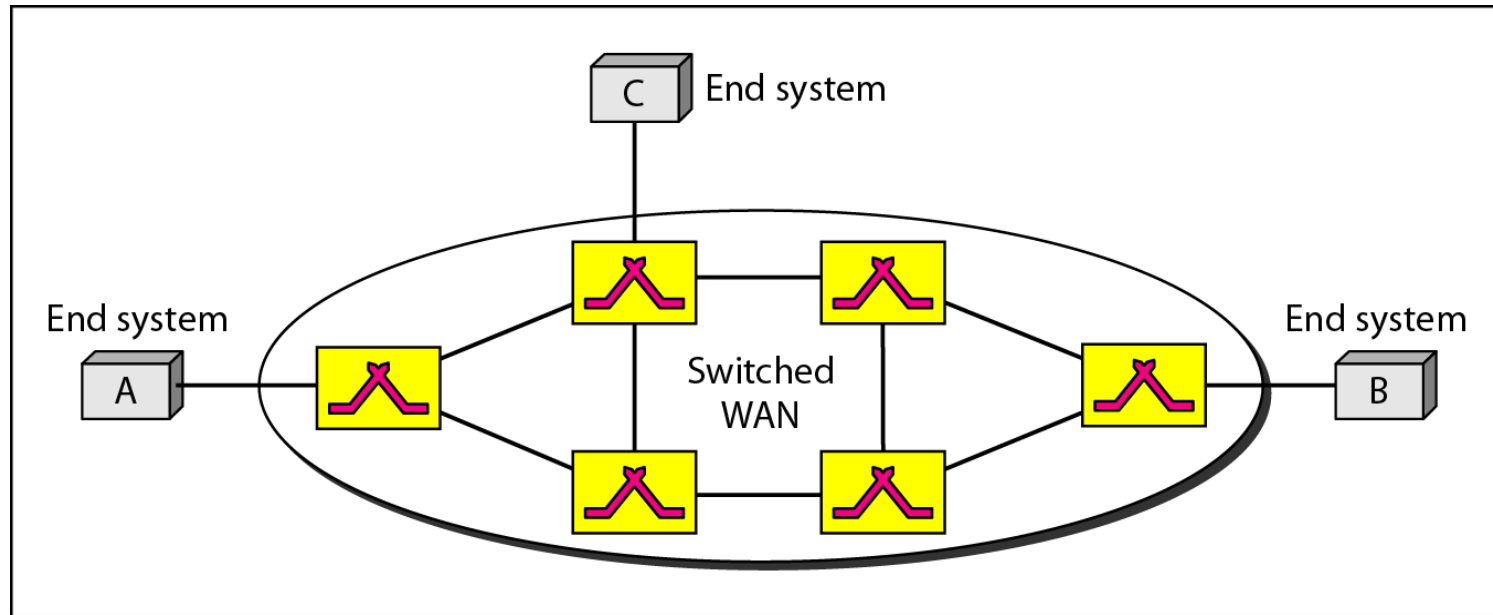
# Categories of Networks

1. Local Area Network (LAN)
2. Wireless Local Area Network (WLAN)
3. Metropolitan Area Network (MAN)
4. Wide Area Network (WAN)

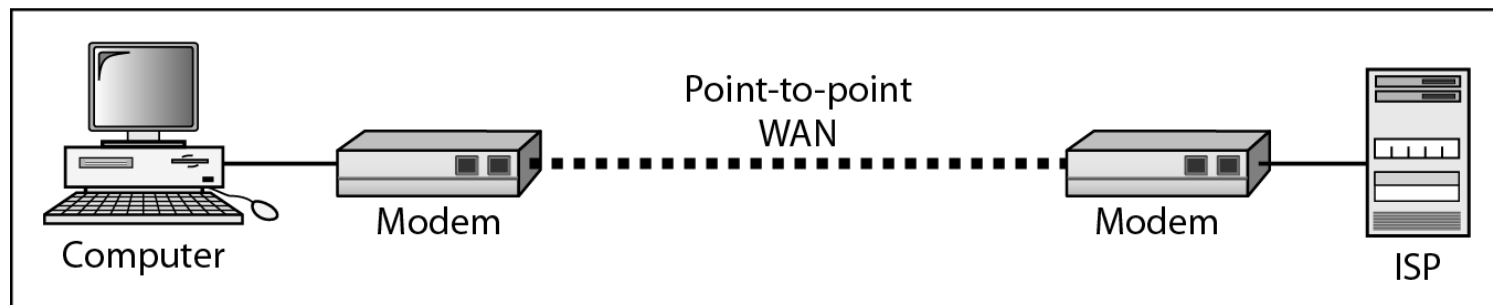
*An isolated LAN connecting 12 computers to a hub in a closet*



## *WANs: a switched WAN and a point-to-point WAN*



a. Switched WAN

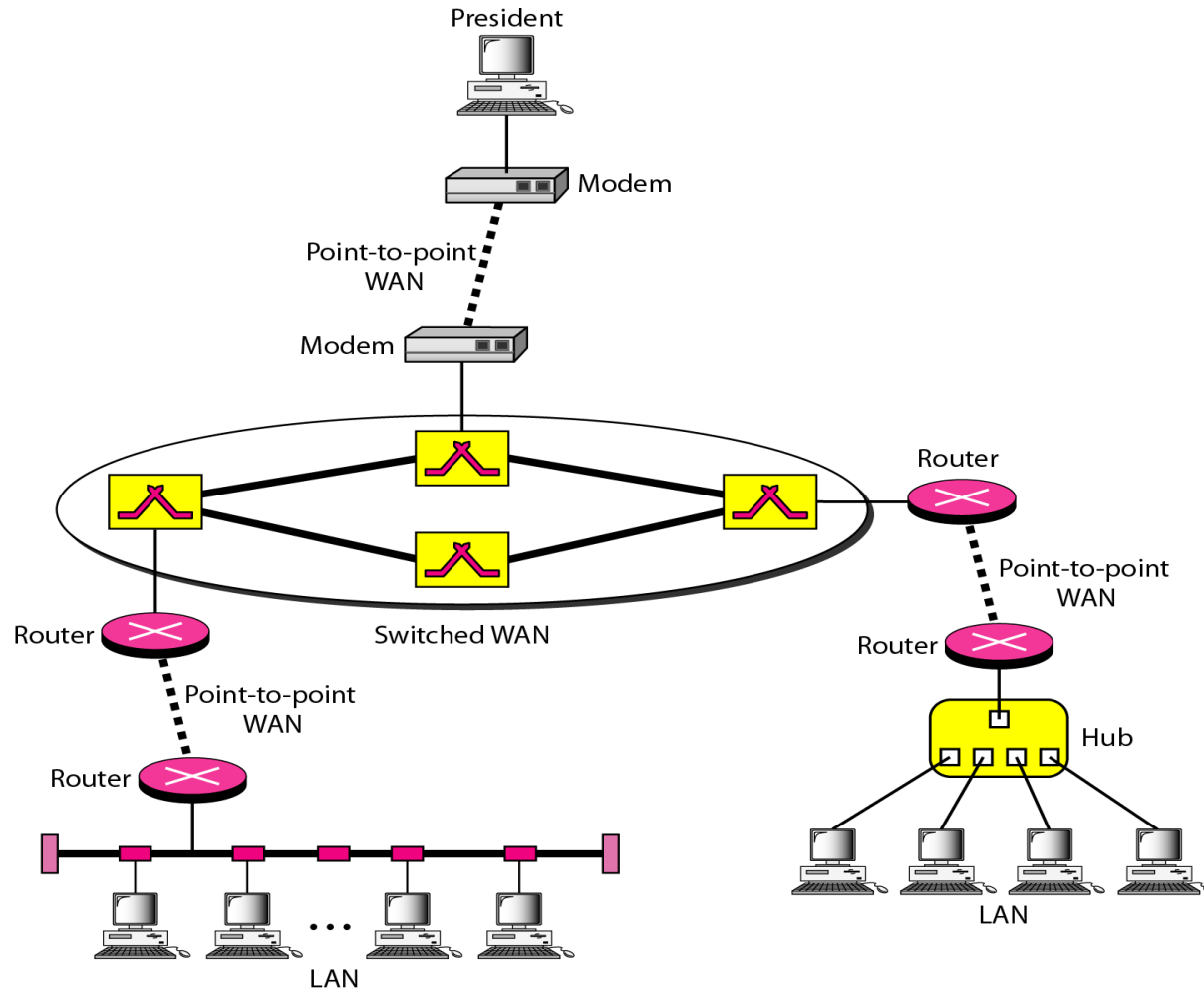


b. Point-to-point WAN



# Interconnection of Networks: internet

*A heterogeneous network made of four WANs and two LANs*



# 1-3 THE INTERNET

*The **Internet** has changed many aspects of our daily lives. It has affected the way we do business as well as the way we spend our leisure time. The Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use.*

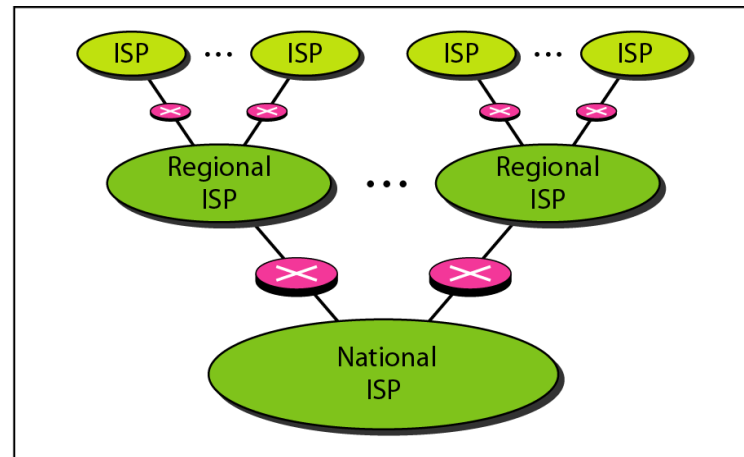
*Topics discussed in this section:* Internet is communication system

**A Brief History → ARPANET**

- **1967 ACM**
- **1969 UCLA, UCSB, SRI, UoU**
- **1972 TCP**

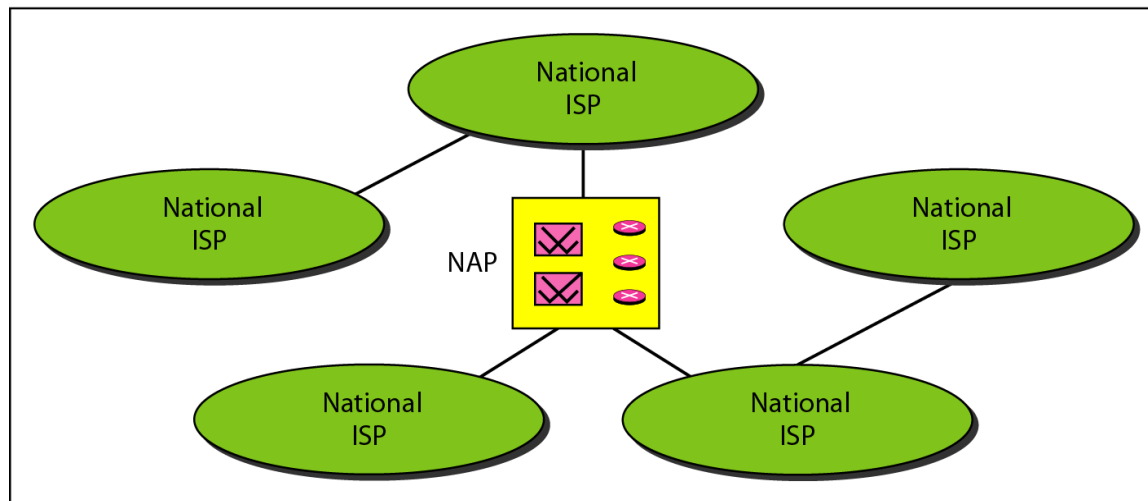
**The Internet Today (ISPs)**

# *Hierarchical organization of the Internet*



a. Structure of a national ISP

هذه محذوفة



b. Interconnection of national ISPs

# 1-4 PROTOCOLS AND STANDARDS

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*protocols and standards.*

Protocol is synonymous with rule

*Protocol is synonymous with rule.*

Standards are agreed-upon rule

*Standards are agreed-upon rules.*

*Topics discussed in this section:*

Protocols

Standards

Standards Organizations

Internet Standards

# PROTOCOLS AND STANDARDS

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## Protocols

- **Syntax** → format of the data
- **Semantics** → meaning of each section
- **Timing** → when data should be sent and how fast.

## Standards

- **De facto** → by fact (not approved as a standard)
- **De jure** → by Law (approved)

# PROTOCOLS AND STANDARDS

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## Standards Organizations

- **International Organization for Standardization (ISO)**
- **International Telecommunication Union - Telecommunication Standards (ITU-T)**
- **American National Standards Institute (ANSI)**
- **Institute of Electrical and Electronics Engineers (IEEE)**
- **Electronic Industries Association (EIA)**

# ***Network Models***

## Lecture 2

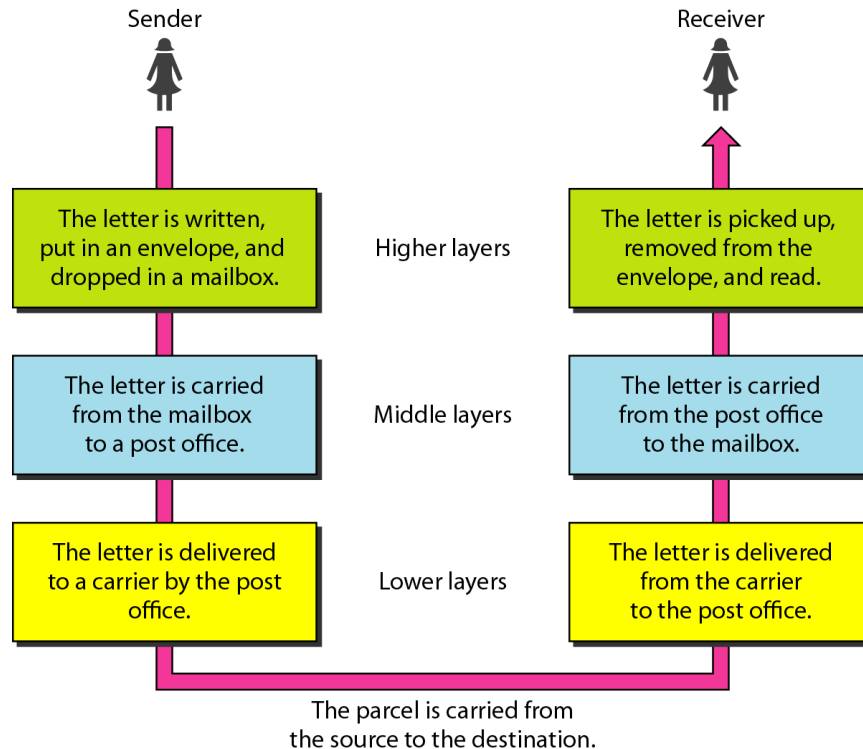
### *OSI Model*

# 1-5 LAYERED TASKS

- A network model is a layered architecture
  - Task broken into subtasks
  - Implemented separately in layers in stack
  - Functions need in both systems
  - Peer layers communicate
- Protocol: مجموعة من القواعد التي تحكم اتصالات البيانات
  - A set of rules that governs data communication
  - It represents an agreement between the communicating devices



# Tasks involved in sending a letter



## Topics discussed in this section:

**Sender, Receiver, and Carrier  
Hierarchy (services)**

# 1-5.1 THE OSI MODEL

***Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards.***

***An ISO is the Open Systems Interconnection (OSI) model is the standard that covers all aspects of network communications from ISO. It was first introduced in the late 1970s.***

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**ISO is the organization.  
OSI is the model.**

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**Topics discussed in this section:**

**Layered Architecture  
Peer-to-Peer Processes  
Encapsulation**

# Layered Architecture

## Layers

Layer 7. [Application](#)

Layer 6. [Presentation](#)

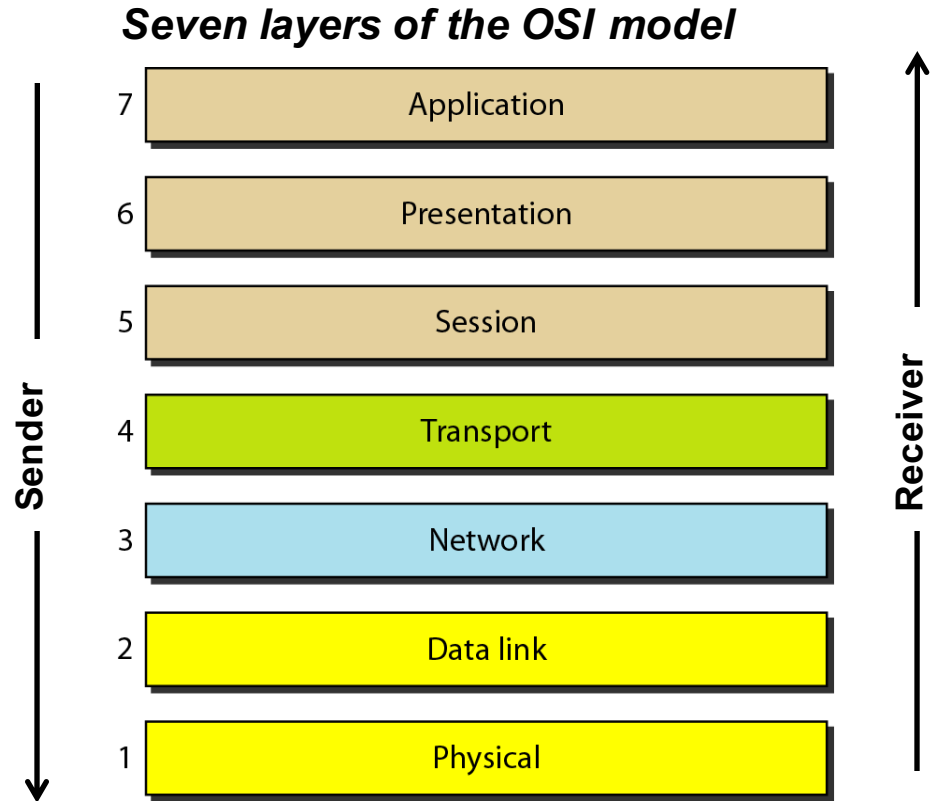
Layer 5. [Session](#)

Layer 4. [Transport](#)

Layer 3. [Network](#)

Layer 2. [Data Link](#)

Layer 1. [Physical](#)



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# Layered Architecture

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- A layered model
- Each layer performs a subset of the required communication functions
- Each layer relies on the next lower layer to perform more primitive functions
- Each layer provides services to the next higher layer by interface through SAP
- Changes in one layer should not require changes in other layers
- The processes on each machine at a given layer are called peer-to-peer process

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# PEER – TO – PEER PROCESS

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- Communication must move downward through the layers on the sending device, over the communication channel, and upward to the receiving device
- Each layer in the sending device adds its own information to the message it receives from the layer just above it and passes the whole package to the layer just below it
- At the receiving device, the message is unwrapped layer by layer, with each process receiving and removing the data meant for it

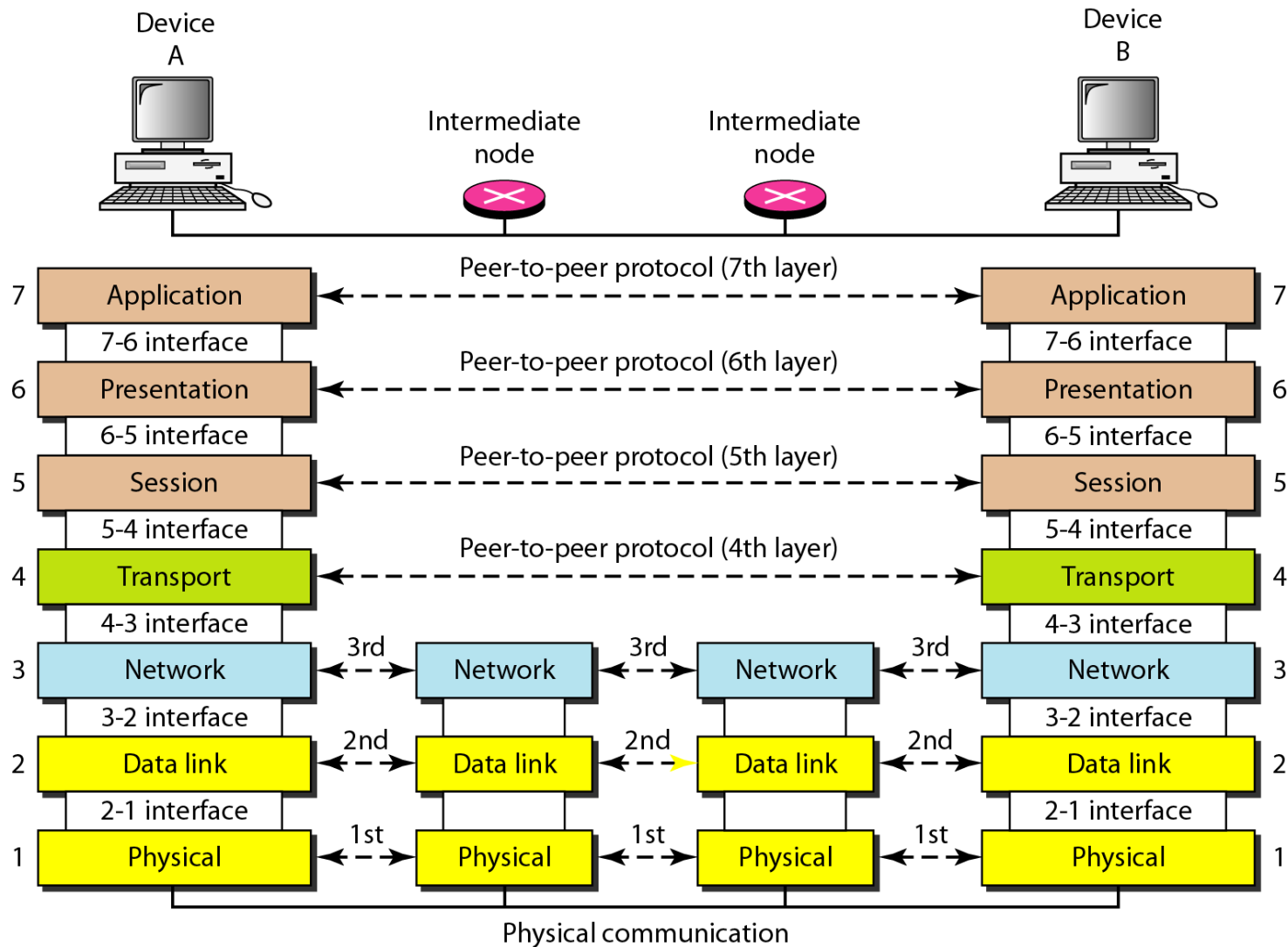
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# PEER – TO – PEER PROCESS

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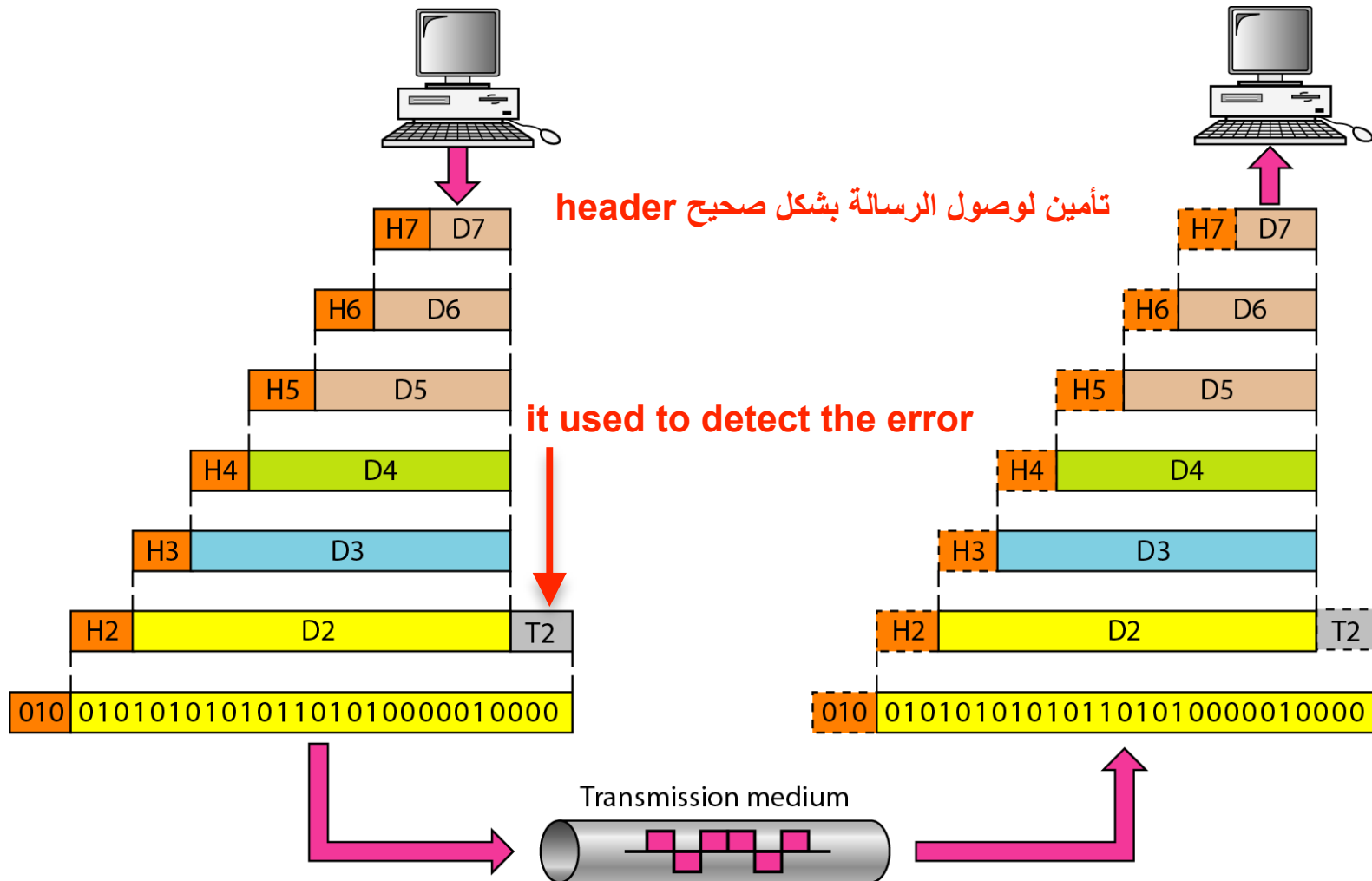
- The passing of the data and network information down through the layers of the sending device and backup through the layers of the receiving device is made possible by interface between each pair of adjacent layers
- Interface defines what information and services a layer must provide for the layer above it.

# The interaction between layers in the OSI model





# An exchange using the OSI model



# LAYERS IN THE OSI MODEL

## **Topics discussed in this section:**

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

# Physical Layer

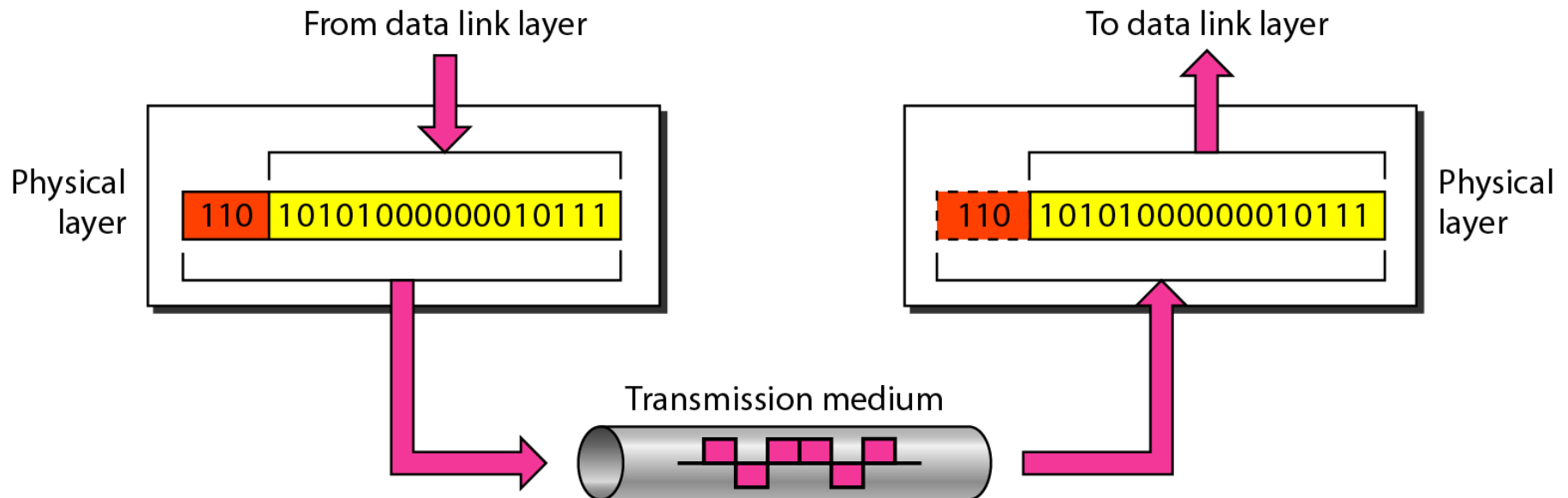
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**The physical layer is responsible for movements of individual bits from one hop (node) to the next.**

## ■ Function

- Physical characteristics of interfaces and media
- Representation of bits
- Data rate
- Synchronization of bits
- Line configuration (point-to-point or multipoint)
- Physical topology (mesh, star, ring or bus)
- Transmission mode ( simplex, half-duplex or duplex)

# Physical layer

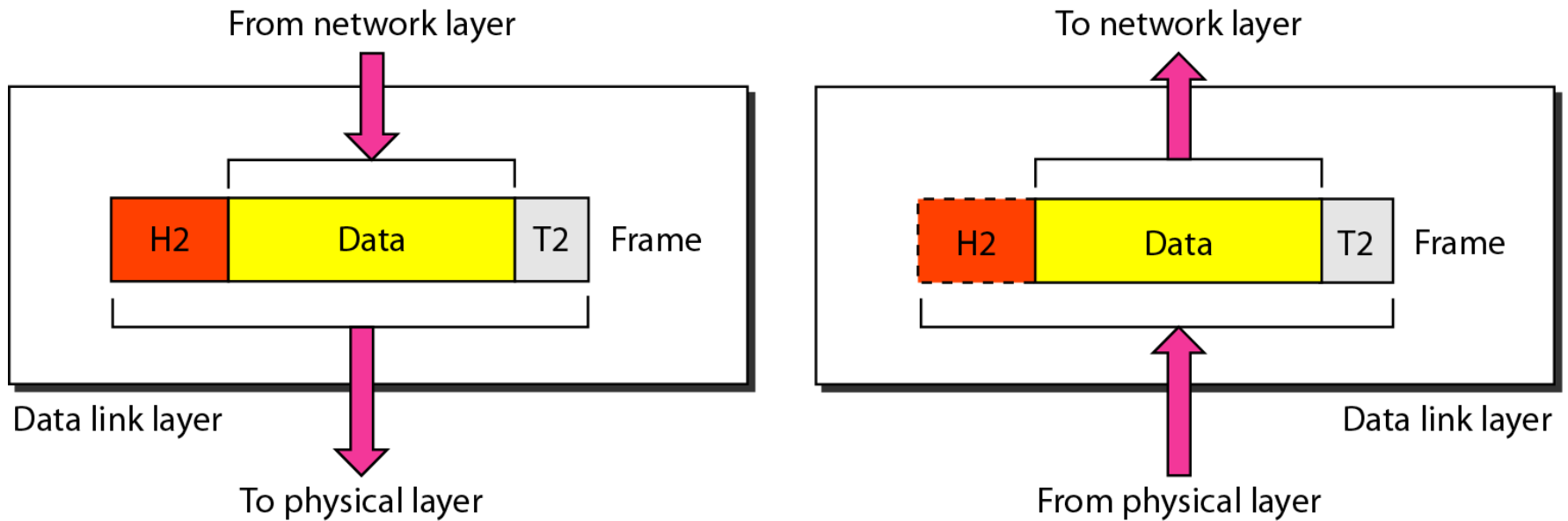


**The data link layer is responsible for moving frames from one hop (node) to the next.**

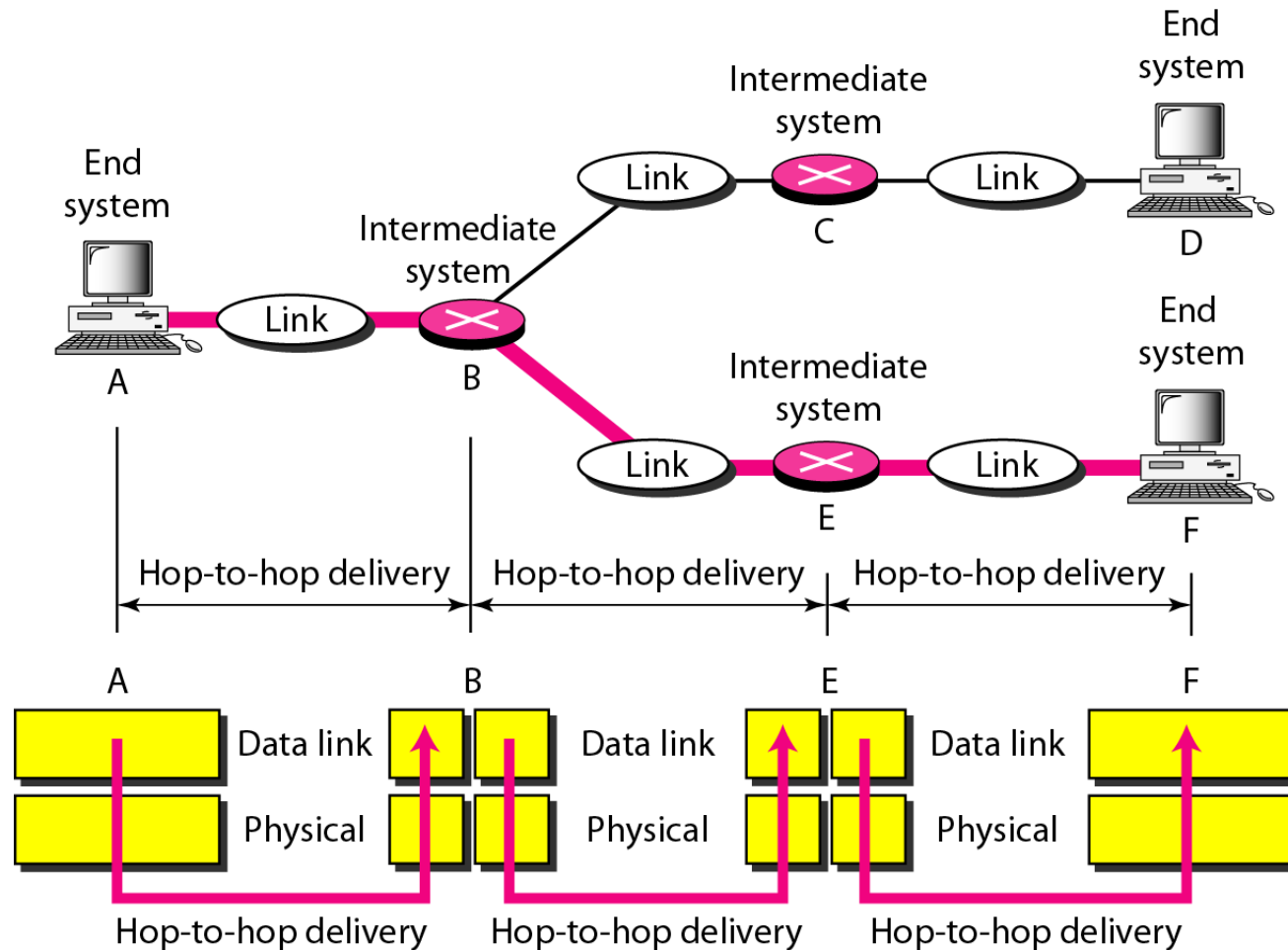
### ■ Function

- Framing
- Physical addressing
- Flow control
- Error control **it used to detect the error**
- Access control

## Data link layer

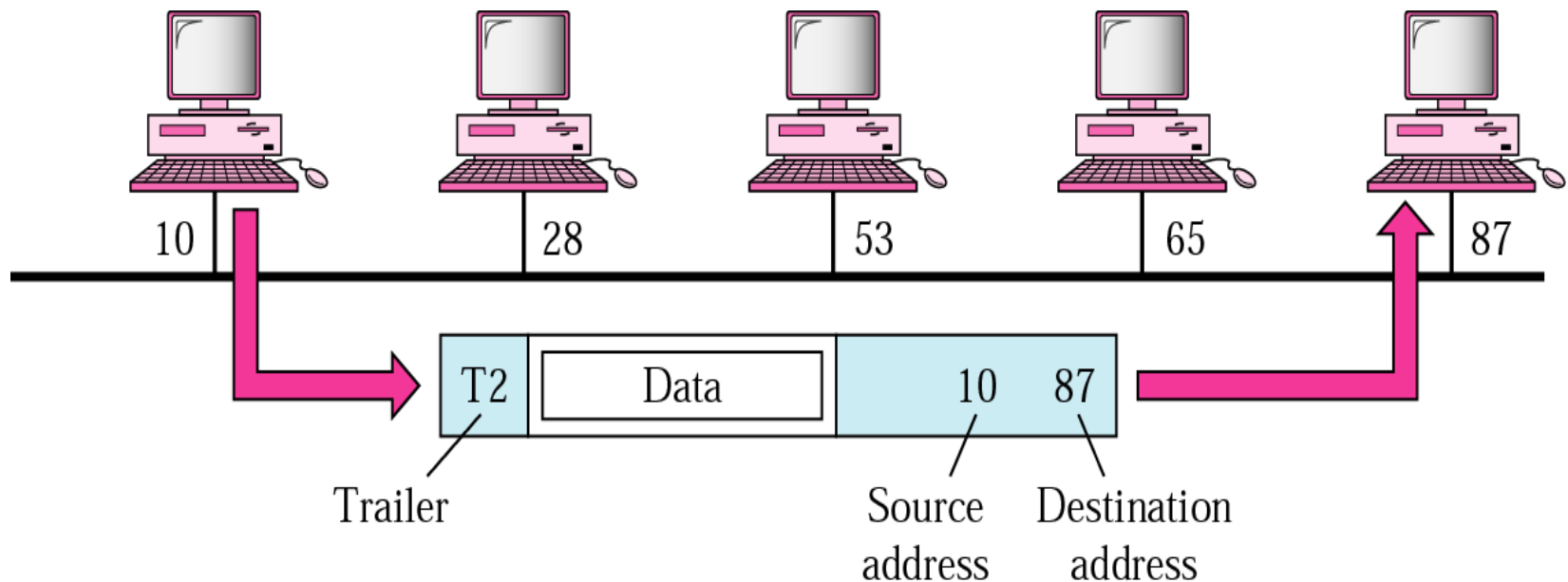


# Hop-to-hop delivery



# Example 1

In following Figure a node with physical address **10** sends a frame to a node with physical address **87**. The two nodes are connected by a link. At the data link level this frame contains physical addresses in the header. These are the only addresses needed. The rest of the header contains other information needed at this level. The trailer usually contains extra bits needed for error detection

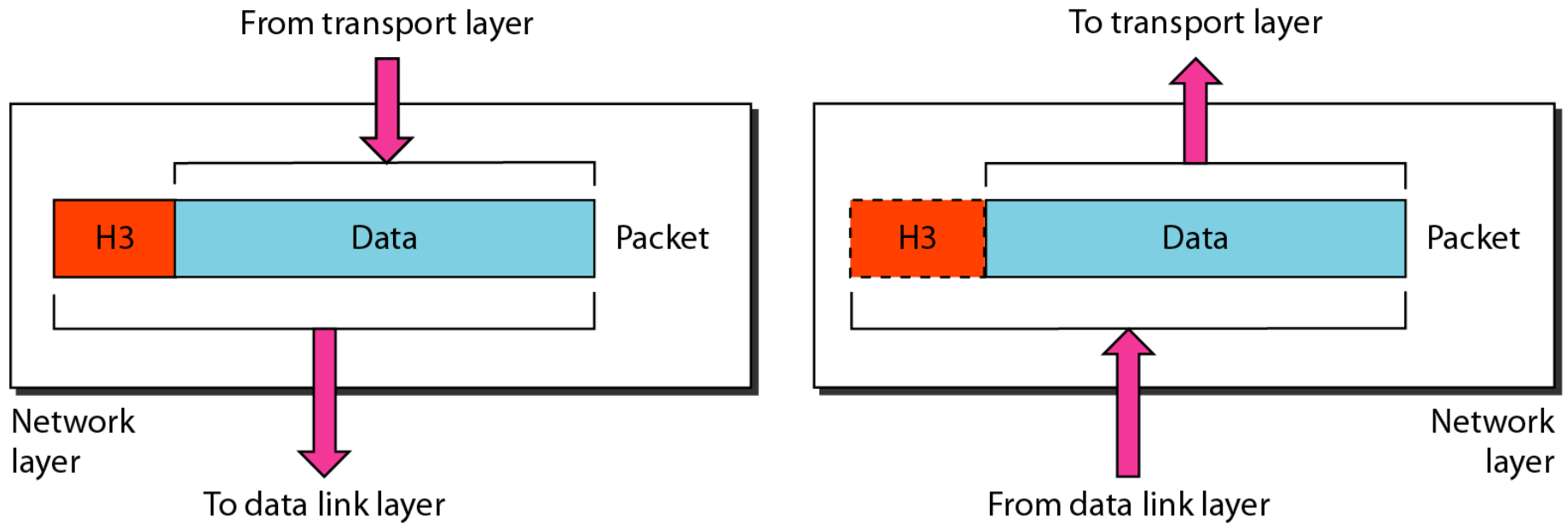




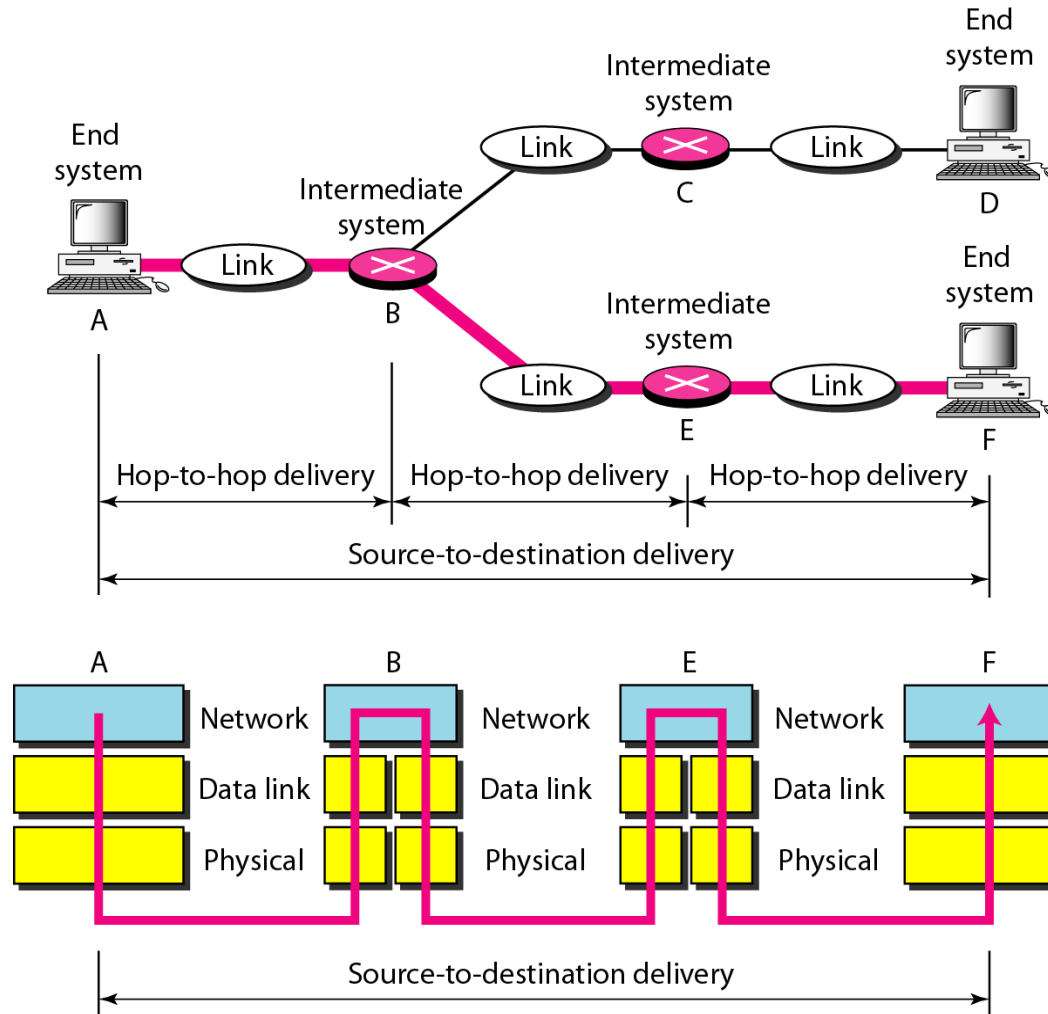
**The network layer is responsible for the delivery of individual packets from the source host to the destination host.**

- Source-to-destination delivery
- Responsible from the delivery of packets from the original source to the final destination
- Functions
  - Logical addressing which is an IP address in the most of cases
  - routing

# Network layer

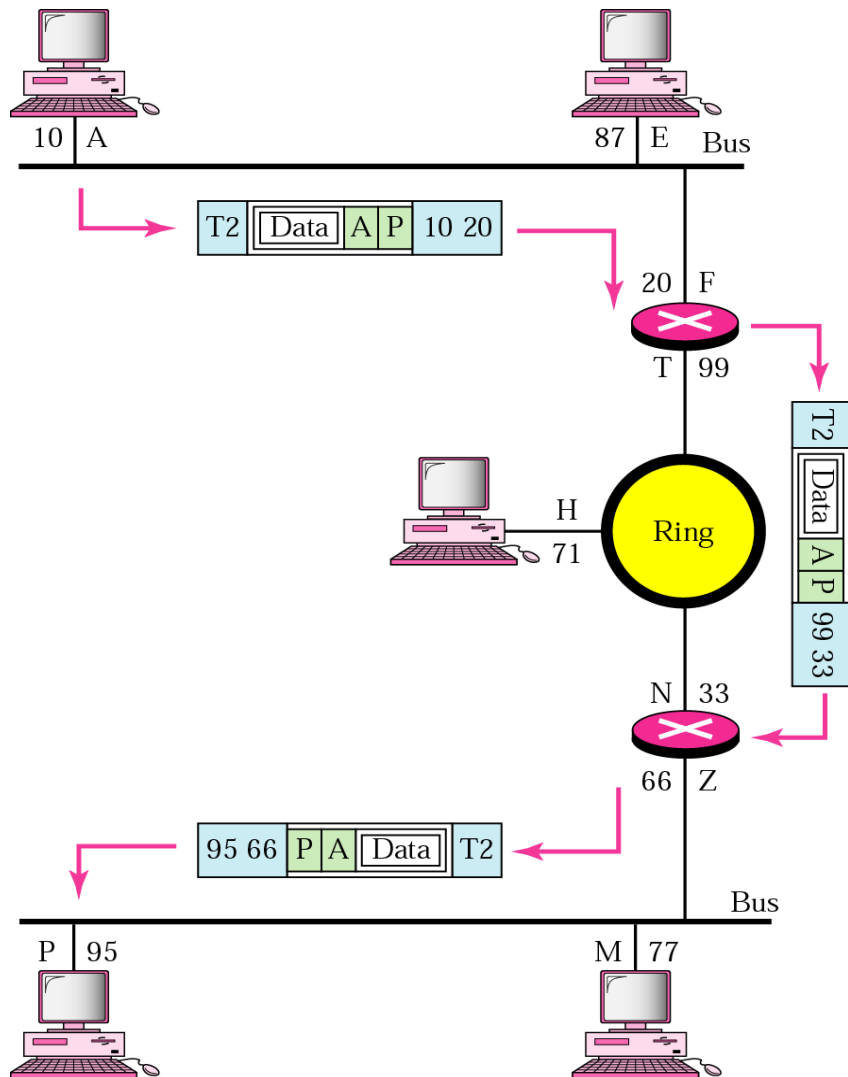


# Source-to-destination delivery



## Example 2

We want to send data from a node with network address **A** and physical address 10, located on one LAN, to a node with a network address **P** and physical address 95, located on another LAN. Because the two devices are located on different networks, we cannot use physical addresses only; the physical addresses only have local influence. What we need here are **universal addresses** that can pass through the LAN boundaries. The network (logical) addresses have this characteristic.

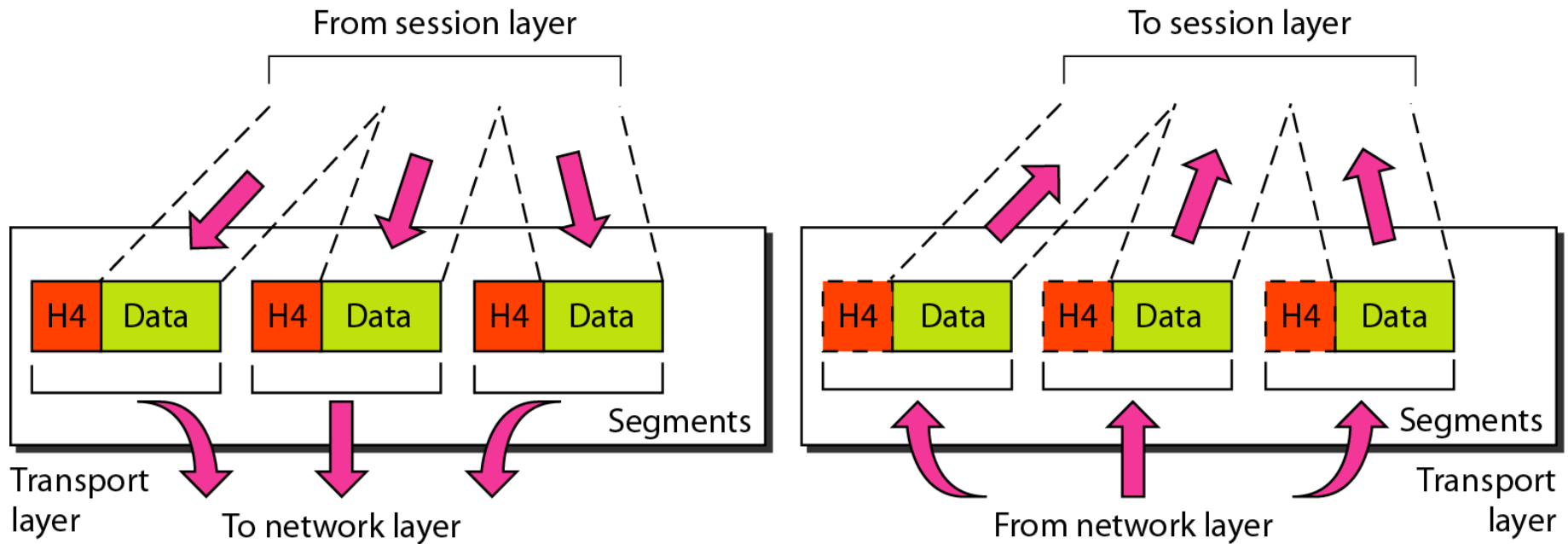


**The transport layer is responsible for the delivery of a message from one process to another.**

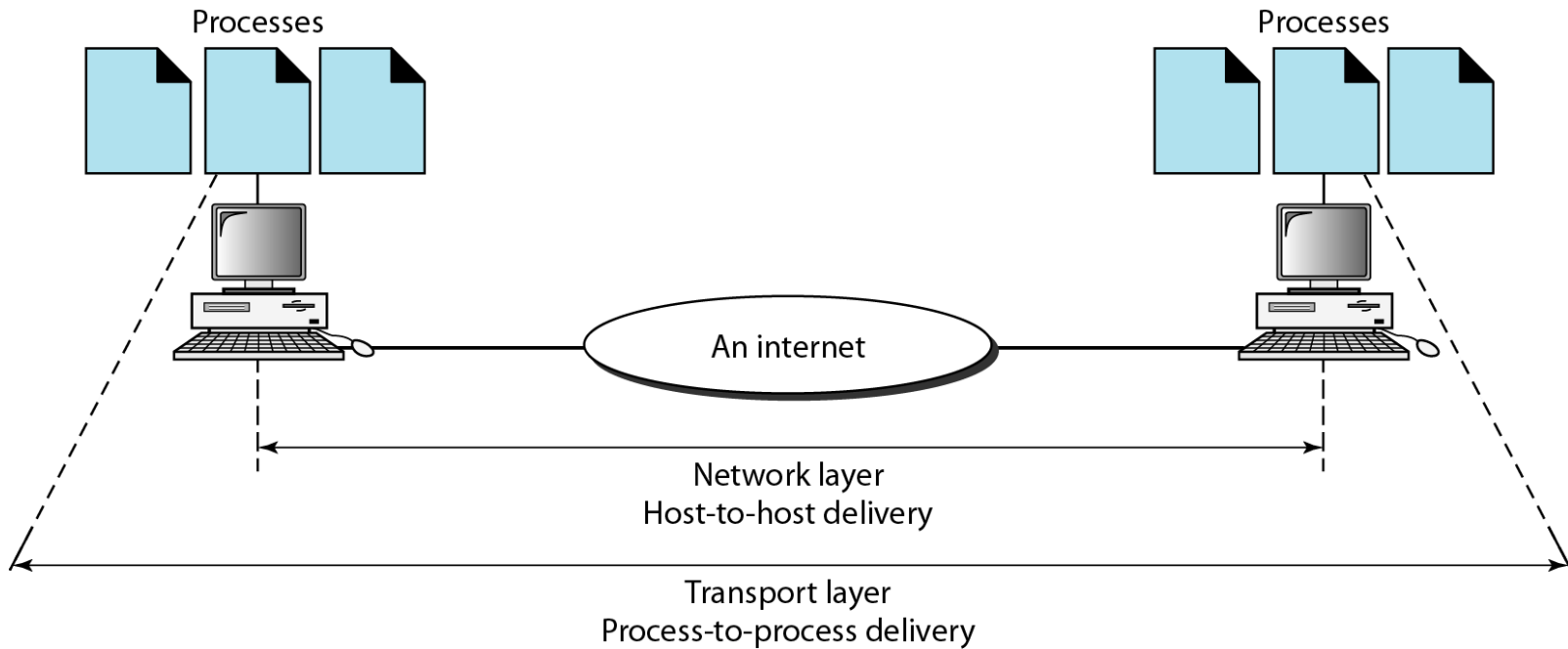
- Process-to- process delivery
- Functions
  - Port addressing
  - Segmentation and reassembly تقسيم وإعادة تجميع
  - Connection control ( Connection-oriented or connection-less)
  - Flow control
  - Error control

# Transport layer

## Segmentation and reassembly

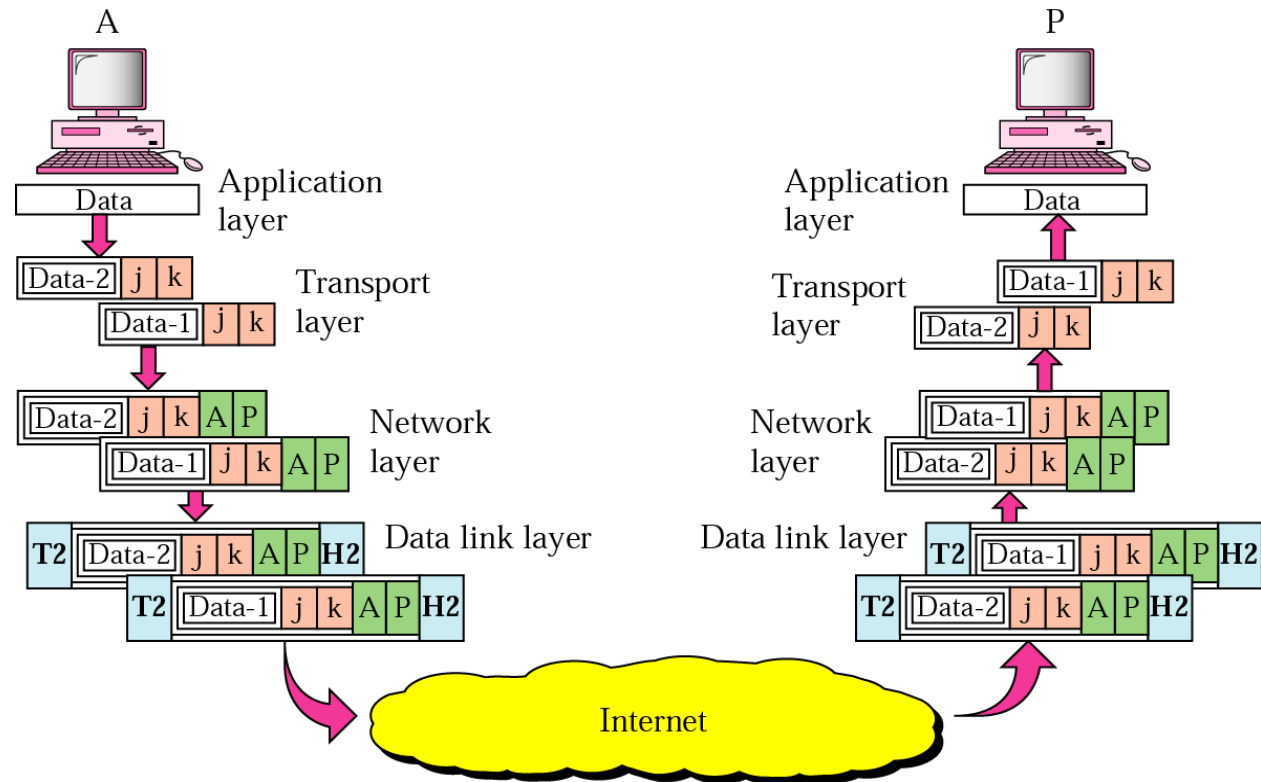


# *Reliable process-to-process delivery of a message*



# Example 3

Data coming from the upper layers have port addresses **j** and **k** (**j** is the address of the sending process, and **k** is the address of the receiving process). Since the data size is larger than the network layer can handle, the data are split into two packets, each packet retaining the port addresses (**j** and **k**). Then in the network layer, network addresses (**A** and **P**) are added to each packet.





# Session Layer

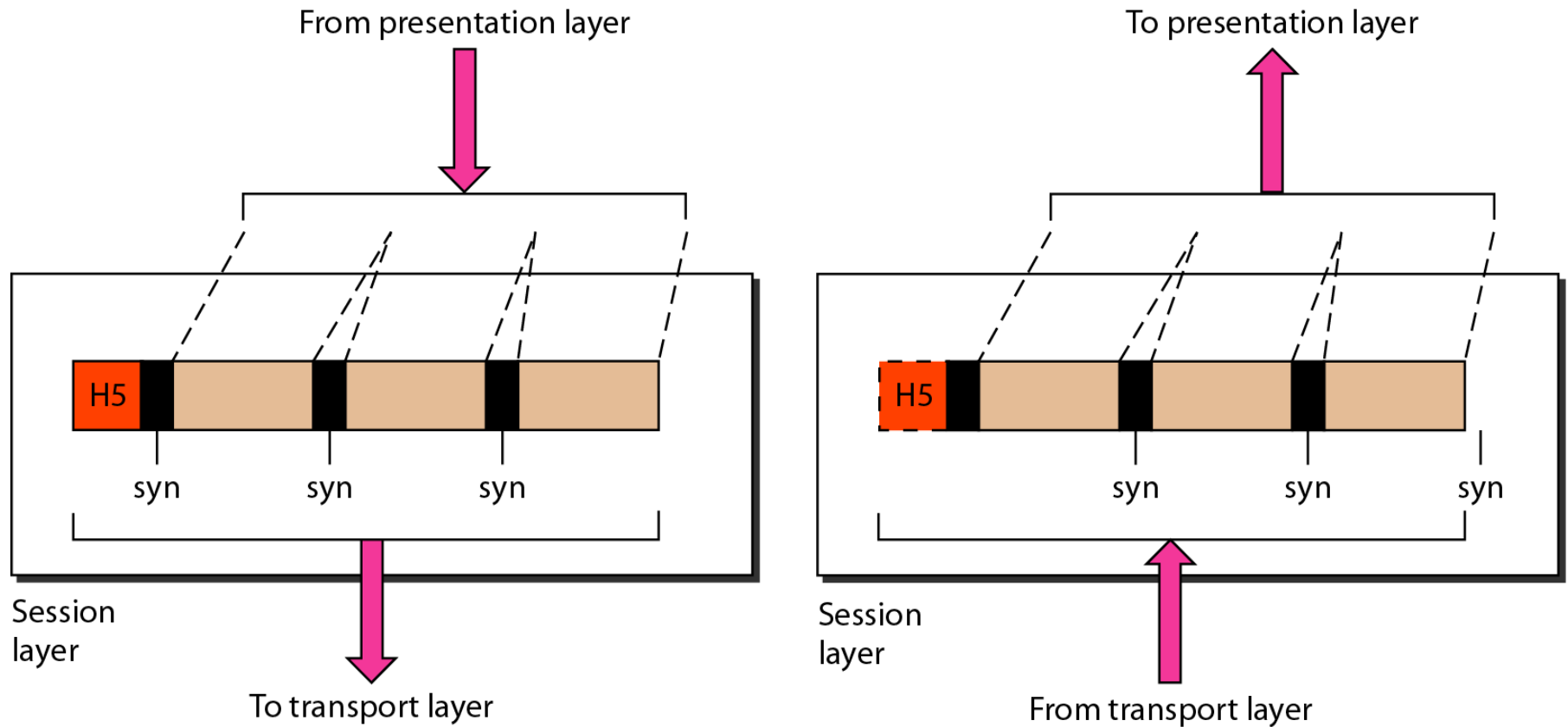
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The session layer is responsible for **dialog control and synchronization.**

- It establishes, maintains and synchronize the interaction between communicating system
- **Function**
  - Dialog control
  - Synchronization (checkpoints)

# Session layer

## Synchronization



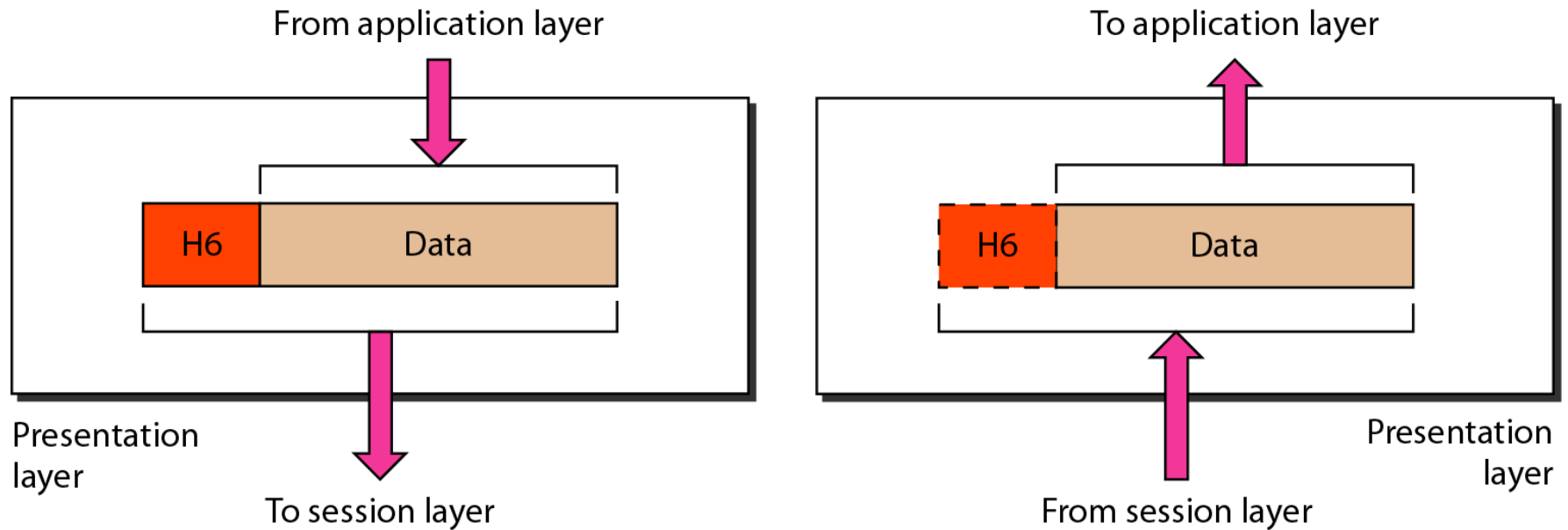
# Presentation Layer

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The presentation layer is responsible for translation, compression, and encryption.

- Concerned with the syntax and semantics of the information exchanged between two system
- **Functions**
  - **Translation** ( EBCDIC-coded text file → ASCII-coded file)
  - **Encryption and Decryption**
  - **Compression**

# Presentation layer



# Application Layer

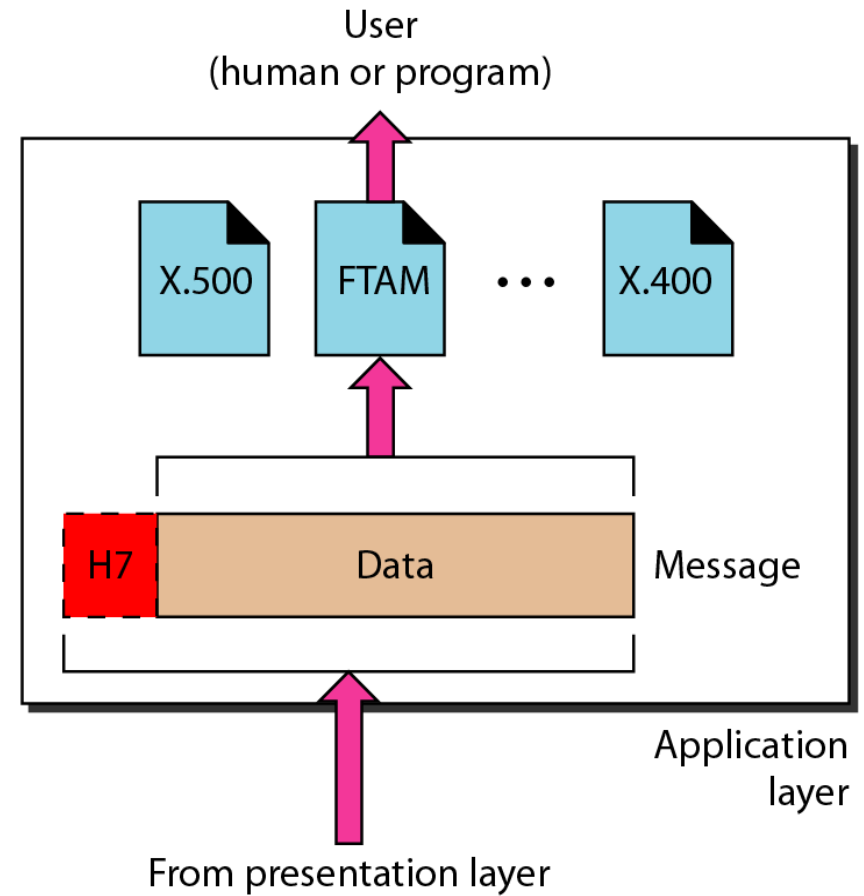
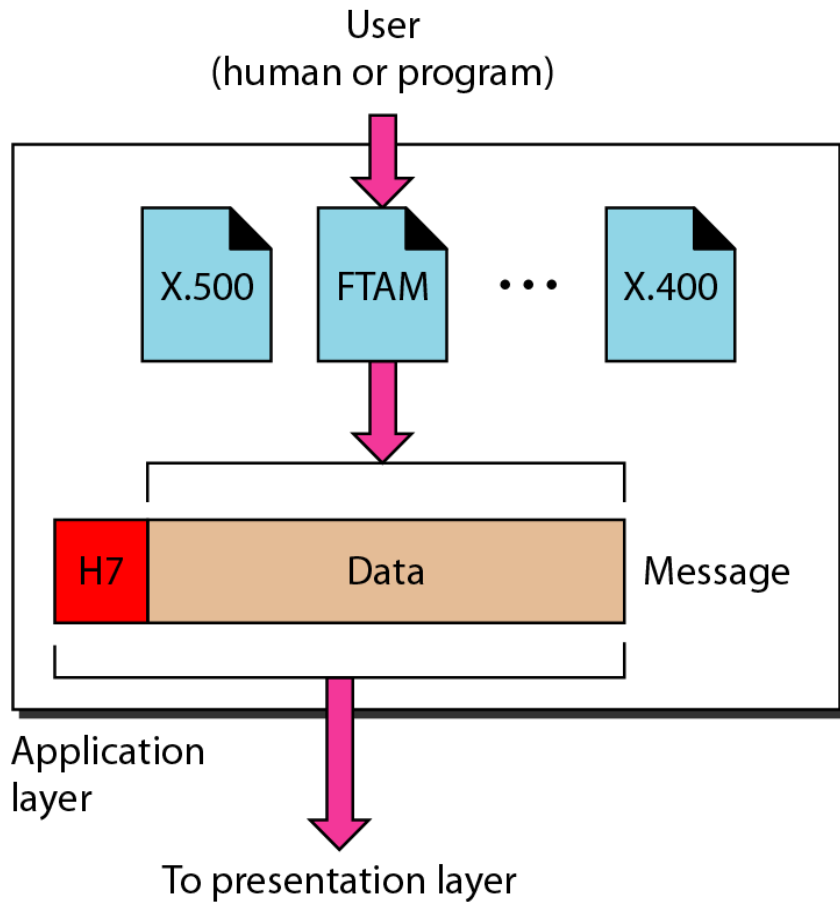
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**The application layer is responsible for providing services to the user.**

- **Functions**

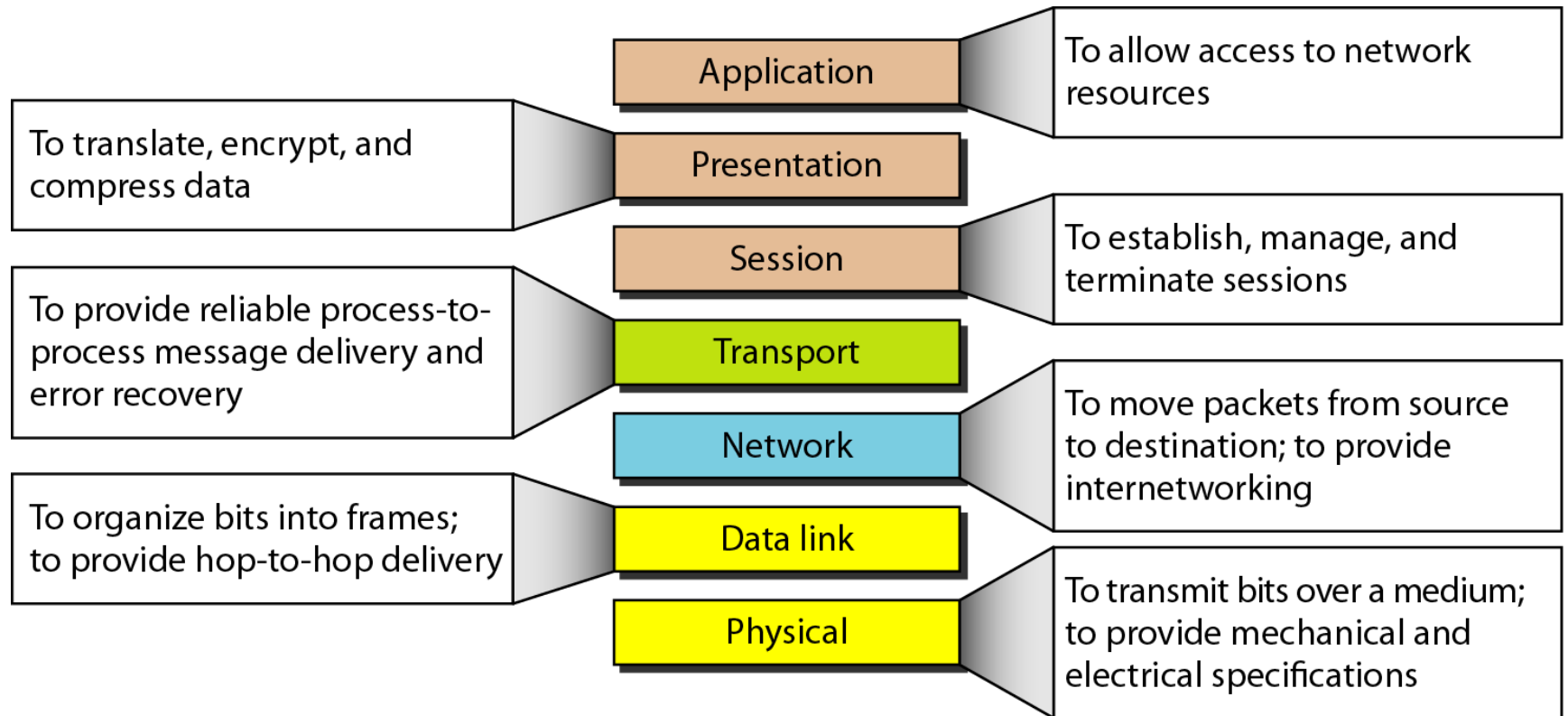
- Network virtual terminal (Remote log-in)
- File transfer and access
- Mail services
- Directory services (Distributed Database)
- Accessing the World Wide Web

# Application layer



# Summary of layers

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# Summary of layers

OSI Model			
	Data unit	Layer	Function
<div> <div>Sender</div> <div>↓</div> </div>	Data	7. Application	Network process to application
		6. Presentation	Data representation and encryption
		5. Session	Inter-host communication
User ↔ Network	Segment	4. Transport	End-to-end connections and reliability
<div> <div>Network support layers</div> <div>↓</div> </div>	Packet	3. Network	Path determination and logical addressing
	Frame	2. Data Link	Physical addressing
	Bit	1. Physical	Media, signal and binary transmission
			<div> <div>Receiver</div> <div>↑</div> </div>



# ***Network Models***

## Lecture 3

### ***TCP/IP Model***

# 1-5.2 TCP/IP PROTOCOL SUITE

*The layers in the **TCP/IP protocol suite** do not exactly match those in the OSI model. The original TCP/IP protocol suite was defined as having four layers: **host-to-network**, **internet**, **transport**, and **application**. However, when TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers: **physical**, **data link**, **network**, **transport**, and **application**.*

## **Topics discussed in this section:**

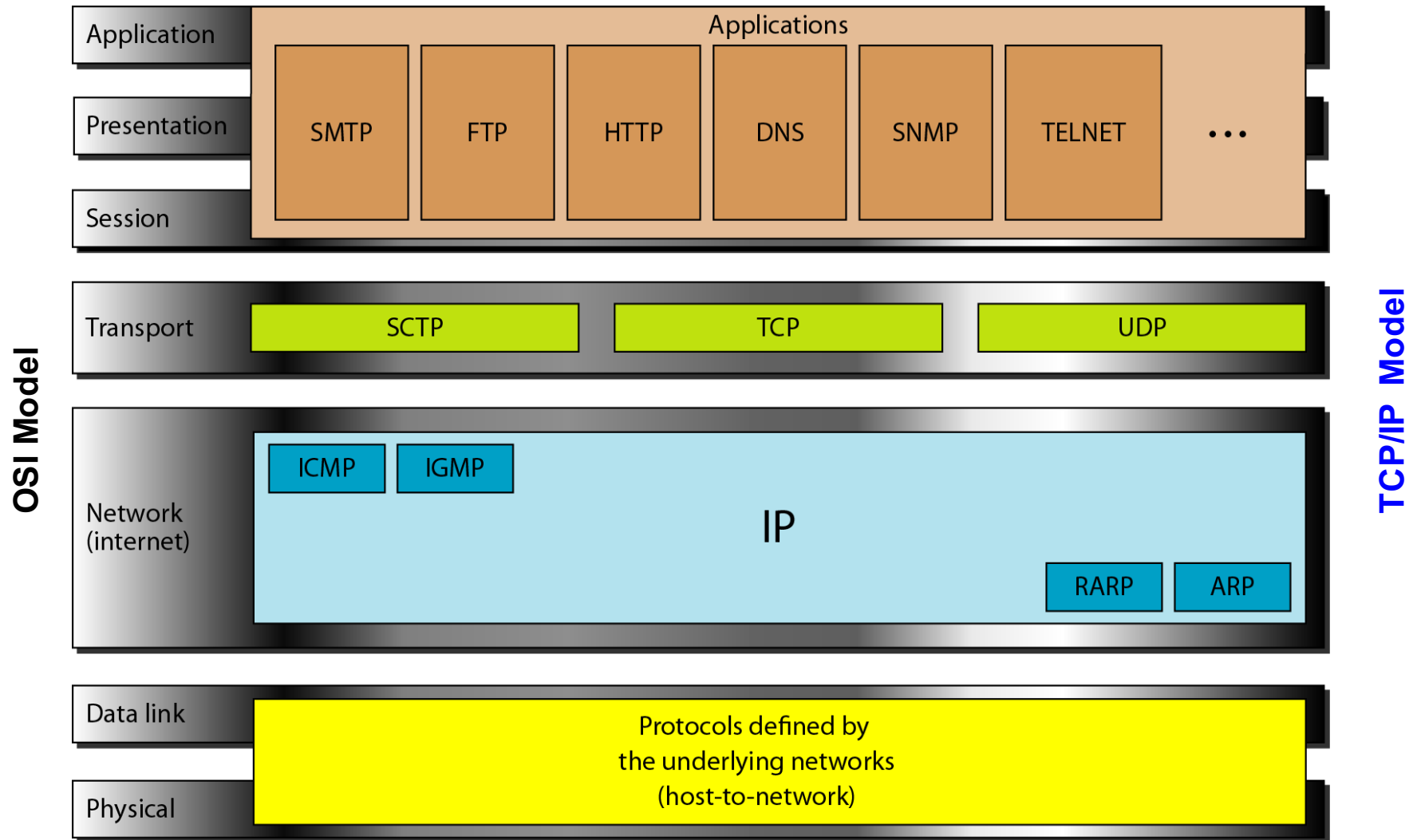
**Physical and Data Link Layers**

**Network Layer**

**Transport Layer**

**Application Layer**

# TCP/IP and OSI model



# Internet Layer

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**TCP/IP support the Internet Protocol IP ( unreliable).  
IP is a host-to-host protocol.**

***Supporting protocols:***

- Address Resolution Protocol (ARP)
- Reverse Address Resolution Protocol (RARP)
- Internet Control Message Protocol (ICMP)
- Internet Group Message Protocol (IGMP)

# Transport Layer

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## **Process-to-process protocol.**

- User Datagram Protocol (UDP)
- Transmission Control Protocol (TCP)
- Stream Control Transmission Protocol (SCTP)

# 1-6 ADDRESSING

***Four levels of addresses are used in an internet employing the TCP/IP protocols:  
*physical, logical, port, and specific.****

## **Topics discussed in this section:**

**Physical Addresses**

**Logical Addresses**

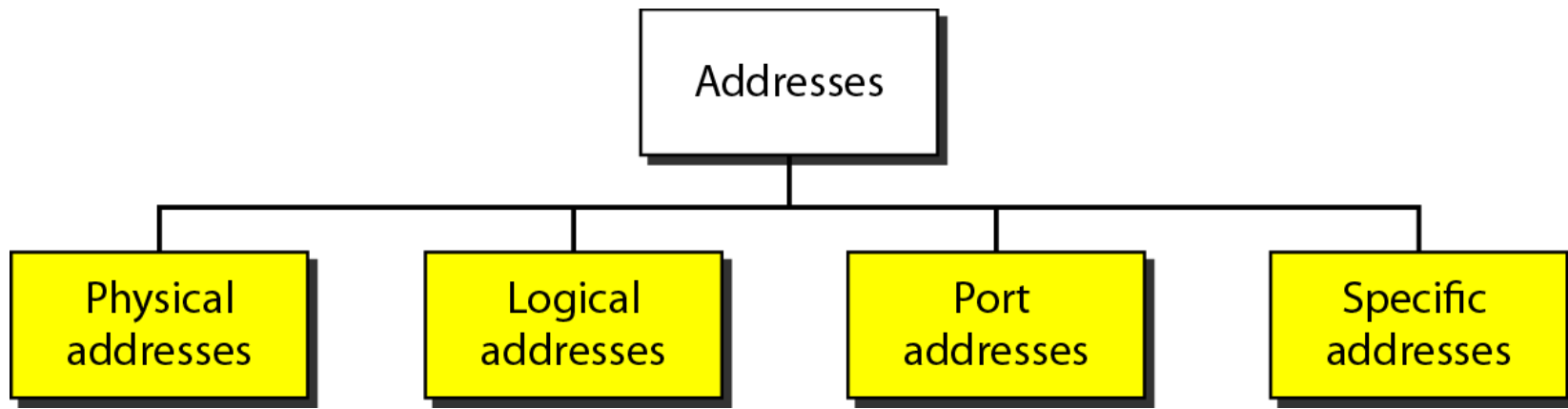
**Port Addresses**

**Specific Addresses**

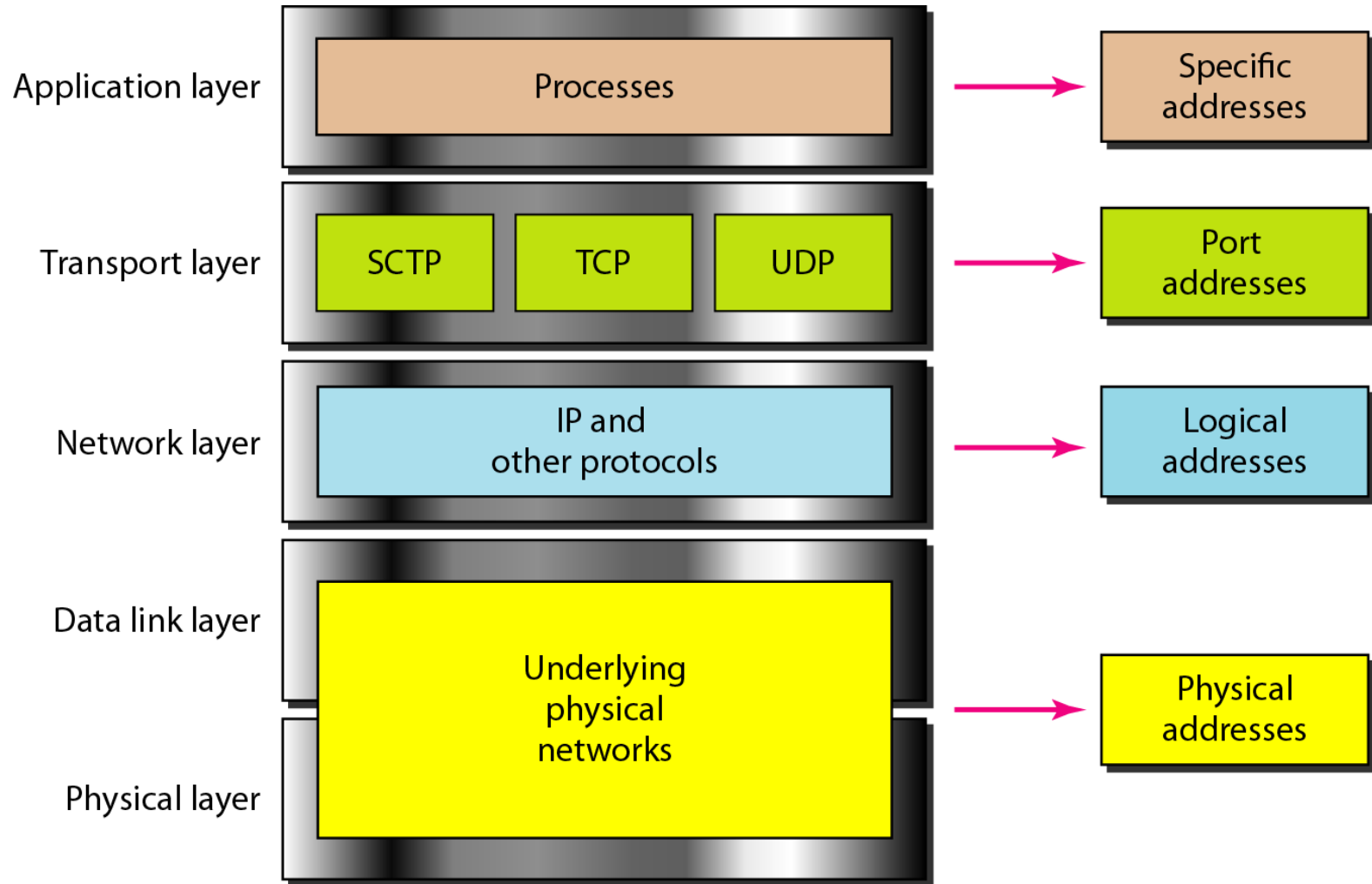
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## *Addresses in TCP/IP*

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# Relationship of layers and addresses in TCP/IP





# Physical Address

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Physical addresses are imprinted on the NIC. Most local-area networks (Ethernet) use a **48-bit** (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon.

**Example:**

**07:01:02:01:2C:4B**

**A 6-byte (12 hexadecimal digits) physical address.**

# ***Physical Address***

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- known also as the MAC address
- Is the address of a node as defined by its LAN or WAN
- It is included in the frame used by data link layer

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**The physical addresses in the datagram may change from hop to hop.**

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# Logical Address

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- IP addresses are necessary for universal communications that are independent of physical network.
- No two host address on the internet can have the same IP address
- IP addresses in the Internet are 32-bit address that uniquely define a host.

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**The physical addresses will change from hop to hop, but the logical addresses usually remain the same.**

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# Port addresses

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Port address is a 16-bit address represented by one decimal number ranged from (0-65535) to choose a process among multiple processes on the destination host.

- Destination port number is needed for delivery.
- Source port number is needed for receiving a reply as an acknowledgments.

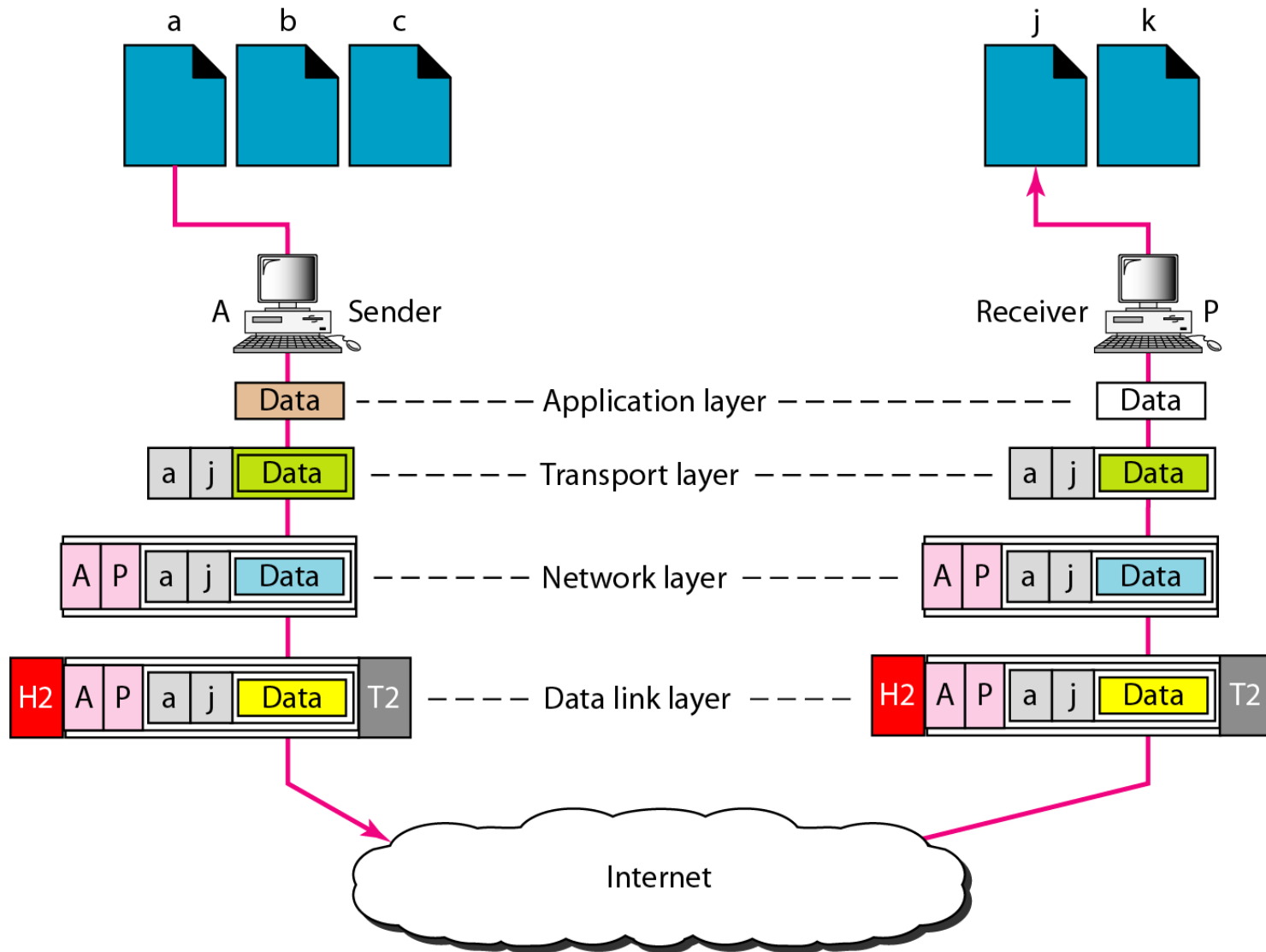
**In TCP/IP , a 16-bit port address represented as one single number. Example: 753**

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**The physical addresses change from hop to hop, but the logical and port addresses usually remain the same.**

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# Port addresses



# ***Specific addresses***

E-mail address (user1@ksu.edu.sa)

Universal Resource Locator (URL) (www.ksu.edu.sa)

The Domain Name System (DNS) translates human-friendly computer hostnames ( URL) into IP addresses. For example, *www.example.com* is translated to *208.77.188.166*