Data Communications and Networking Fourth Edition
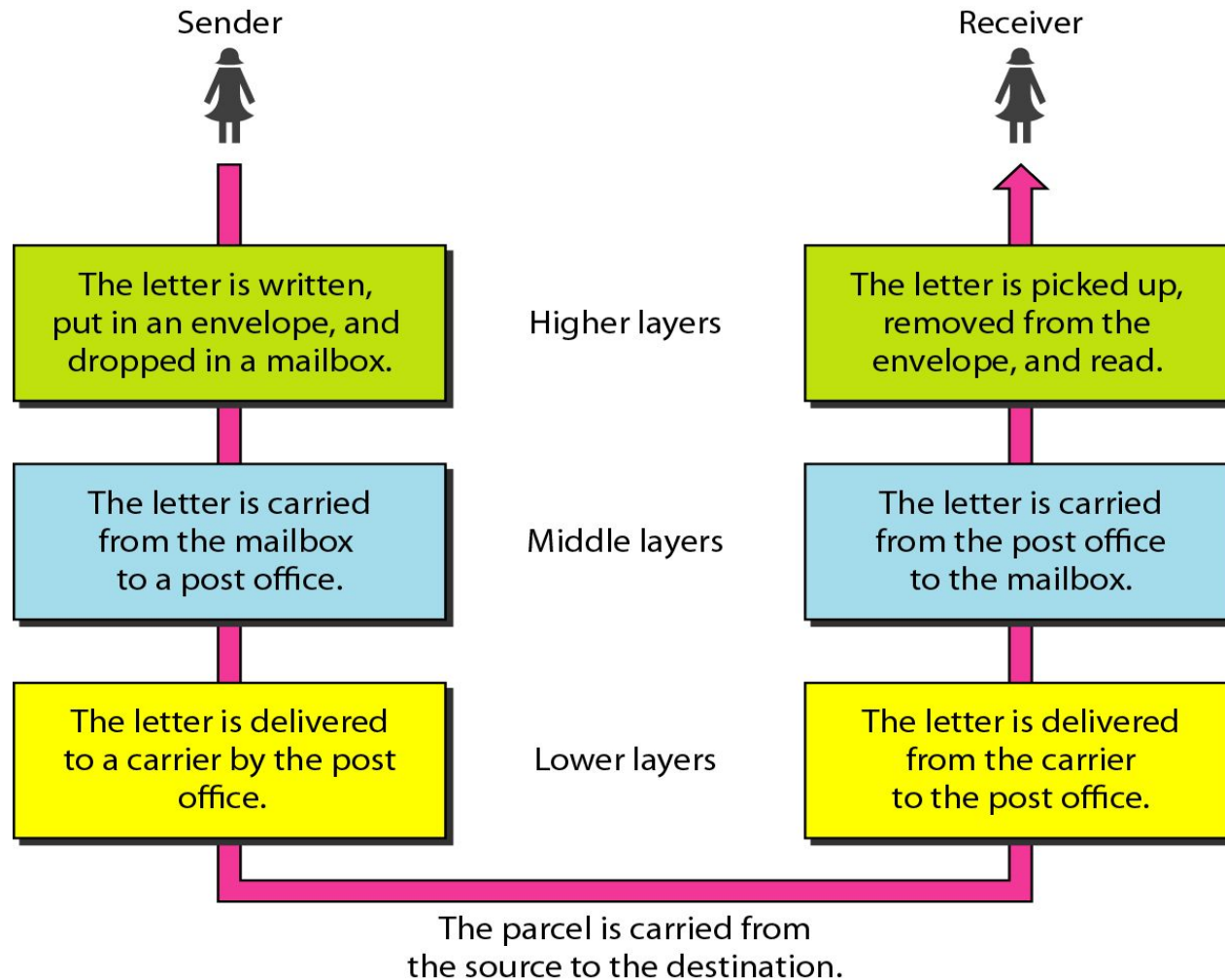
Chapter 2

Network Models

2.1   LAYERED TASKS

We use the concept of layers in our daily life. As an example, let us consider two friends who communicate through postal mail. The process of sending a letter to a friend would be complex if there were no services available from the post office.

Topics discussed in this section:

Sender, Receiver, and Carrier
Hierarchy

Layered Tasks

❑ **Sender, Receiver and Carrier**

Sender

Receiver

| The letter is written, put in an envelope, and dropped in a mailbox. | Higher layers | The letter is picked up, removed from the envelope, and read. |

| The letter is carried from the mailbox to a post office. | Middle layers | The letter is carried from the post office to the mailbox. |

| The letter is delivered to a carrier by the post office. | Lower layers | The letter is delivered from the carrier to the post office. |

The parcel is carried from the source to the destination.

Layered Tasks

❑ **Hierarchy**

    ❖ **Higher Layer**

    ❖ **Middle Layer**

    ❖ **Lower Layer**

❑ **Services**

    ❖ **The Each layer uses the services of the layer immediately below it.**

2.2   THE OSI MODEL

Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards. An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model. It was first introduced in the late 1970s.

ISO is the organization.
OSI is the model.

Topics discussed in this section:

Layered Architecture
Peer-to-Peer Processes
Encapsulation

Layered Architecture

❑ **The OSI model is composed of seven layers ;**

- **Physical (layer1), Data link (layer2), Network (layer3)**
- **Transport (layer4), Session (layer5), Presentation (layer6)**
- **Application (layer7)**

❑ **Layer**

- ❖ **Designer identified which networking functions had related uses and collected those functions into discrete groups that became the layers.**
- ❖ **The OSI model allows complete interoperability between otherwise incompatible systems.**
- ❖ **The Each layer uses the services of the layer immediately below it.**

Layered Architecture (cont'd)

Figure 2.2 *Seven layers of the OSI model*

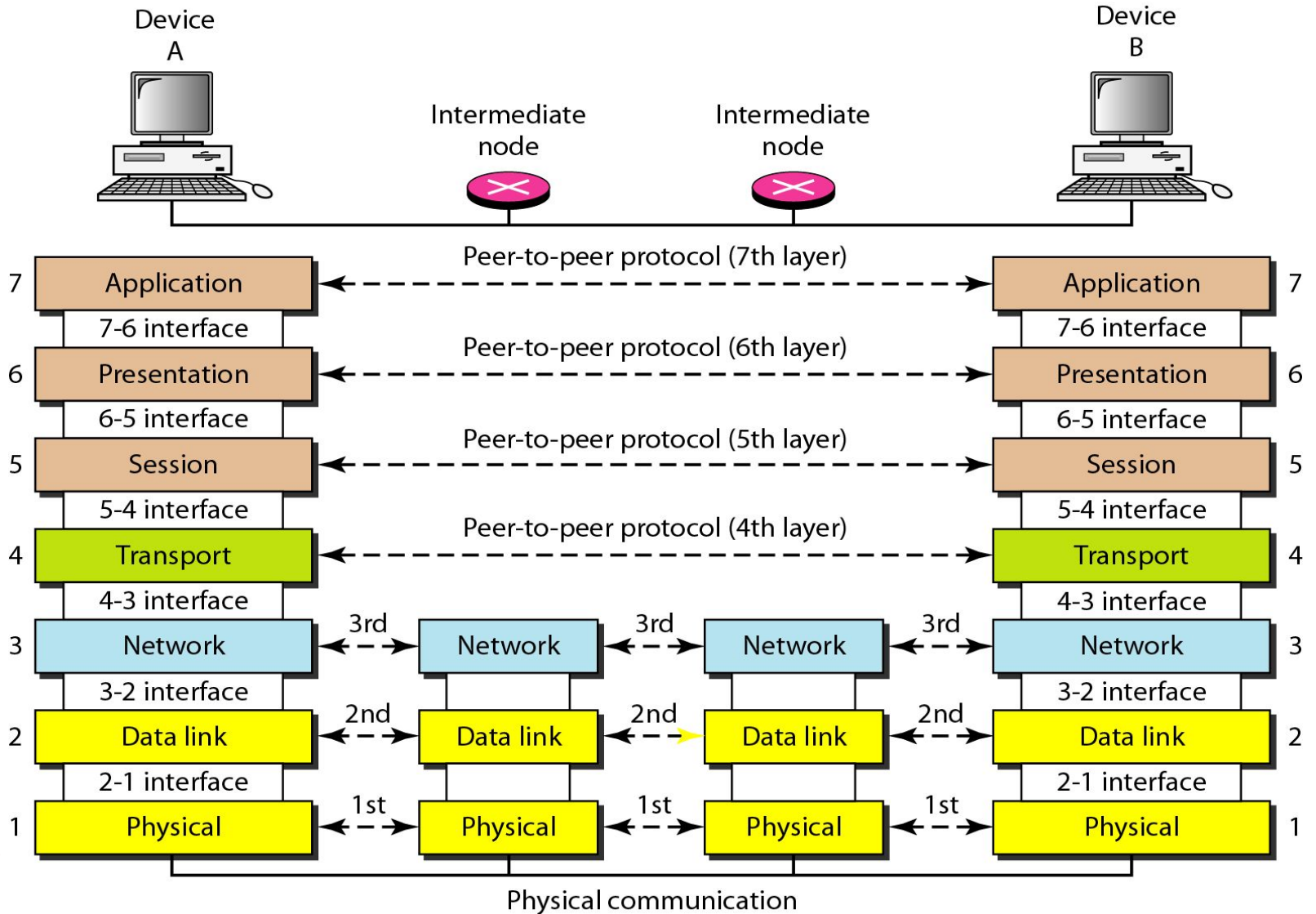|	
7	Application
6	Presentation
5	Session
4	Transport
3	Network
2	Data link
1	Physical

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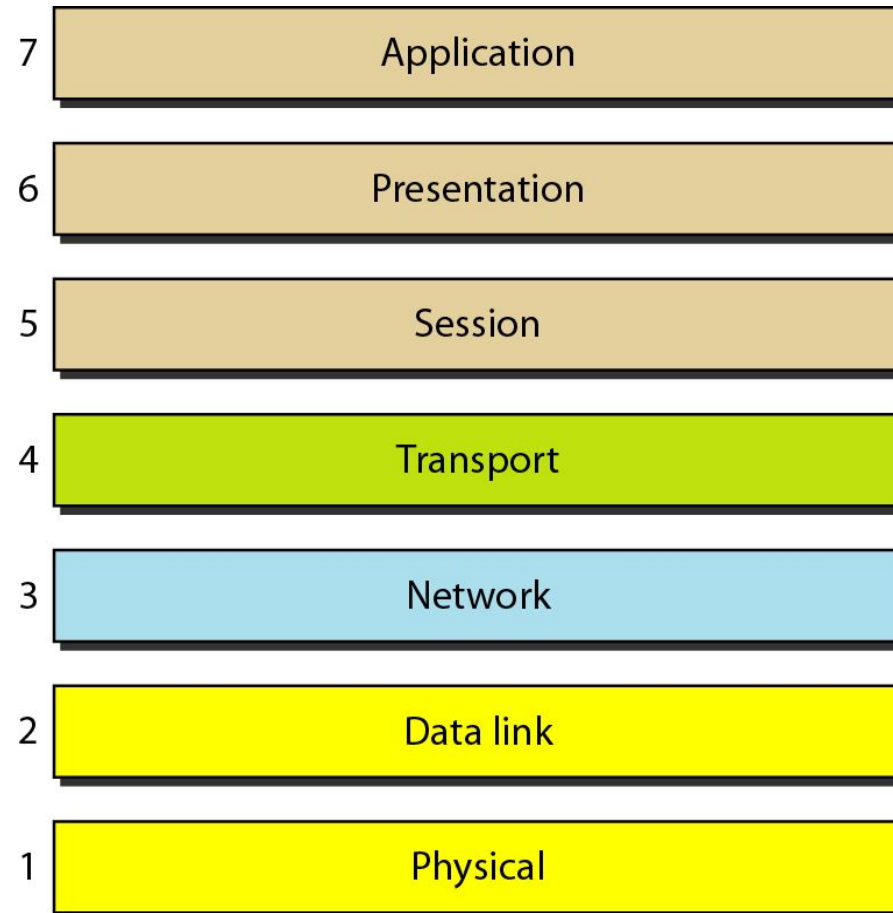
Peer-to-peer Processes

❑ **Layer x on one machine communicates with layer x on another machine - called Peer-to-Peer Processes.**

❑ **Interfaces between Layers**

- **Each interface defines what information and services a layer must provide for the layer above it.**
- **Well defined interfaces and layer functions provide modularity to a network**

❑ **Organizations of the layers**

- ❖ **Network support layers : Layers 1, 2, 3**
- ❖ **User support layer : Layer 5, 6, 7**
  - ● **It allows interoperability among unrelated software systems**
- ❖ **Transport layer (Layer 4) : links the two subgroups**
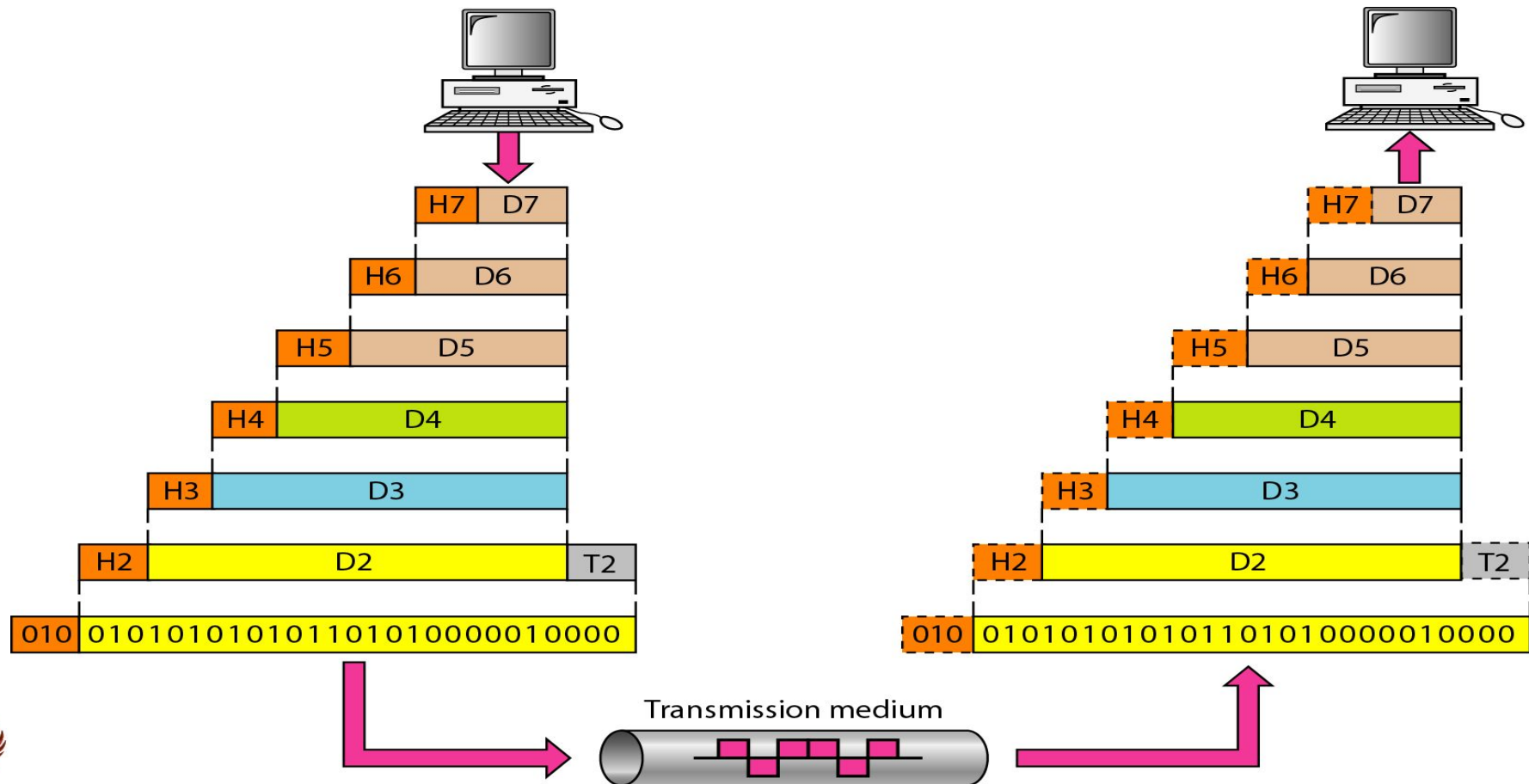
Peer-to-peer Processes (cont'd)

Figure 2.3 *The interaction between layers in the OSI model*

Figure 2.4 *An exchange using the OSI model*

☐ **The data portion of a packet at level N-1 carries the whole packet from level N. – The concept is called encapsulation.**

2.3   LAYERS IN THE OSI MODEL

In this section we briefly describe the functions of each layer in the OSI model.

Topics discussed in this section:
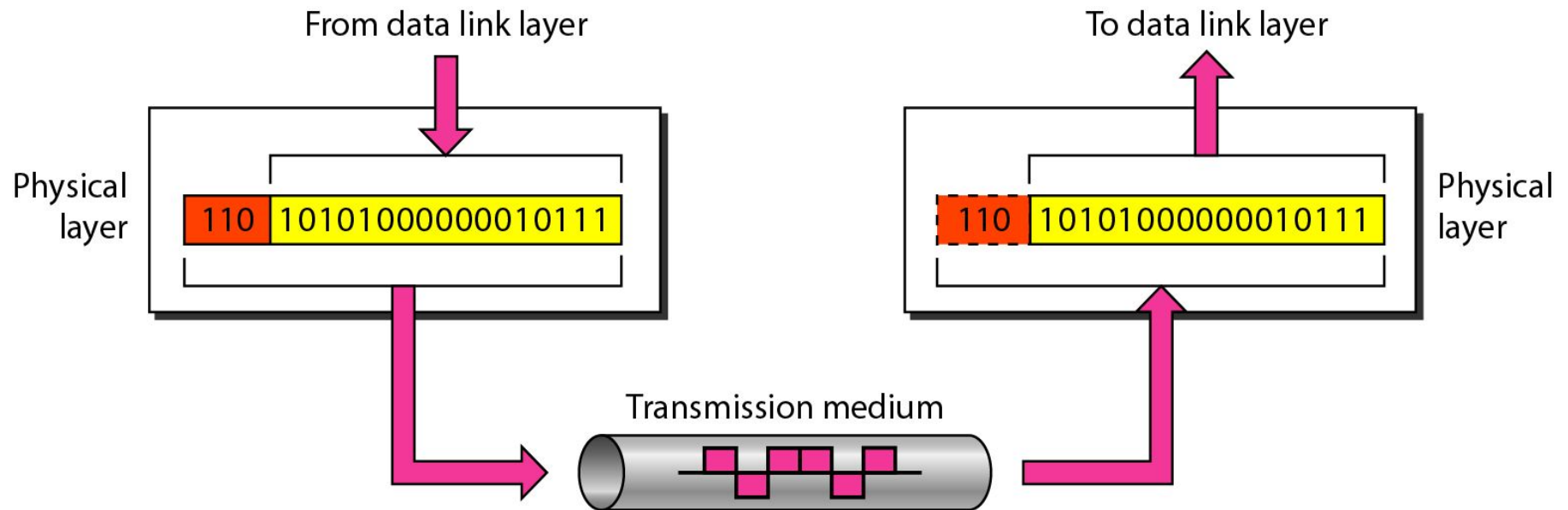
Physical Layer
Data Link Layer
Network Layer
Transport Layer
Session Layer
Presentation Layer
Application Layer

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Physical Layer

❑ **Physical layer coordinates the functions required to transmit a bit stream over a physical medium.**

From data link layer → To data link layer

Physical layer | 110 | 10101000000010111 |

Physical layer | 110 | 10101000000010111 |

Transmission medium

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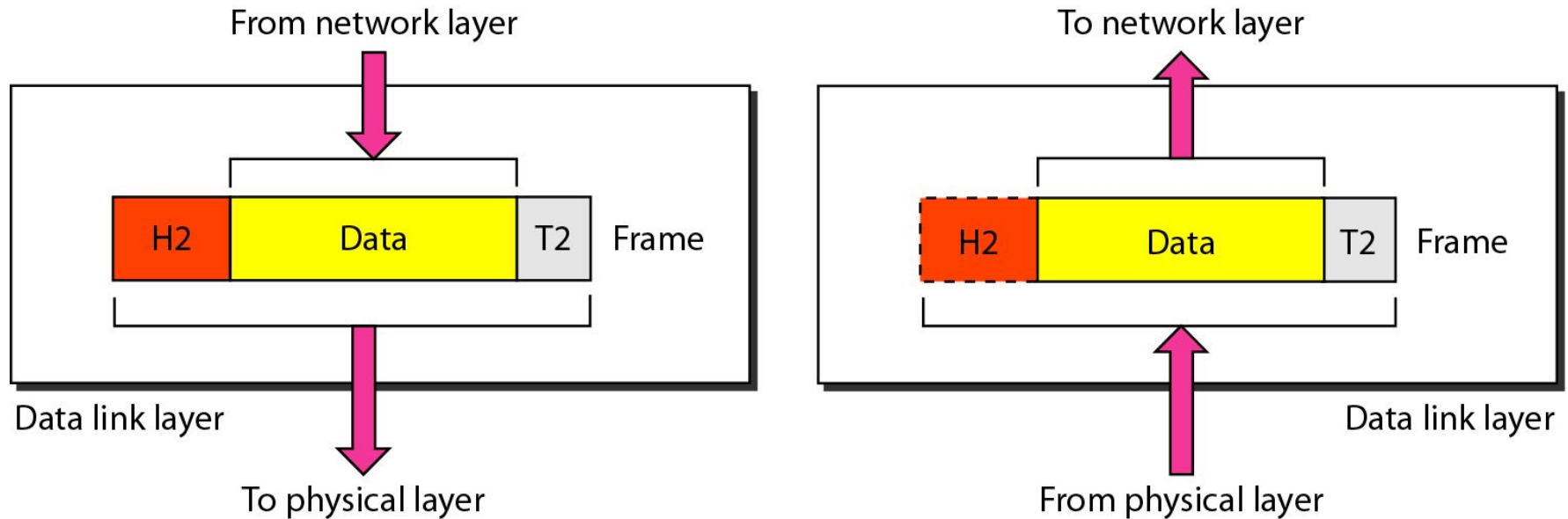
Physical Layer

❑ **Physical layer is concerned with the following:**

(deal with the mechanical and electrical specification of the primary connections: cable, connector)

- ❖ Physical characteristics of interfaces and medium
- ❖ Representation of bits
- ❖ Data rate : transmission rate
- ❖ Synchronization of bits
- ❖ Line configuration
- ❖ Physical topology
- ❖ Transmission mode

Data Link Layer

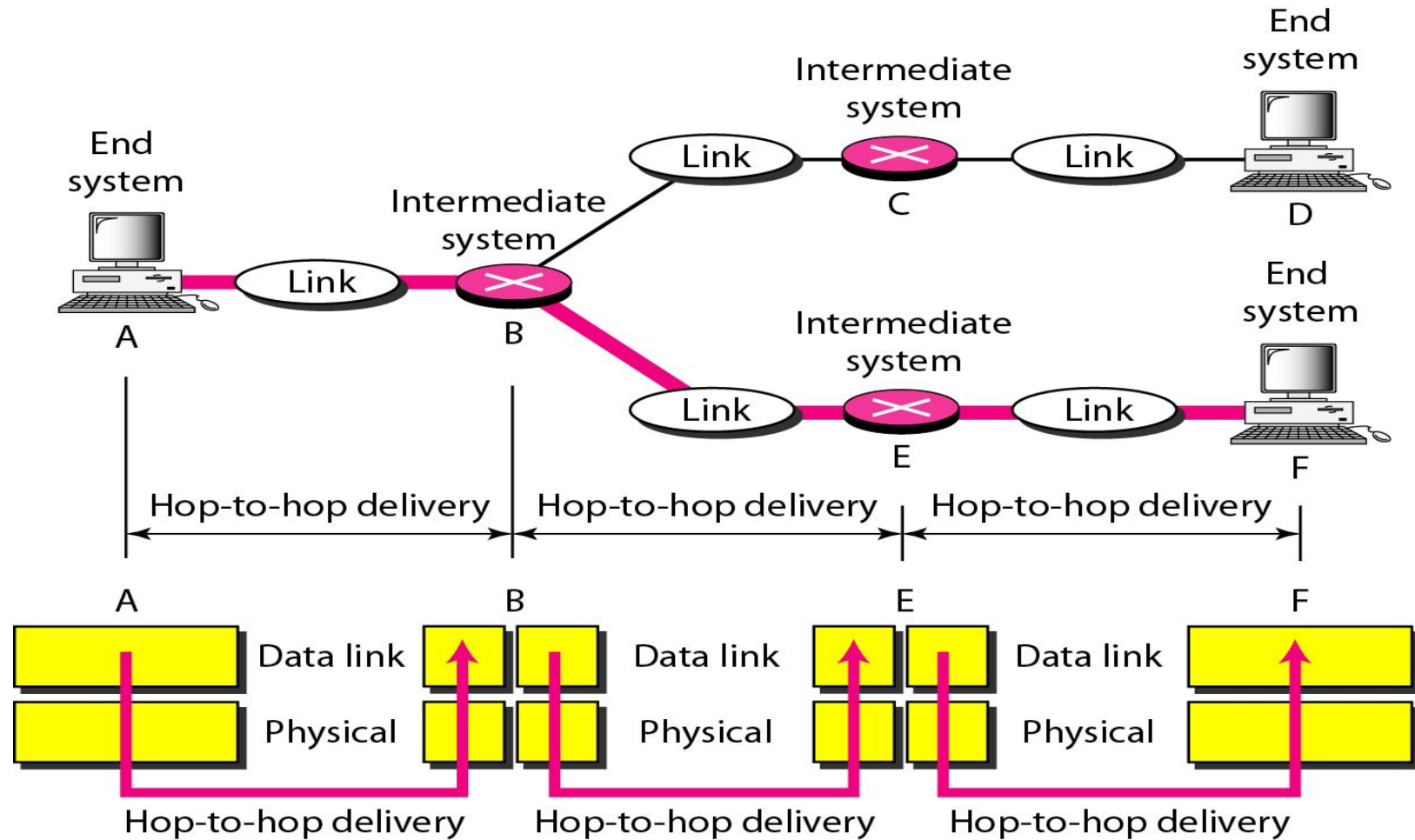❑ **The data link layer is responsible for moving frames from one hop (node) to the next.**

Data Link Layer

❑ **Major duties**

  ◆ **Framing**

  ◆ **Physical addressing**

  ◆ **Flow control**
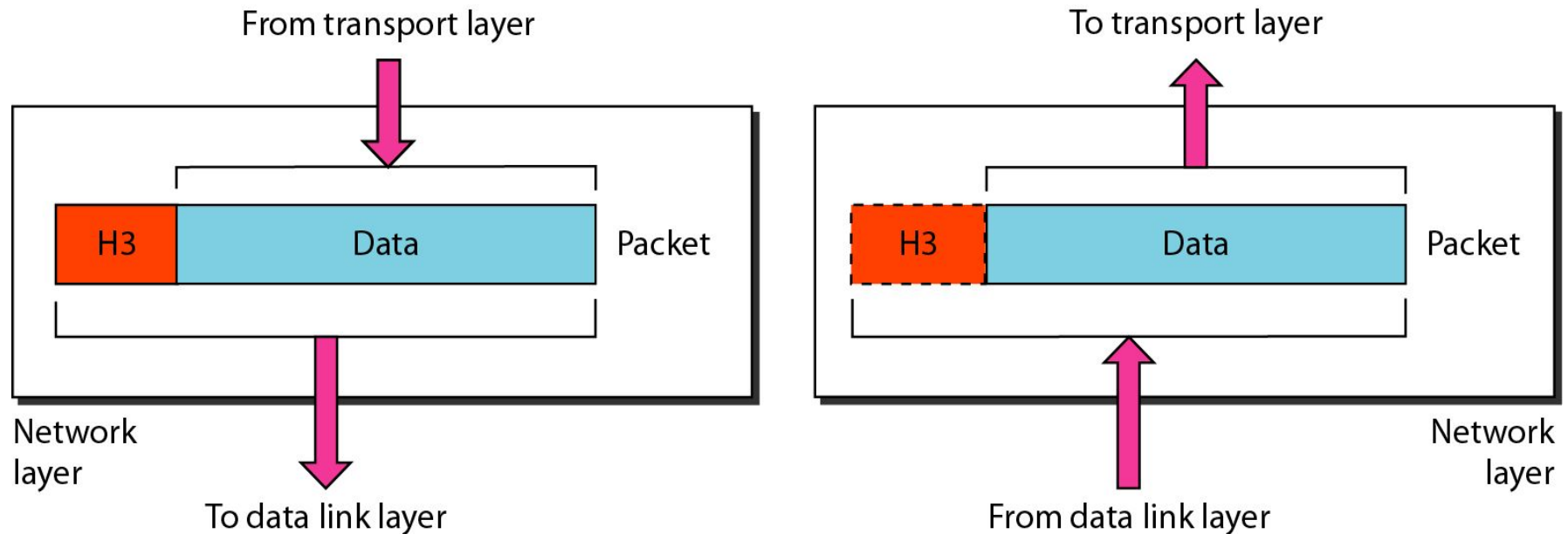
  ◆ **Error control**

  ◆ **Access control**
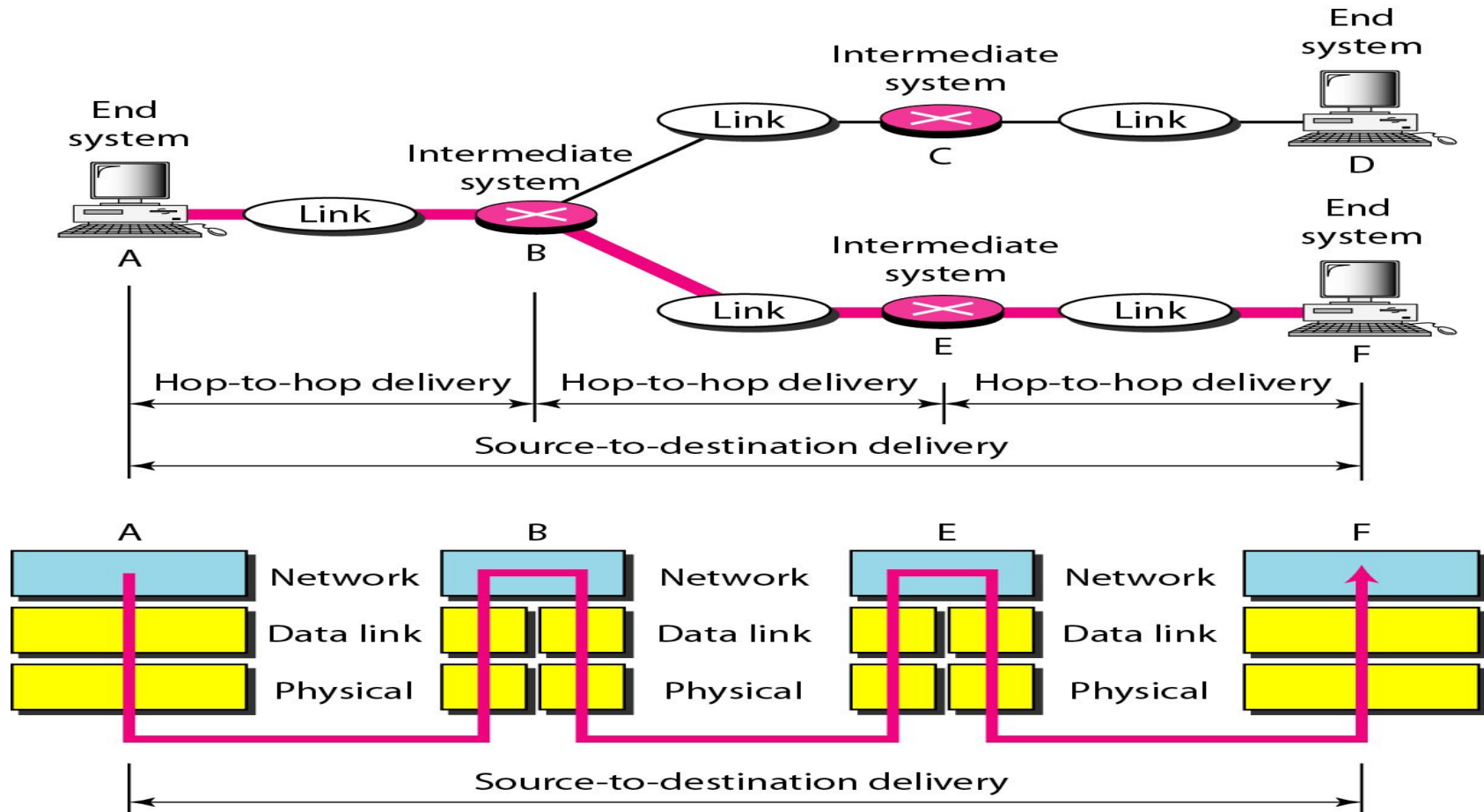
Data Link Layer

❑ **Hop-to-hop (node-to-node) delivery**

Network Layer

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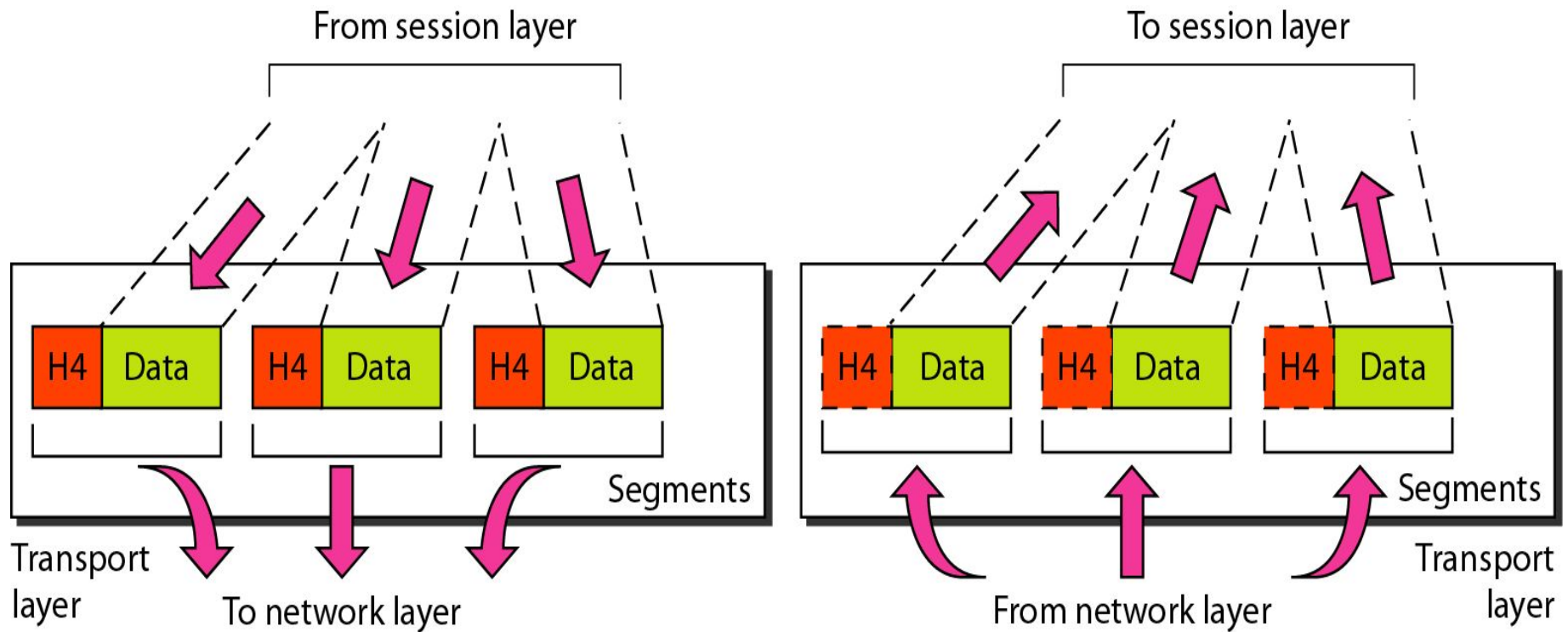

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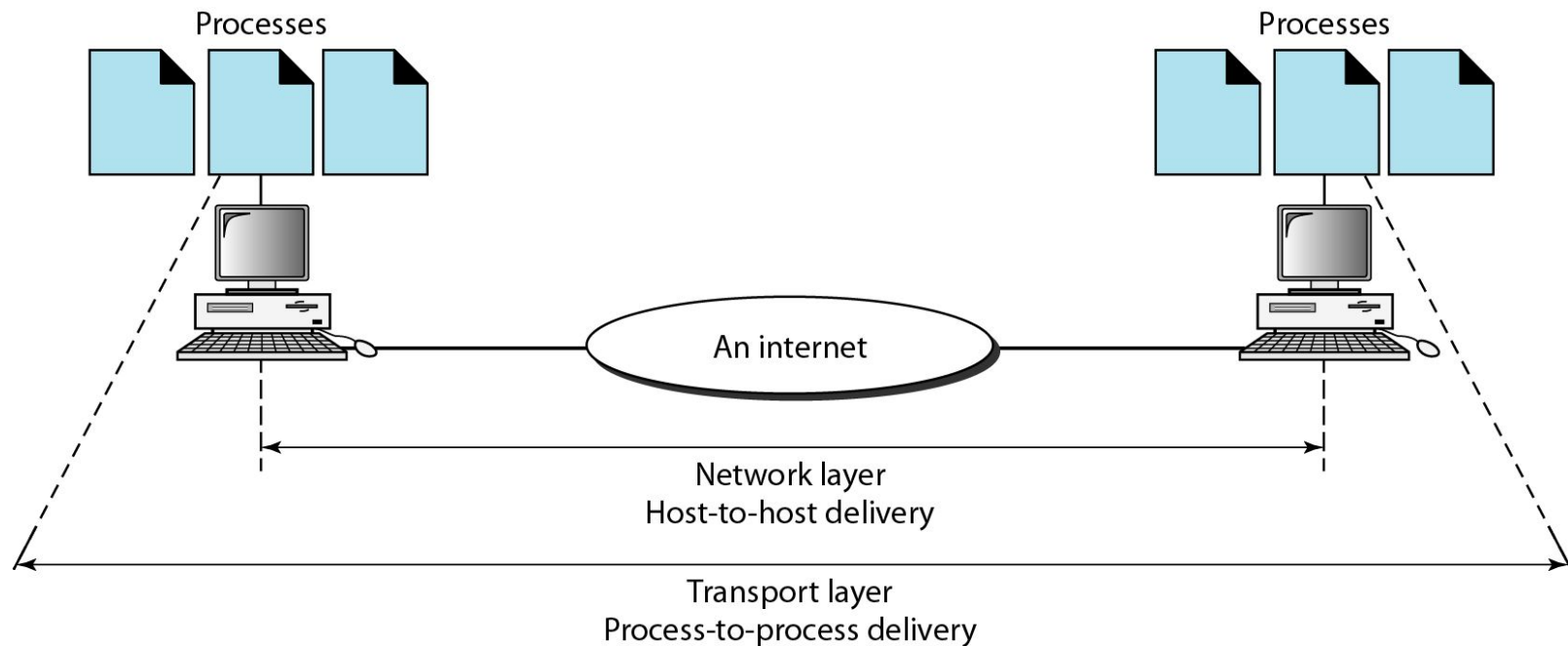# Network Layer

❑ **Logical addressing**

❑ **Routing**

Transport Layer

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

Transport Layer

**Figure 2.11** *Reliable process-to-process delivery of a message*

Processes

Processes

An internet

Network layer
Host-to-host delivery

Transport layer
Process-to-process delivery

Transport Layer

❑ **Service port addressing**

❑ **Segmentation and reassembly**

❑ **Connection control**

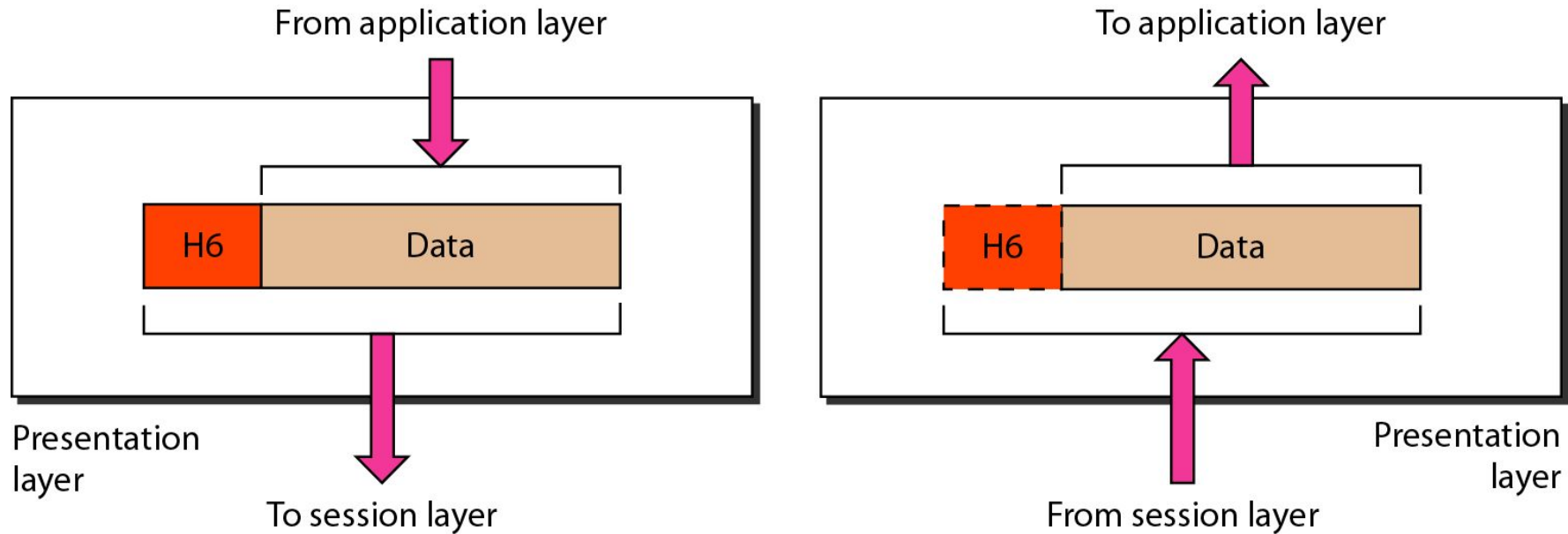❑ **Flow control**

❑ **Error control**

Session Layer

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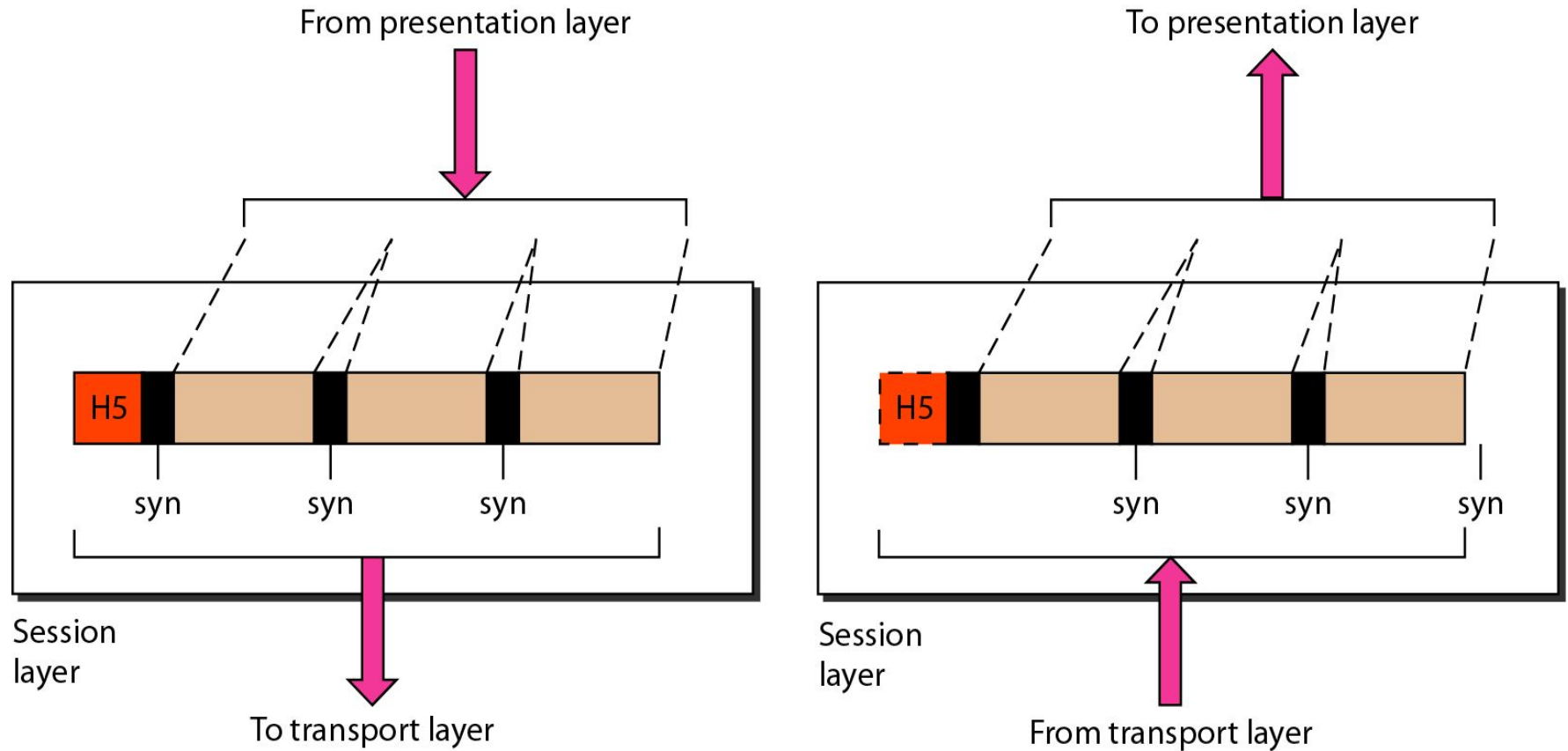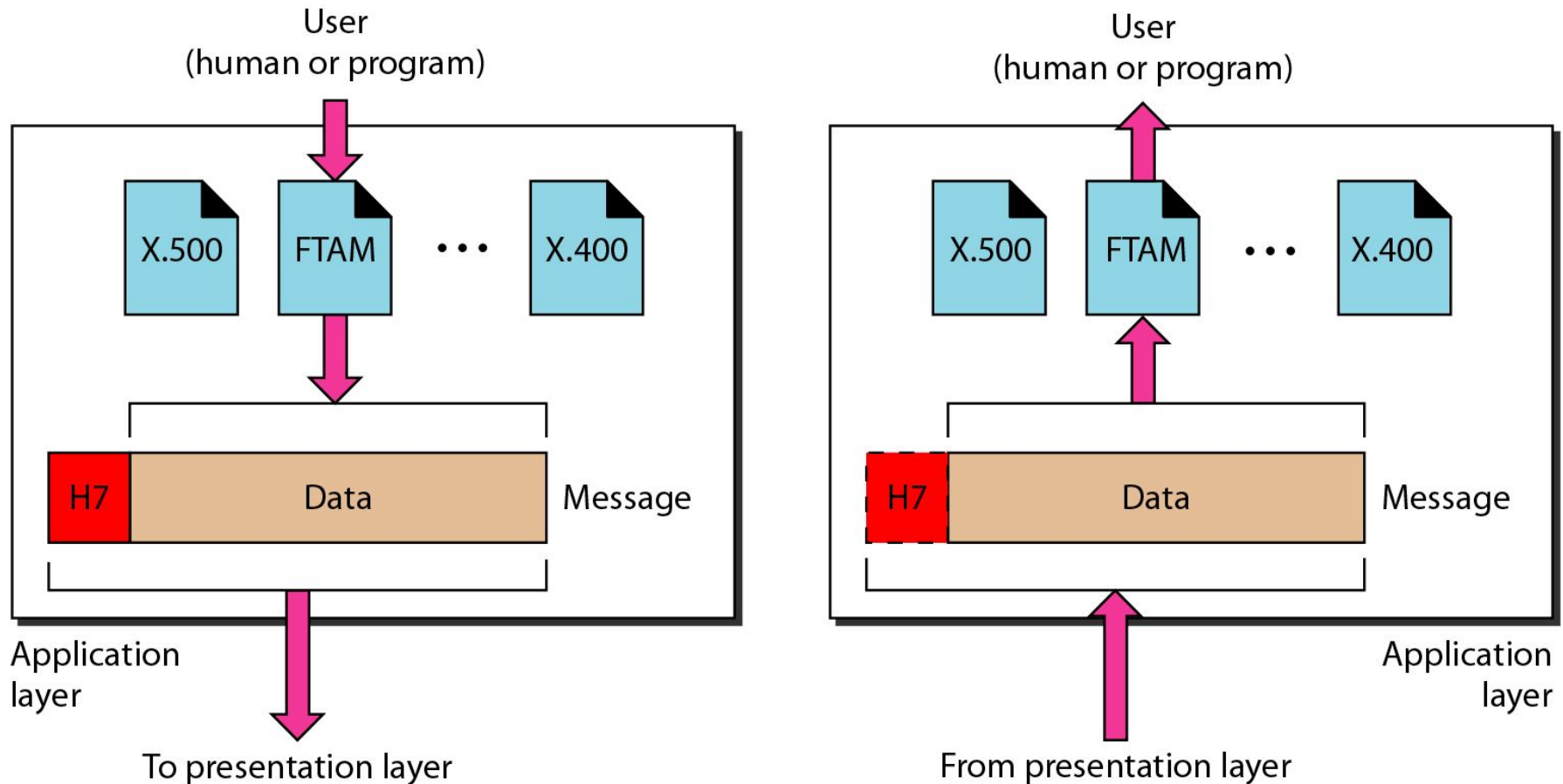
Presentation Layer

❑ **The presentation layer is responsible for translation, compression, and encryption**

Application Layer

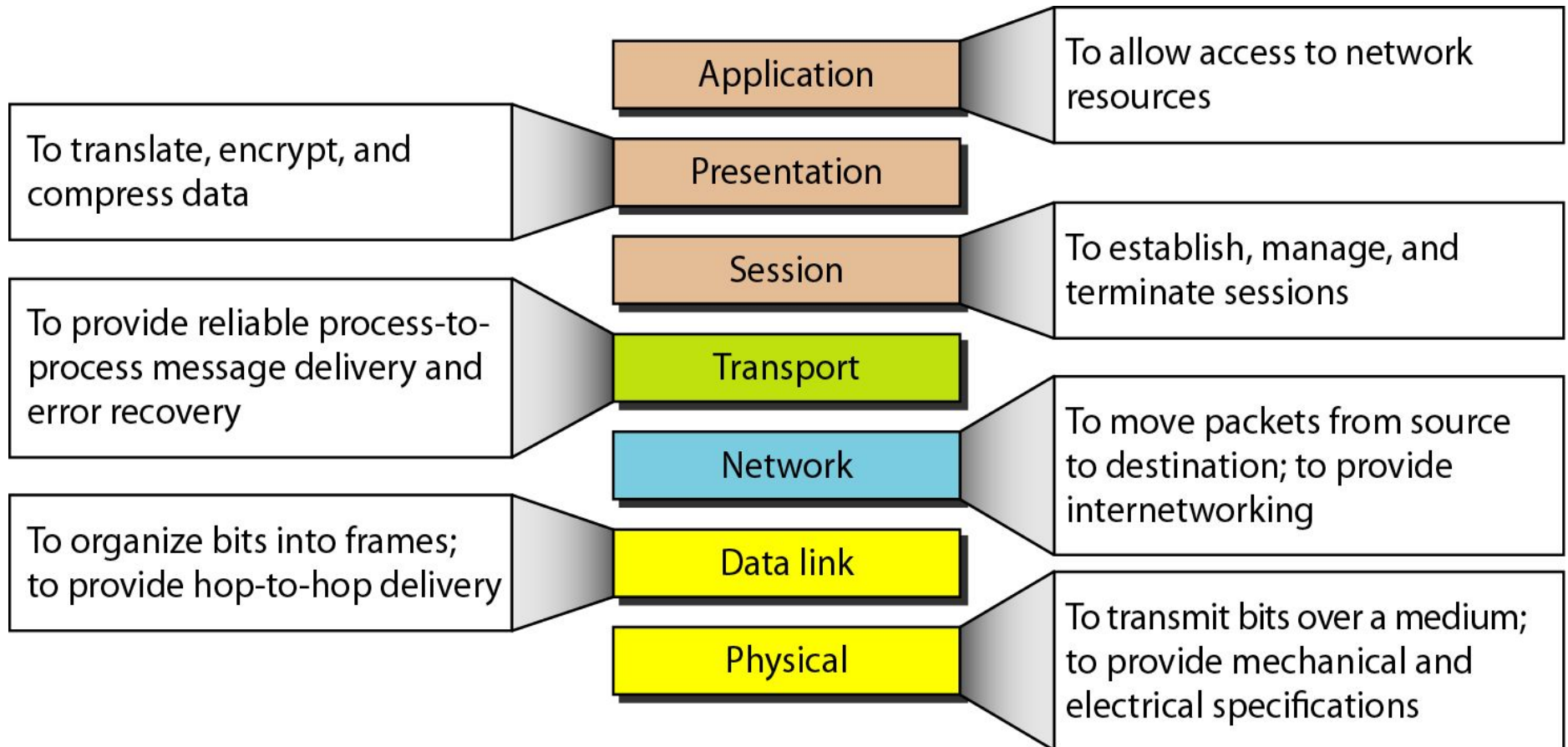❑ **The application layer is responsible for providing services to the user.**

Application Layer

❑ **The major duties of the application**

❖ **Network virtual terminal**

❖ **File transfer, access, and management**

❖ **Mail services**

❖ **Directory services**

Summary of Layers

Figure 2.15 *Summary of layers*

	Layer	
	Application	To allow access to network resources
To translate, encrypt, and compress data	Presentation	
	Session	To establish, manage, and terminate sessions
To provide reliable process-to-process message delivery and error recovery	Transport	
	Network	To move packets from source to destination; to provide internetworking
To organize bits into frames; to provide hop-to-hop delivery	Data link	
	Physical	To transmit bits over a medium; to provide mechanical and electrical specifications

2.4 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.

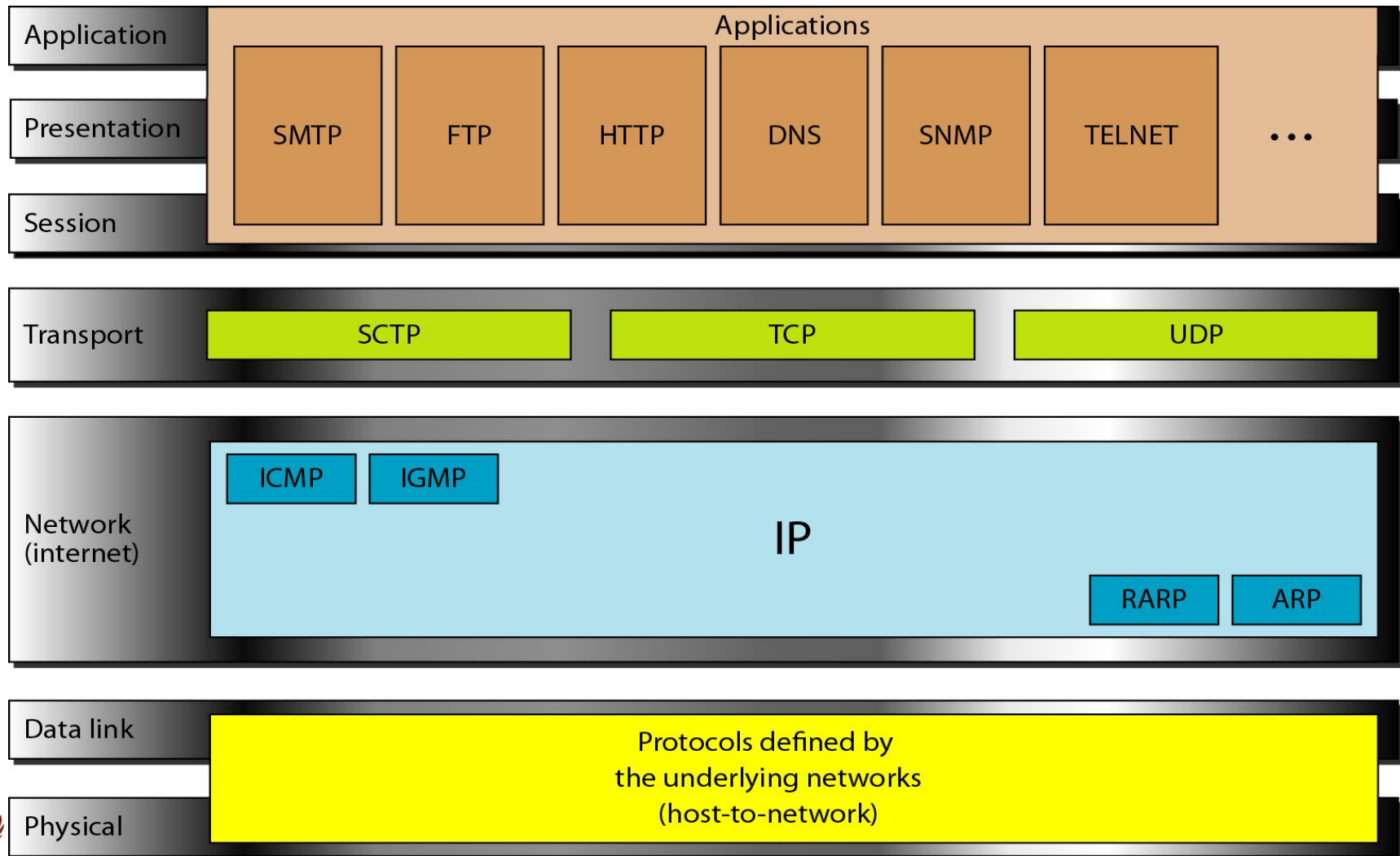*Topics discussed in this section:*

Physical and Data Link Layers
Network Layer
Transport Layer
Application Layer

TCP/IP Protocol Suite

Figure 2.16 *TCP/IP and OSI model*

	Applications						
Application	SMTP	FTP	HTTP	DNS	SNMP	TELNET	...
Presentation							
Session							

Transport	SCTP	TCP	UDP

Network (internet)	ICMP IGMP IP RARP ARP

Data link	Protocols defined by the underlying networks (host-to-network)
Physical	

Physical and Data Link Layers

❑ At the physical and data link layers, TCP/IP does not define any specific protocol.

❑ It supports all the standard and proprietary protocols.

❑ A network in a TCP/IP internetwork can be a local-area network or a wide-area network.

Network Layer

❑   **TCP/IP supports the Internetworking Protocol.**

❑   **IP uses four supporting protocols : ARP, RARP, ICMP, and IGMP.**

   ❖ **IP (Internetworking Protocol)**

   ❖ **ARP (Address Resolution Protocol)**

   ❖ **RARP (Reverse Address Resolution Protocol)**

   ❖ **ICMP (Internet Control Message Protocol)**

   ❖ **IGMP (Internet Group Message Protocol)**

Transport Layer

❑ **The transport layer was represented in TCP/IP by two protocols : TCP and UDP.**

- **IP is a host-to-host protocol**

- **TCP and UDP are transport level protocols responsible for delivery of a message from a process to another process.**

❑ **UDP (User Datagram Protocol)**

❑ **TCP (Transmission Control Protocol)**

❑ **SCTP (Stream Control Transmission Protocol)**

Application Layer

❑ The application layer in TCP/IP is equivalent to the combined session, presentation, and application layers in the OSI model.

❑ Many protocols are defined at this layer.

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

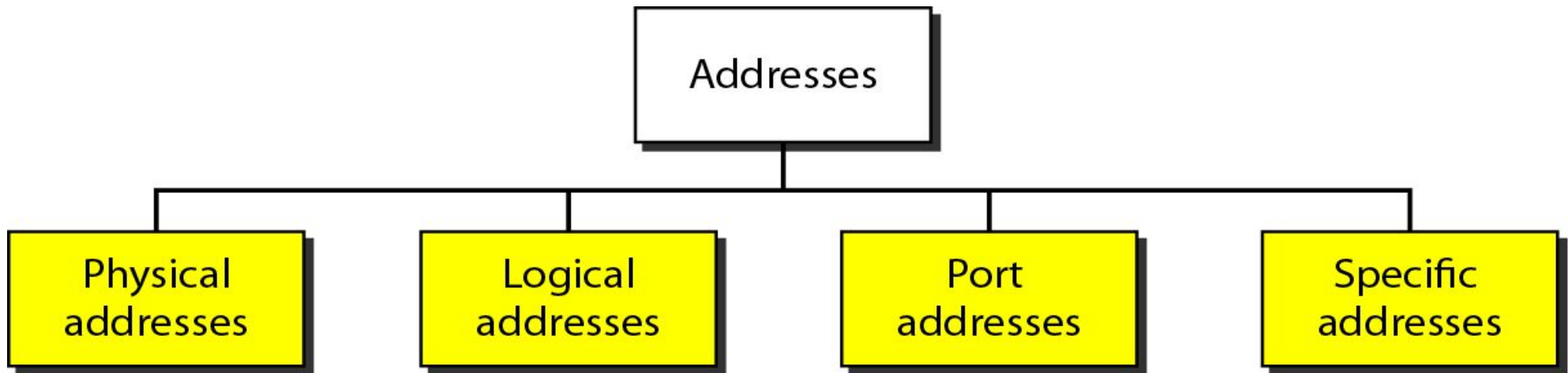**Topics discussed in this section:**

Physical Addresses
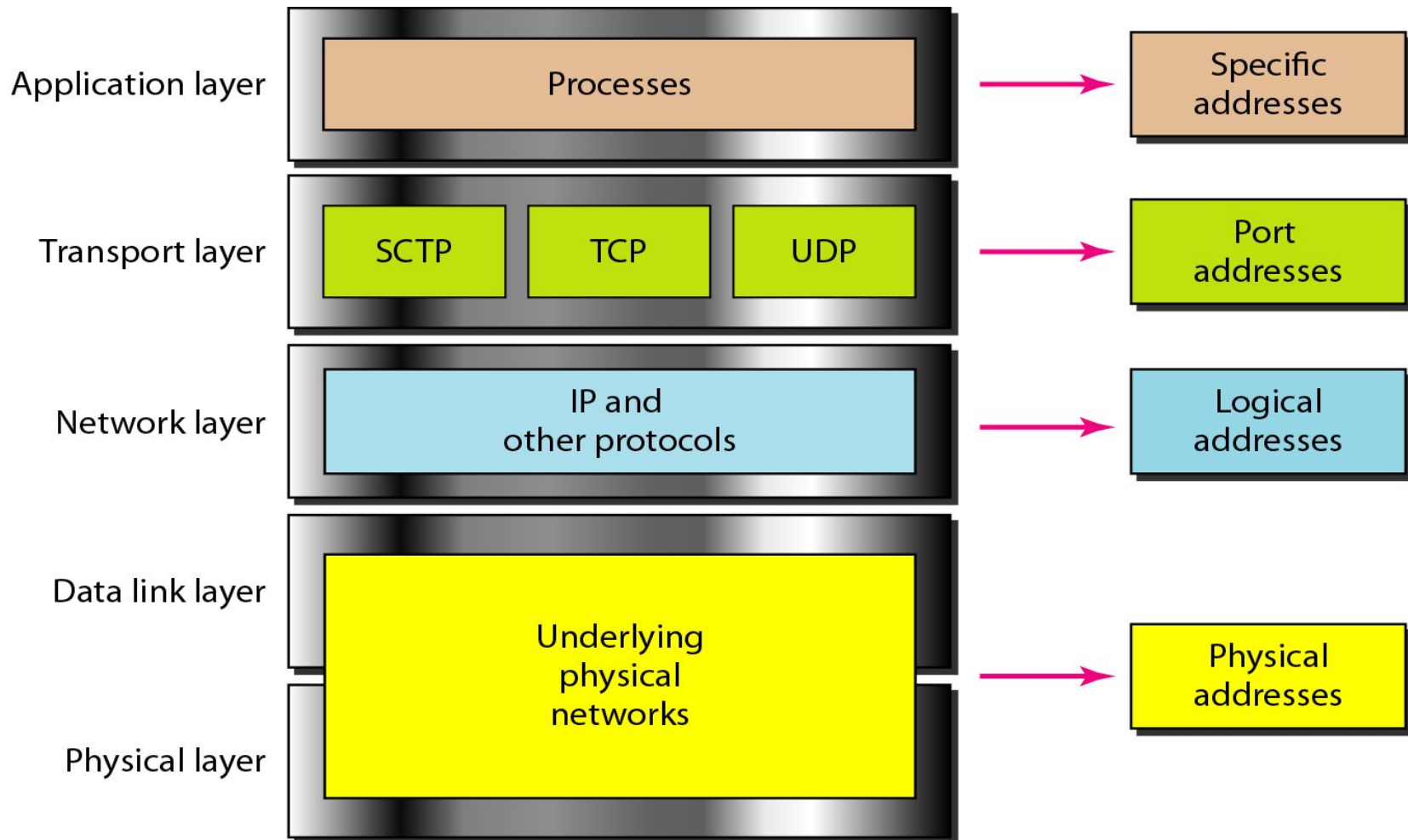**Logical Addresses**
Port Addresses
Specific Addresses

Addresses

Figure 2.17 *Addresses in TCP/IP*

Figure 2.18 *Relationship of layers and addresses in TCP/IP*

Physical Addresses

❑ **The physical address, also known as the link address, is the address of a node as defined by its LAN or WAN.**

❑ **It is included in the frame used by the data link layer.**

❖ **The physical addresses have authority over the network (LAN or WAN).**

❖ **The size and format of these addresses vary depending on the network.**

Example 2.1

In Figure 2.19 a node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link (bus topology LAN). As the figure shows, the computer with physical address 10 is the sender, and the computer with physical address 87 is the receiver.

Figure 2.19 *Physical addresses*
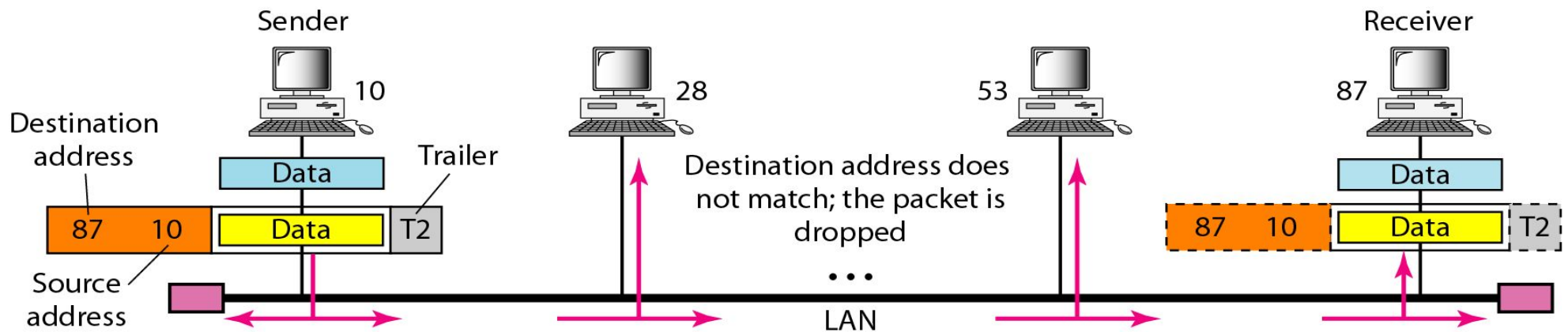
Example 2.2

As we will see in Chapter 13, most local-area networks use a **48-bit** (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:

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

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

Logical Addresses

❑ **Logical addresses are necessary for universal communications that are independent of underlying physical networks.**

❖ **Physical addresses are not adequate in an internetwork environment where different networks can have different address formats.**

❖ **A universal addressing system is needed in which host can be identified uniquely, regardless of the underlying physical network.**

Example 2.3

Figure 2.20 shows a part of an internet with two routers connecting three LANs. Each device (computer or router) has **a pair of addresses** (logical and physical) for **each connection**. In this case, each computer is connected to only one link and therefore has only one pair of addresses. Each router, however, is connected to three networks (only two are shown in the figure). So each router has three pairs of addresses, one for each connection.

Figure 2.20 *IP addresses*
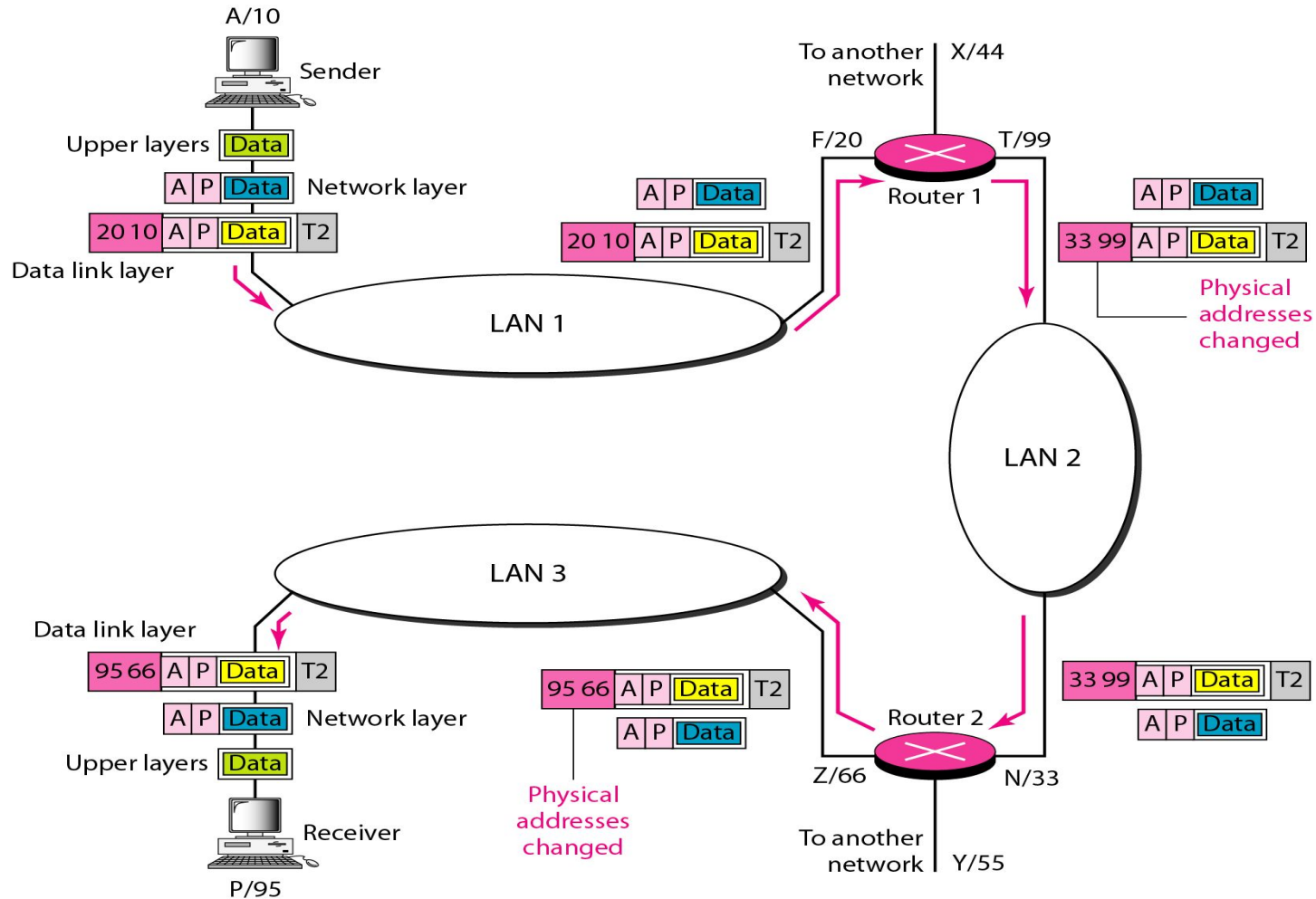
The physical addresses will change from hop to hop,
but the logical addresses usually remain the same.

Port Addresses

❑ The IP and the physical address are necessary for a quantity of data to travel from a source to the destination host.

❑ The end object of Internet communication is a process communicating with another process.

❑ For these processes to receive data simultaneously, we need a method to label assigned to a process is called a port address.

❑ A port address in TCP/IP is 16 bits in length.

Example 2.4

Figure 2.21 shows two computers communicating via the Internet. The sending computer is running three processes at this time with port addresses a, b, and c. The receiving computer is running two processes at this time with port addresses j and k. Process a in the sending computer needs to communicate with process j in the receiving computer. Note that although physical addresses change from hop to hop, logical and port addresses remain the same from the source to destination.

Figure 2.21 *Port addresses*
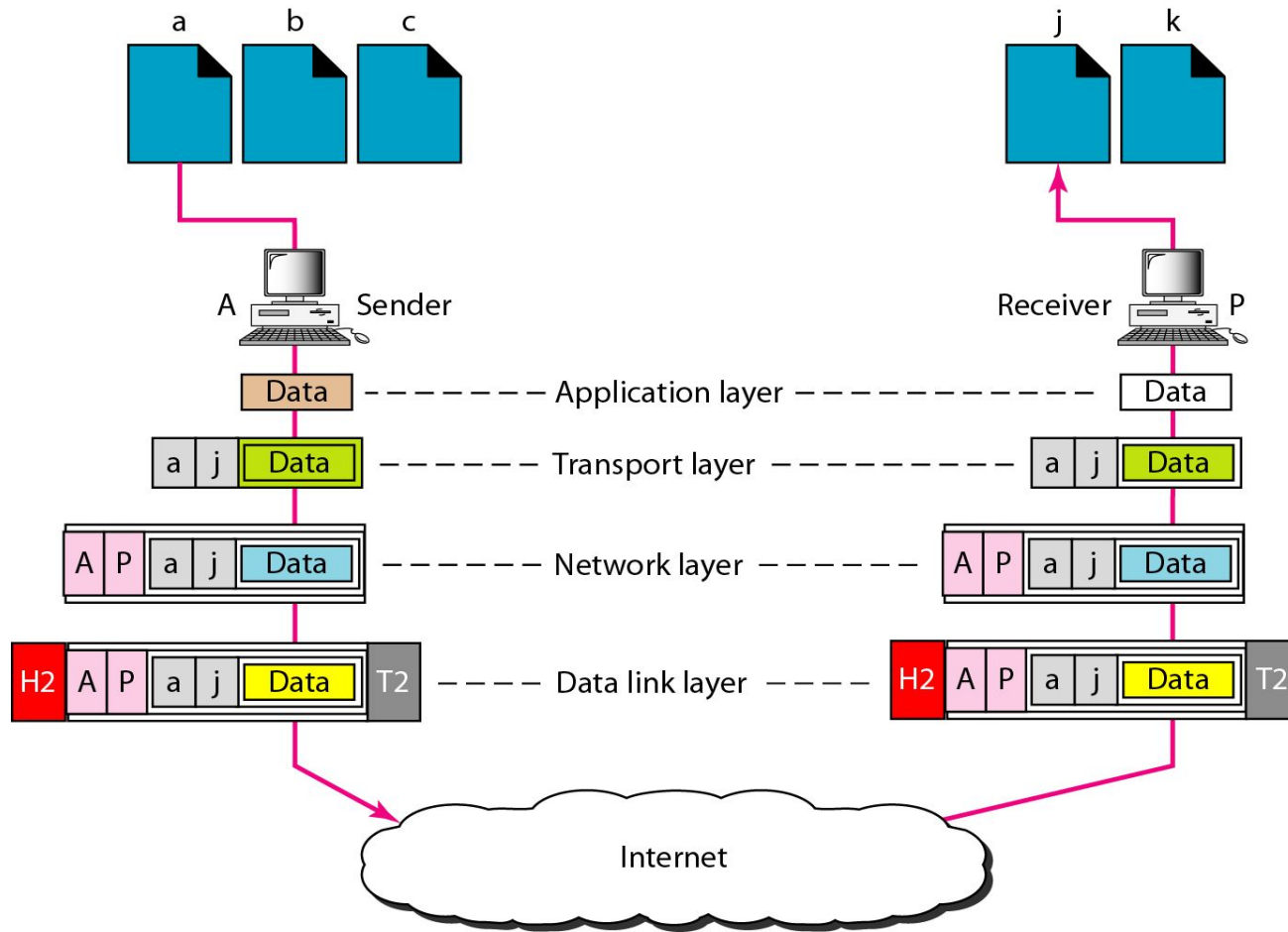
The physical addresses will change from hop to hop, but the logical and port addresses usually remain the same.

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Example 2.5

As we will see in Chapter 23, a port address is a 16-bit address represented by one decimal number as shown.

753
A 16-bit port address represented
as one single number.

Specific Addresses

❑ **Some applications have user-friendly addresses that are designed for that specific address.**

❖ **E-mail address**

❖ **URL (Universal Resource Locator)**

Summary (1)

- The International Standards Organization (ISO) created a model called the Open Systems Interconnection, which allows diverse systems to communicate.

- The seven-layer OSI model provides guidelines for the development of universally compatible networking protocols.

- The physical, data link, and network layers are the network support layers.

- The session, presentation, and application layers are the user support layers.

- The transport layer links the network support layers and the user support layers.

- The physical layer coordinates the functions required to transmit a bit stream over a physical medium.

- The data link layer is responsible for delivering data units from one station to the next without errors.

Summary (2)

❑ **The network layer is responsible for the source-to-destination delivery** of a packet across multiple network links.

❑ **The transport layer** is responsible for the **process-to-process delivery** of the entire message.

❑ The session layer establishes, maintains, and synchronizes the interactions between communicating devices.

❑ The presentation layer ensures interoperability between communicating devices through transformation of data into a mutually agreed upon format.

❑ The application layer enables the users to access the network.

❑ TCP/IP is a five-layer hierarchical protocol suite developed before the OSI model.

❑ The TCP/IP application layer is equivalent to the combined session, presentation, and application layers of the OSI model.

Summary (3)

❑ **Four levels of addresses** are used in an internet following the TCP/IP protocols: **physical (link)** addresses, **logical (IP)** addresses, **port addresses**, and **specific addresses**.

❑ **The physical address, also known as the link address, is the address of a node as defined by its LAN or WAN.**

❑ **The IP address uniquely defines a host on the Internet.**

❑ **The port address identifies a process on a host.**

❑ **A specific address is a user-friendly address.**

Q & A