Chapter 2

Network Models

Network Models

- A Network is a combination of hardware and software that sends data from one location to another.

- Hardware consists of the physical equipment that carriers signal from one point of the network to another.

- Software consists of instruction sets to make possible the services that are expected from the network.

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.
- Hierarchy of Tasks:
  - Sender
  - Carrier
  - Receiver

Layered Tasks (Conti…)

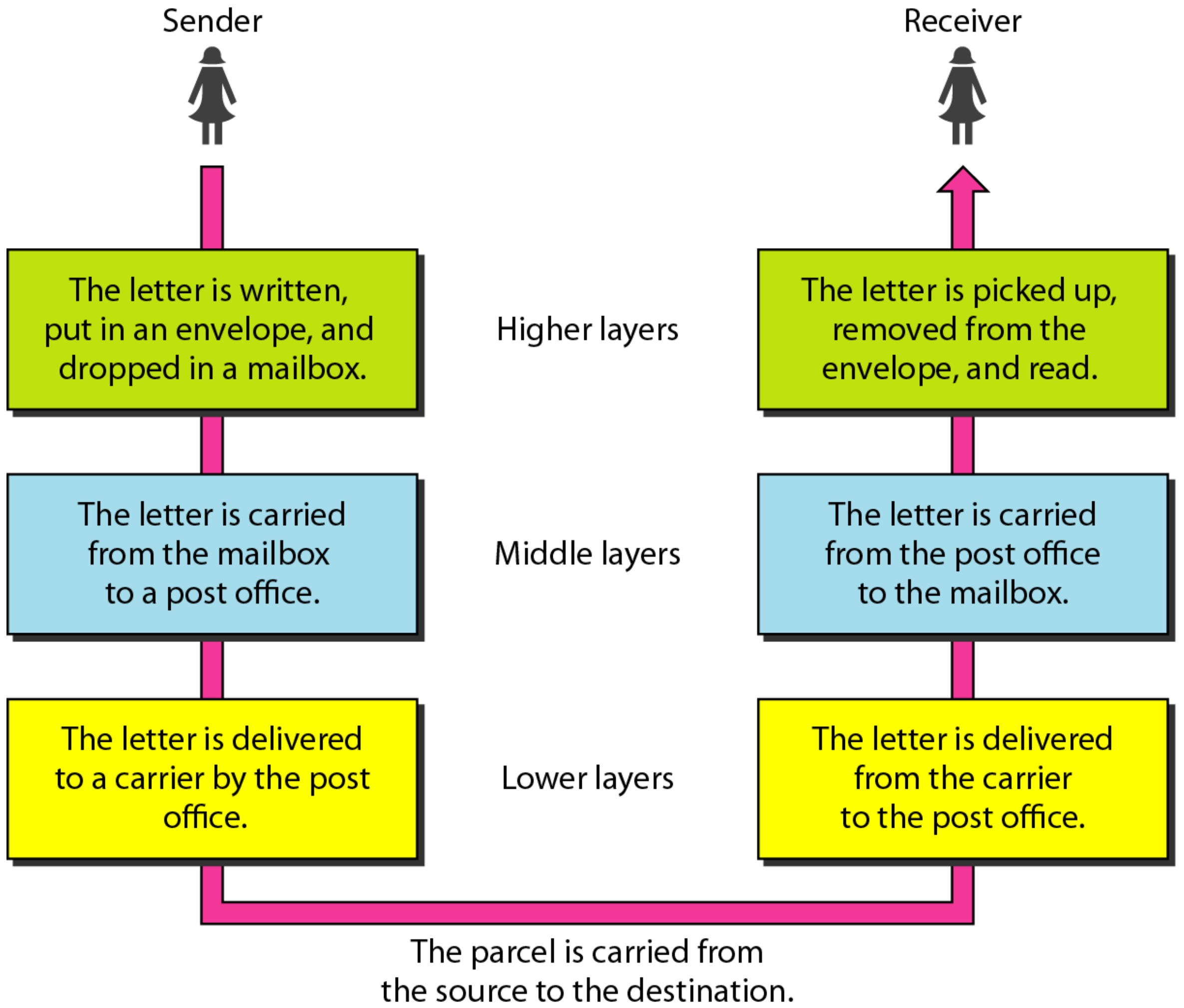


Figure 2.1 Tasks involved in sending a letter

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.
- OSI model is a layered framework to design network systems
- It allows communication between all types of communicating devices

Note

ISO is the organization.
OSI is the model.

The OSI Model (Conti…)

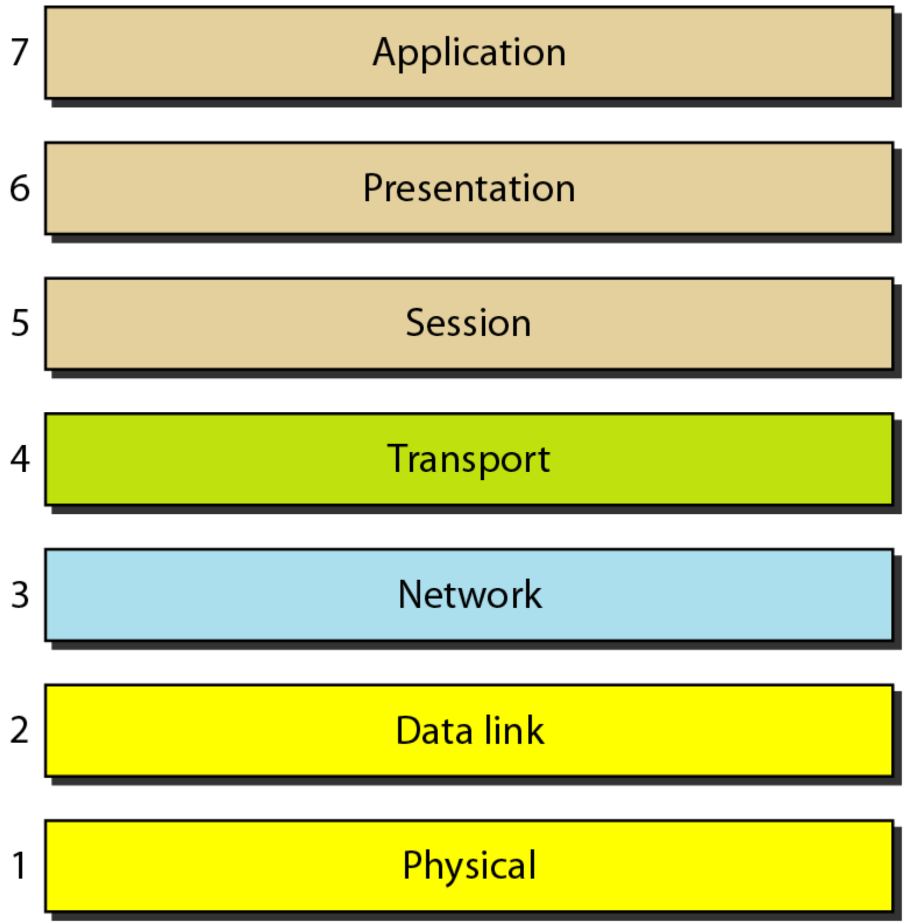


Figure 2.2 *Seven layers of the OSI model*

The OSI Model – Layered Architecture

- OSI Model is consists of seven separate but related layers.
- Each layer defines a part of process of moving information across the network.
- As a message travels from A to B, it may pass through many intermediate nodes (as shown in Figure 2.3).
- The intermediate nodes usually involve only the first three layer of the OSI Model.
- Each layer provides and uses services of the layers above and below it.
    - For Example: Layer 3 uses services provided by Layer 2 and provides services for Layer 4.

The OSI Model – Layered Architecture (Conti…)

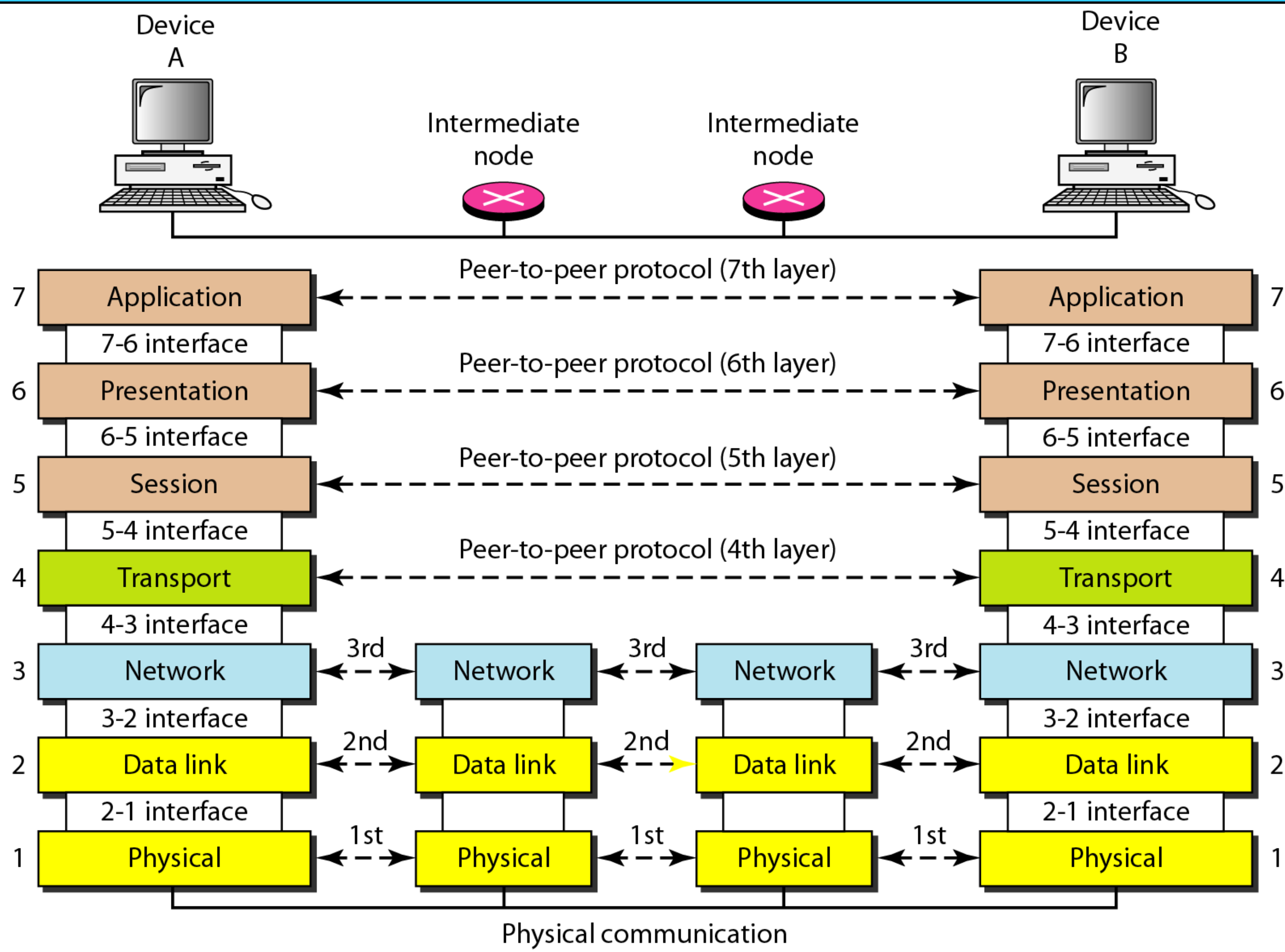


Figure 2.3 *The interaction between layers in the OSI model*

The OSI Model – Peer-to-Peer Processes

- Between two machines, layer x of one machine communicate with layer x of another machine.
- This communication is governed by some agreed-upon rules and processes called protocols.
- The processes on each machine that communicate at a given layer are called peer-to-peer processes.
- Communication must move down through the layers on sender side, and then back up through the layers on the receiver side.
- 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 packet to the layer below it.

The OSI Model – Peer-to-Peer Processes (Conti.

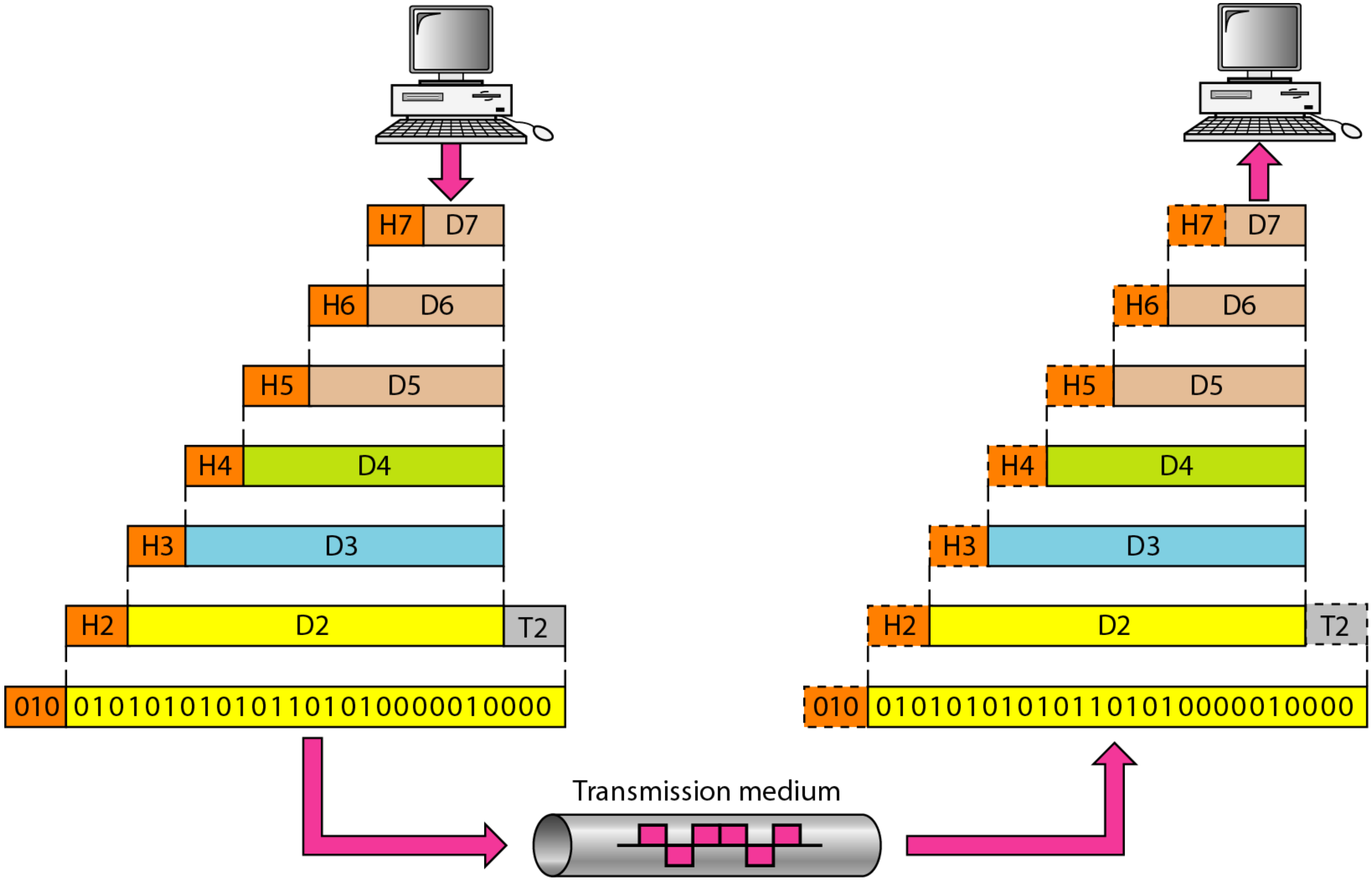


Figure 2.4 *An exchange using the OSI model*

The OSI Model – Interfaces Between Layers

- The passing of data down the layers and back up the layers is made possible by an interface between each pair of adjacent layers
- Each interface defines the information and services a layer must provide for the layer above it.
- Well-defined interfaces and layer functions provide modularity to a network.

The OSI Model – Organization of Layers

- Seven layers can be thought of as belonging to three sub-groups:
- Layers 1, 2, and 3 (Physical, Data Link, and Network) are network support layers
- Layers 5, 6, and 7 (Session, Presentation and Application) can thought as user support layers
- Layer 4 (Transport Layer), links the two sub-groups and ensures that what the lower layers have transmitted is in a form that the upper layers can use.

Layers of OSI Model

- As discussed, the OSI model consists of the following seven layers:
- Physical Layer
- Data Link Layer
- Network Layer
- Transport Layer
- Session Layer
- Presentation Layer
- Application Layer

Layers of OSI Model – Physical Layer

- The Physical Layer is responsible for movement of individual bits from one hop (node) to the next.
- Physical Characteristics of Interfaces and Medium
- Representation of Bits
- Data Rate
- Synchronization of Bits
- Line Configuration
- Physical Topology
- Transmission Mode

Layers of OSI Model – Physical Layer (Conti…)

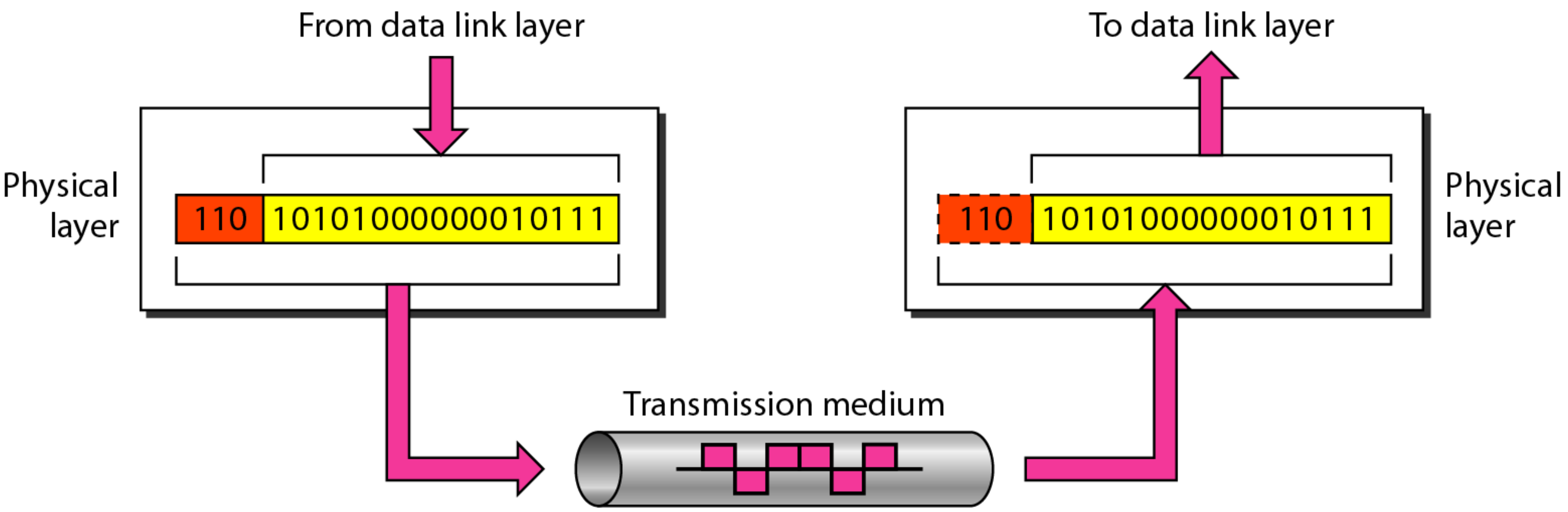


Figure 2.5 *Physical layer*

Layers of OSI Model – Data Link Layer

- The Data Link Layer is responsible for moving frames from one hop (node) to the next.
- It transforms the raw transmission of the physical layer to a reliable link.
- It makes the physical layer appear error-free to the network layer.
- Framing
- Physical Addressing
- Flow Control
- Error Control
- Access Control

Layers of OSI Model – Data Link Layer (Conti…)

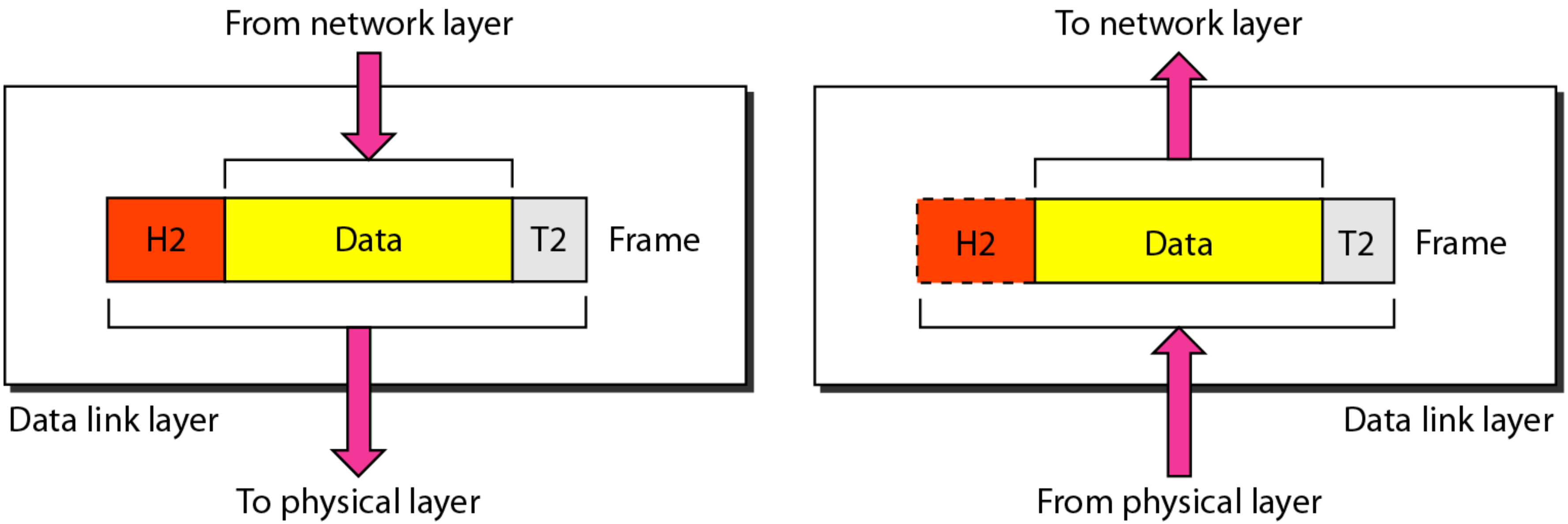


Figure 2.6 *Data link layer*

Layers of OSI Model – Data Link Layer (Conti…)

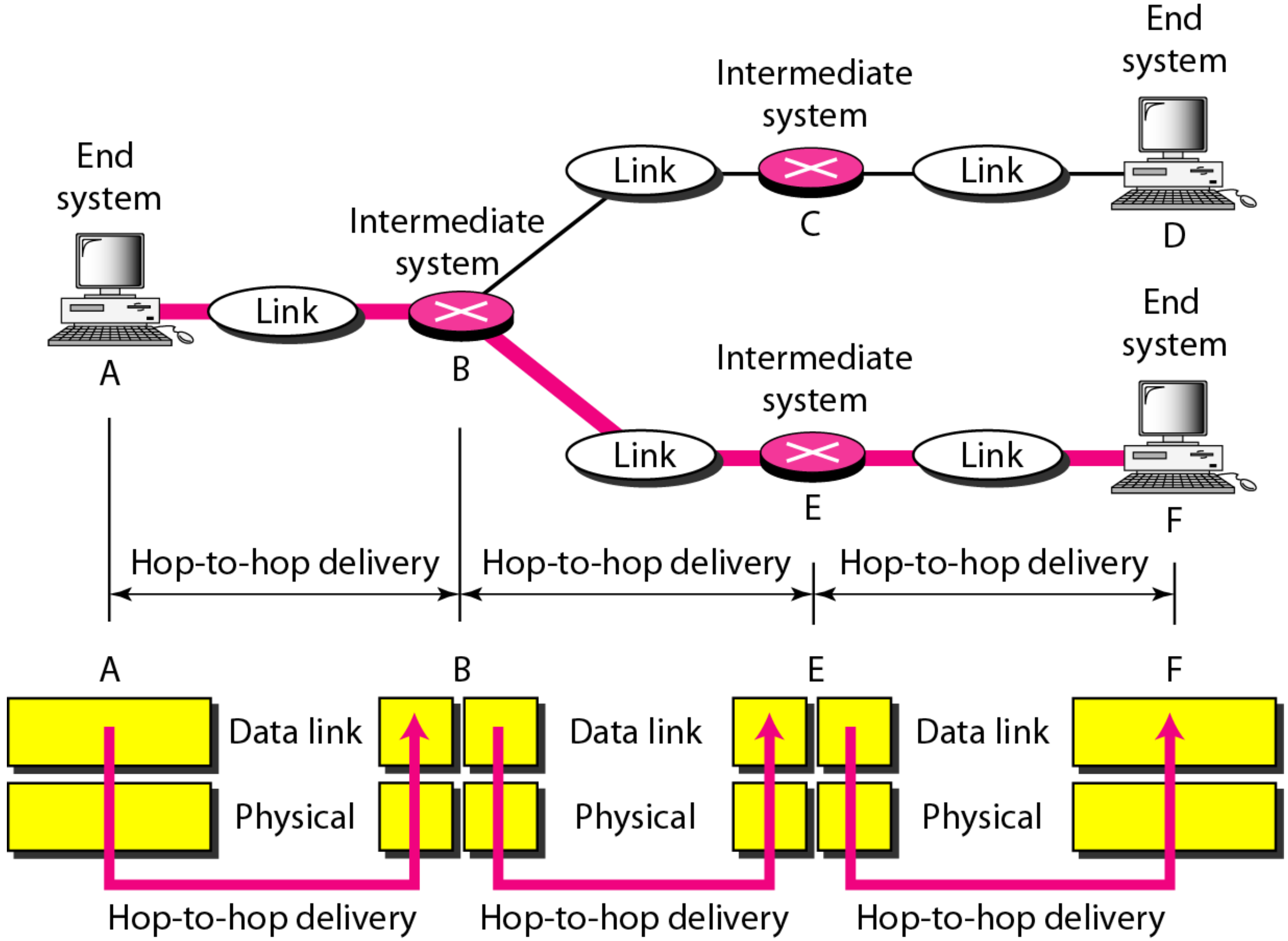


Figure 2.7 *Hop-to-hop delivery*

Layers of OSI Model – Network Layer

- The Network Layer is responsible for the delivery of packets from source to destination i.e. it is responsible for source-to-destination delivery of a packet.
- Data link layer oversees the delivery of frames between two systems on the same network
- Network layer ensures that each packets gets from its point of origin to its final destination.
- Logical Addressing
- Routing

Layers of OSI Model – Network Layer (Conti…)

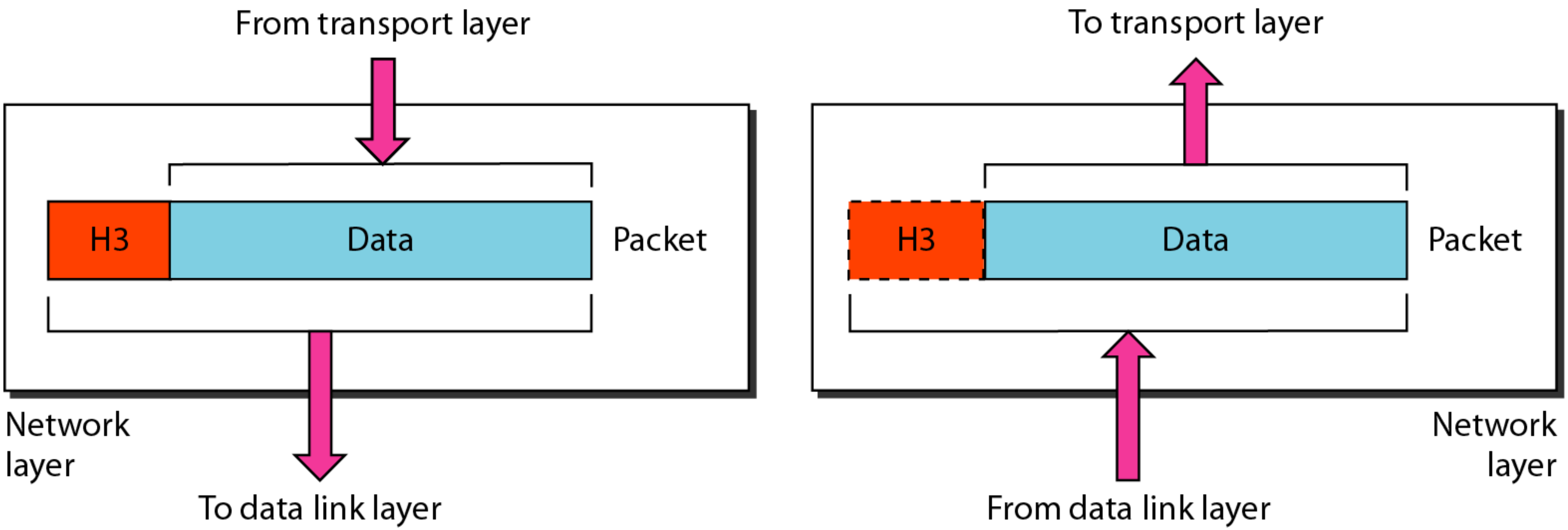


Figure 2.8 *Network layer*

Layers of OSI Model – Network Layer (Conti…)

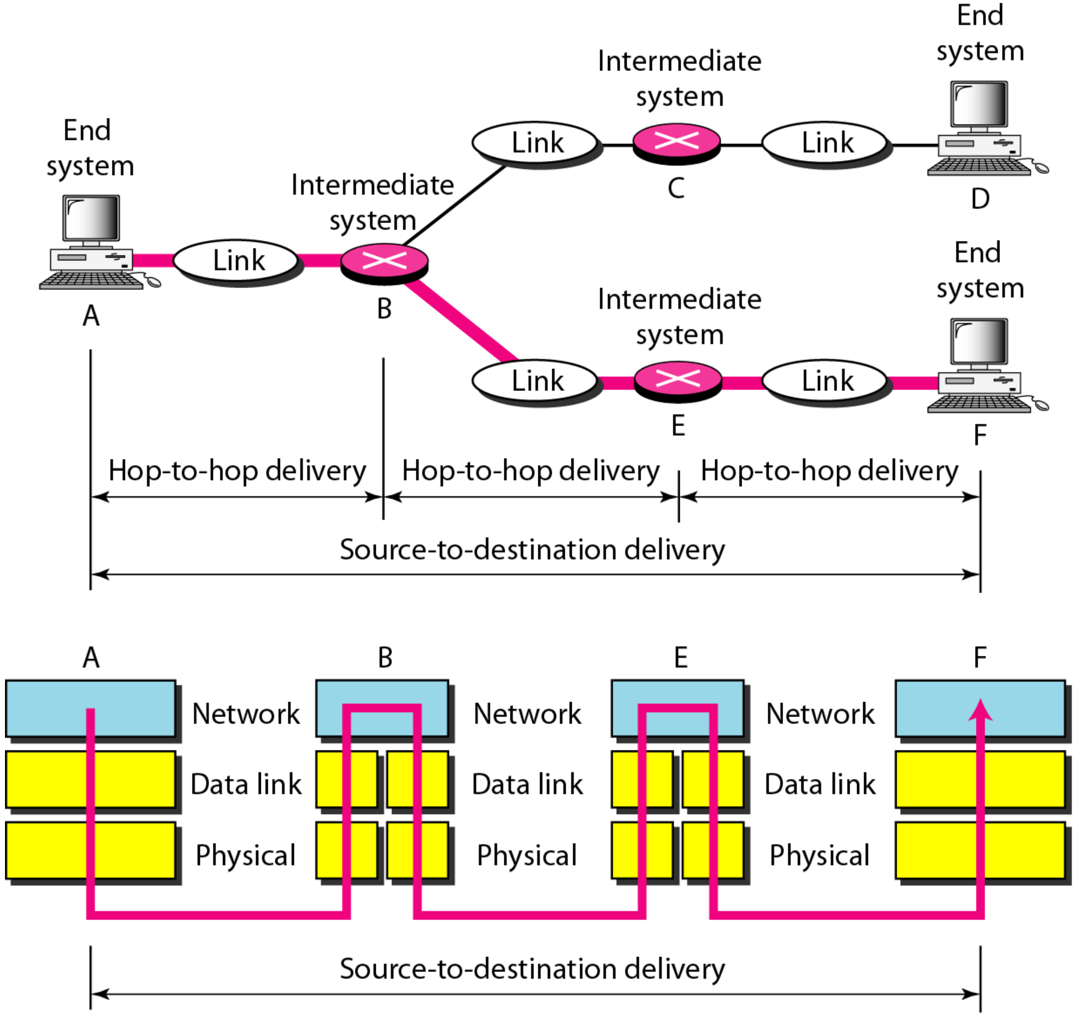


Figure 2.9 *Source-to-destination delivery*

Layers of OSI Model – Transport Layer

- The Transport Layer is responsible for the delivery of a message from one process to another.
- Service-point Addressing
- Segmentation and Reassembly
- Connection Control
- Flow Control
- Error Control

Layers of OSI Model – Transport Layer (Conti…)

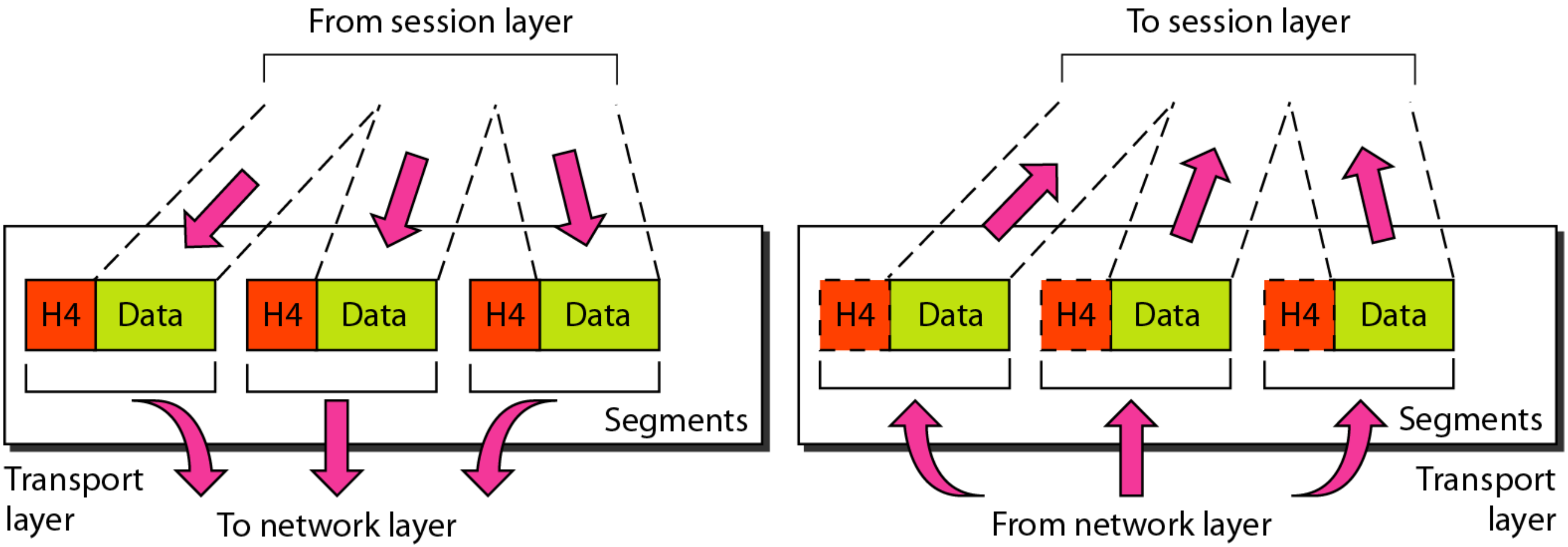


Figure 2.10 *Transport layer*

Layers of OSI Model – Transport Layer (Conti…)

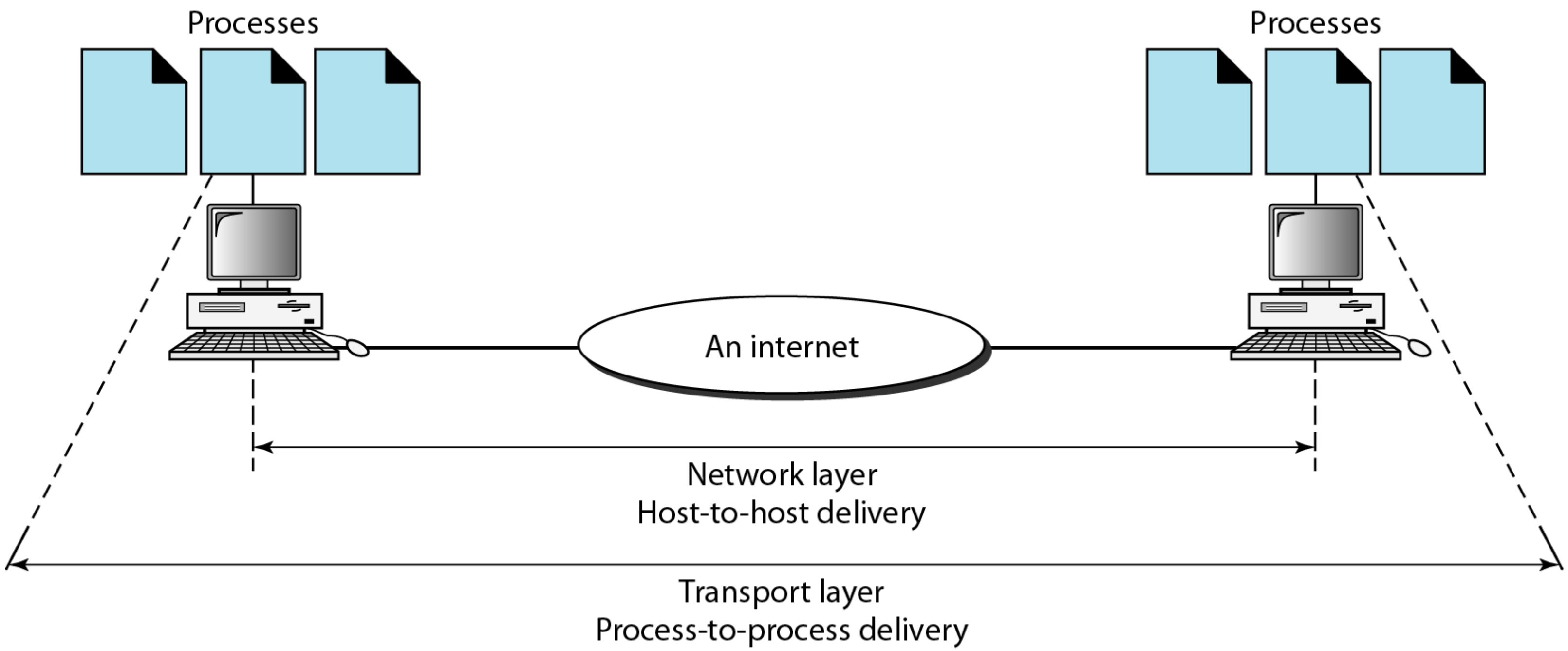


Figure 2.11 *Reliable process-to-process delivery of a message*

Layers of OSI Model – Session Layer

- The Session Layer is responsible for dialog control and synchronization.
- It is the dialog controller of the network.
- It establishes, maintains, and synchronizes the interaction among the communicating systems

Layers of OSI Model – Session Layer (Conti…)

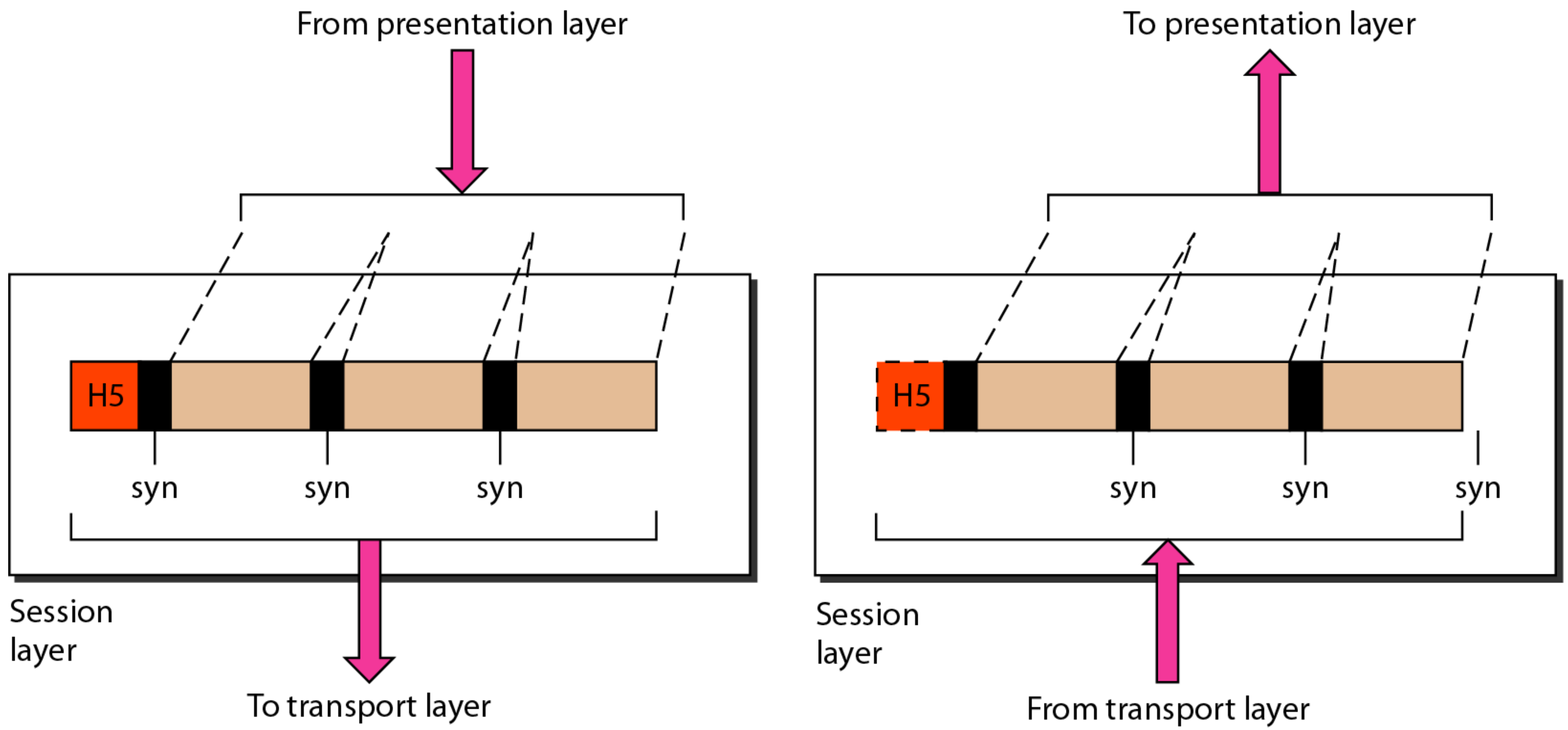


Figure 2.12 *Session layer*

Layers of OSI Model – Presentation Layer

- The Presentation Layer is responsible for translation, compression, and encryption.
- It is concerned with the syntax and semantics of the information exchanged between two systems

Layers of OSI Model – Presentation Layer (Conti…

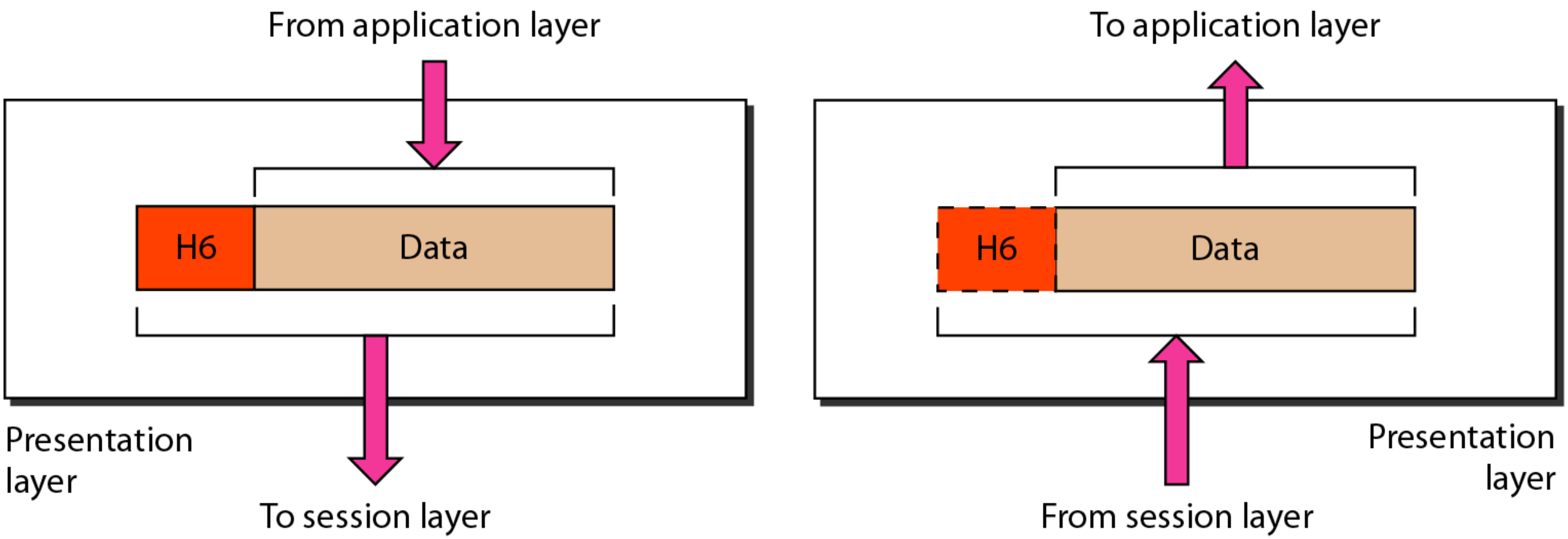


Figure 2.13 *Presentation layer*

Layers of OSI Model – Application Layer

- The Application Layer is responsible for services to the user.
- Network Virtual Terminal
- File Transfer, Access, and Management
- Mail Services
- Directory Services

Layers of OSI Model – Application Layer (Conti…

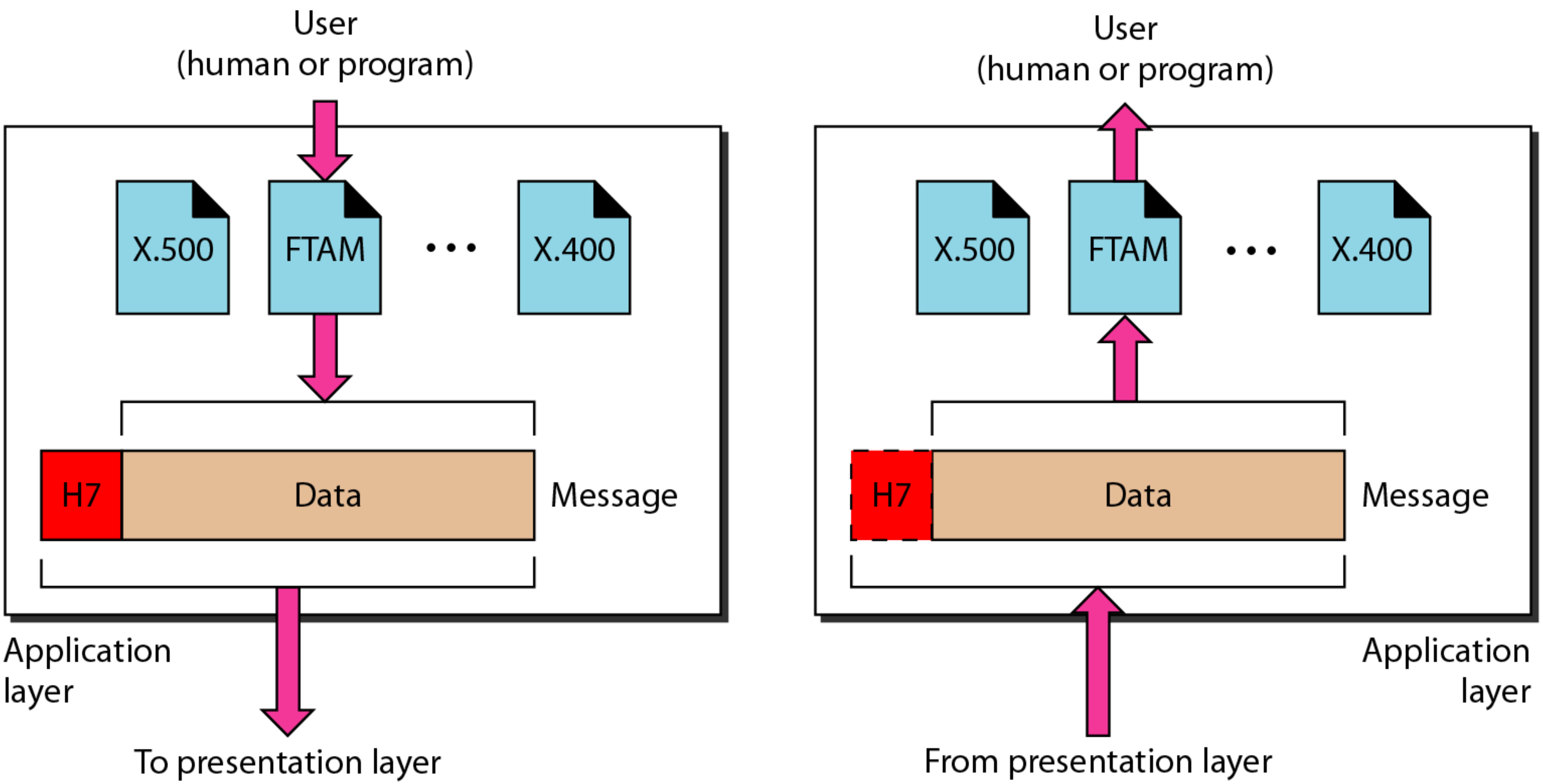
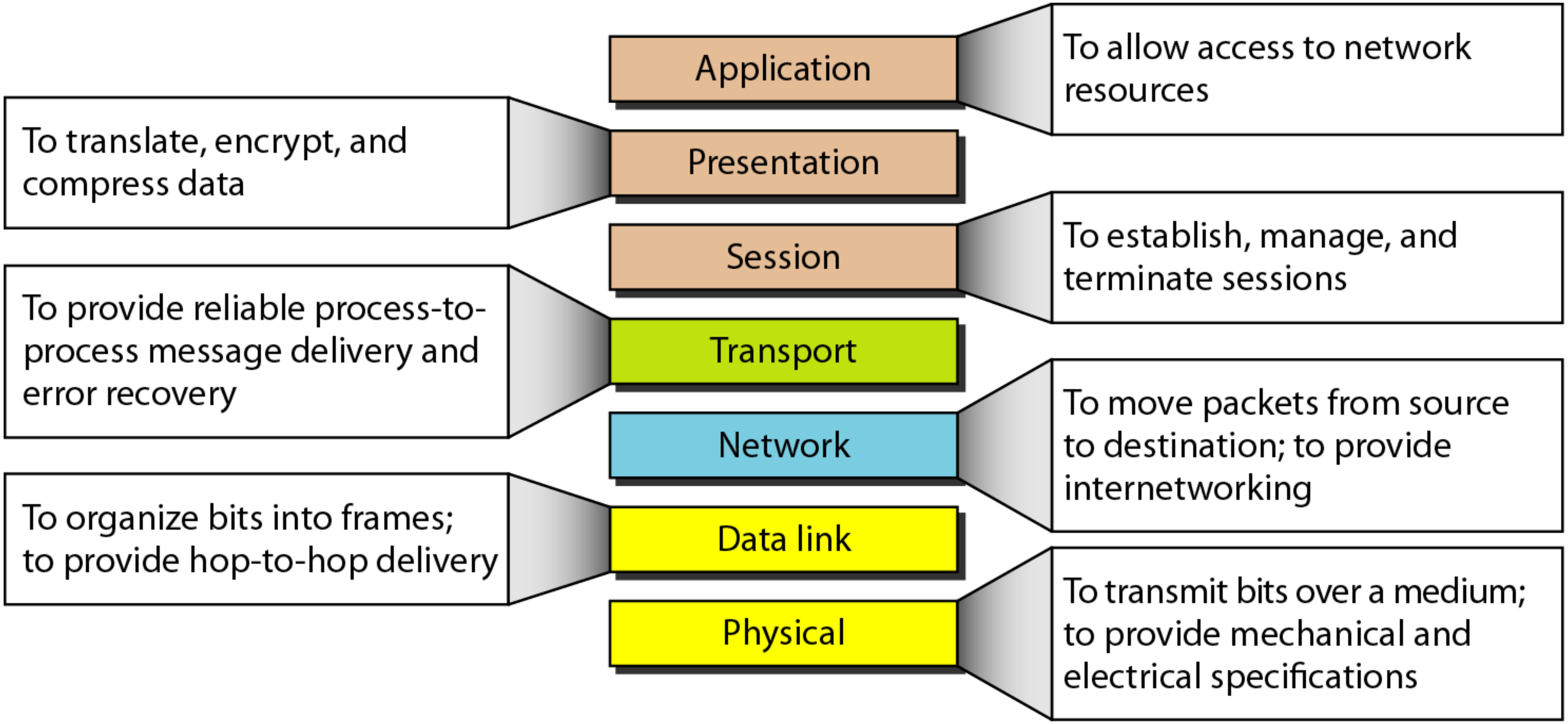


Figure 2.14 *Application layer*

Summary of Layers



TCP/IP Protocol

- The layers in the TCP/IP protocol do not exactly match those in the OSI model (as it was developed prior to 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.

TCP/IP Protocol (Conti…)

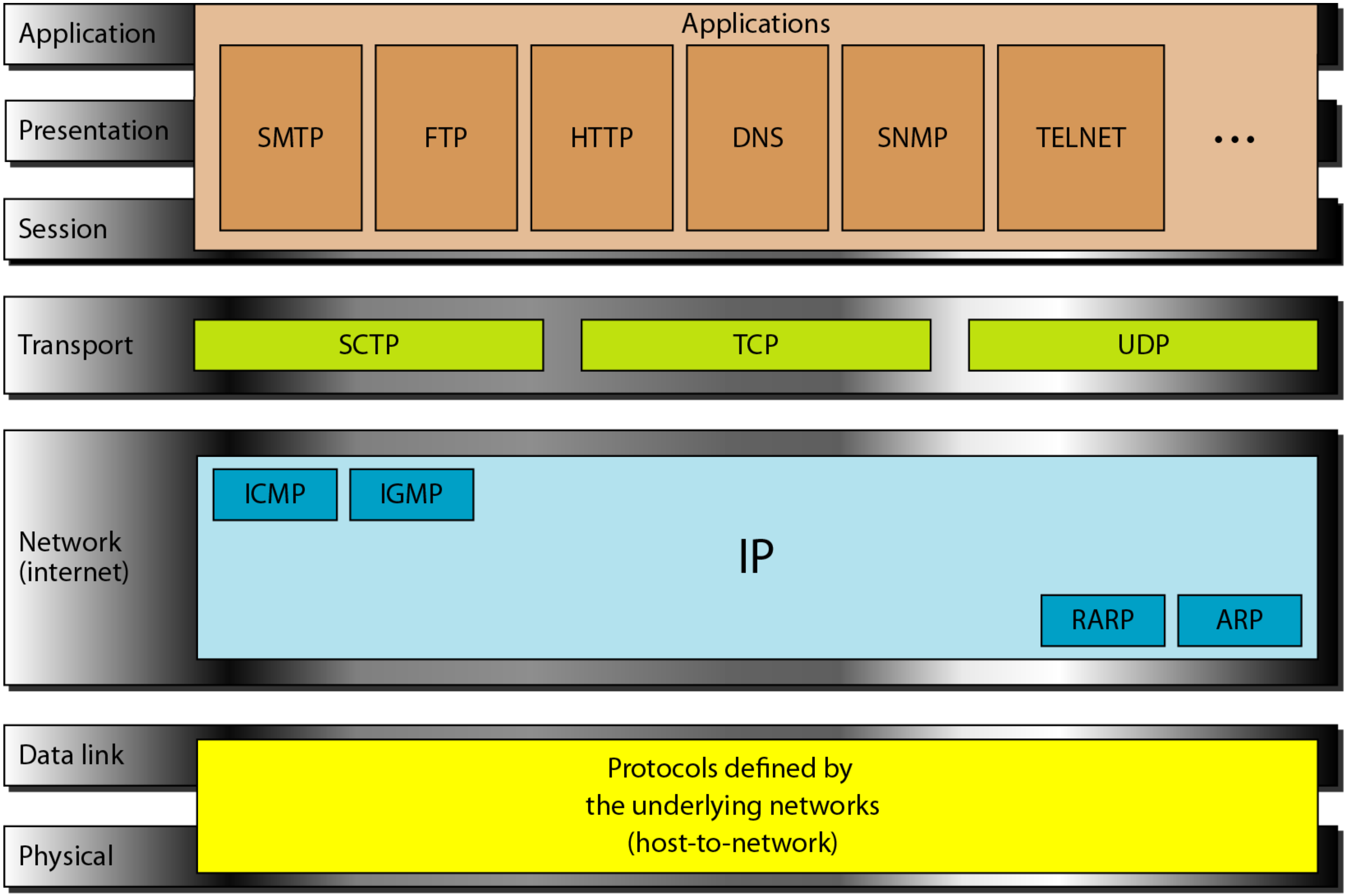


Figure 2.16 *TCP/IP and OSI model*

TCP/IP Protocol – Physical and Data Link Layers

- At physical and data link layers, TCP/IP does not define any specific protocol.
- It supports all the standard protocols.

TCP/IP Protocol – Network Layer

At Network Layer, TCP/IP supports:

- Internetworking Protocol (IP):
  - Transmission mechanism used by TCP/IP protocol
  - Unreliable and connectionless protocol
  - Transports data into packets called datagrams
  - Datagrams can move along different routes and can arrive out of sequence or be duplicated
- Address Resolution Protocol (ARP):
  - Use to associate logical address with a physical address i.e. to find the physical address of a node when its logical address is known.

TCP/IP Protocol – Network Layer (Conti…)

- Reverse Address Resolution Protocol (RARP):
  - Allows the host to discover its logical address when its physical address is known
- Internet Control Message Protocol (ICMP) :
  - Used by hosts and gateways to send notification of datagram problems back to the sender
  - Sends query and error reporting messages
- Internet Group Message Protocol (IGMP):
  - Used to facilitate the simultaneous transmission of a message to a group of recipients

TCP/IP Protocol – Transport Layer

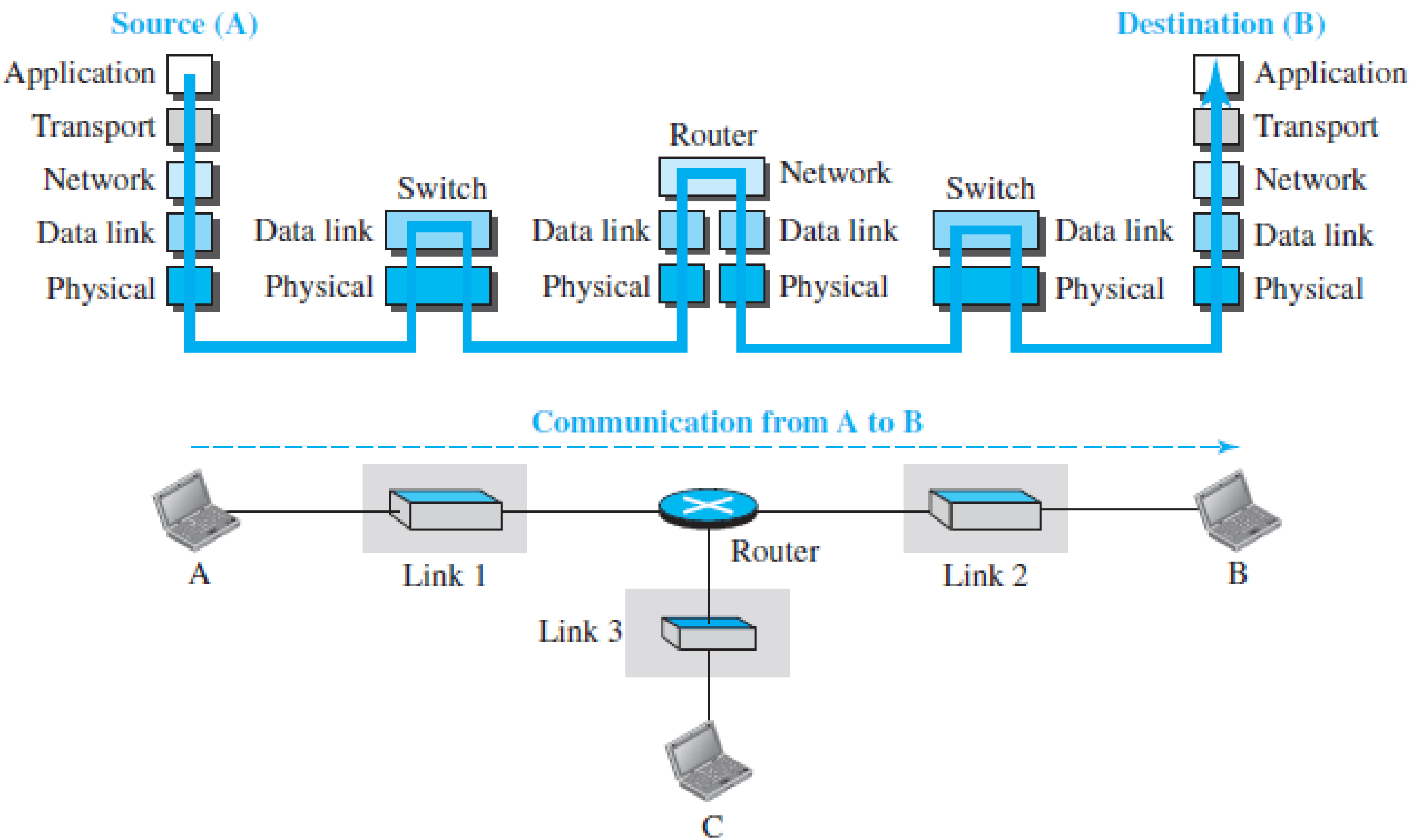
At Transport Layer, TCP/IP supports:

- User Datagram Protocol (UDP):
  - It is connection-less protocol that adds port addresses, checksum error control, and length information to the data from the upper layer.
- Transmission Control Protocol (TCP):
  - It is reliable connection-oriented protocol
  - Connection must be established between both ends before transmission
  - Each segment include a sequence number
- Stream Control Transmission Protocol (SCTP):
  - It provides support for newer application such as voice over the internet
  - It combines the best features of UDP and TCP

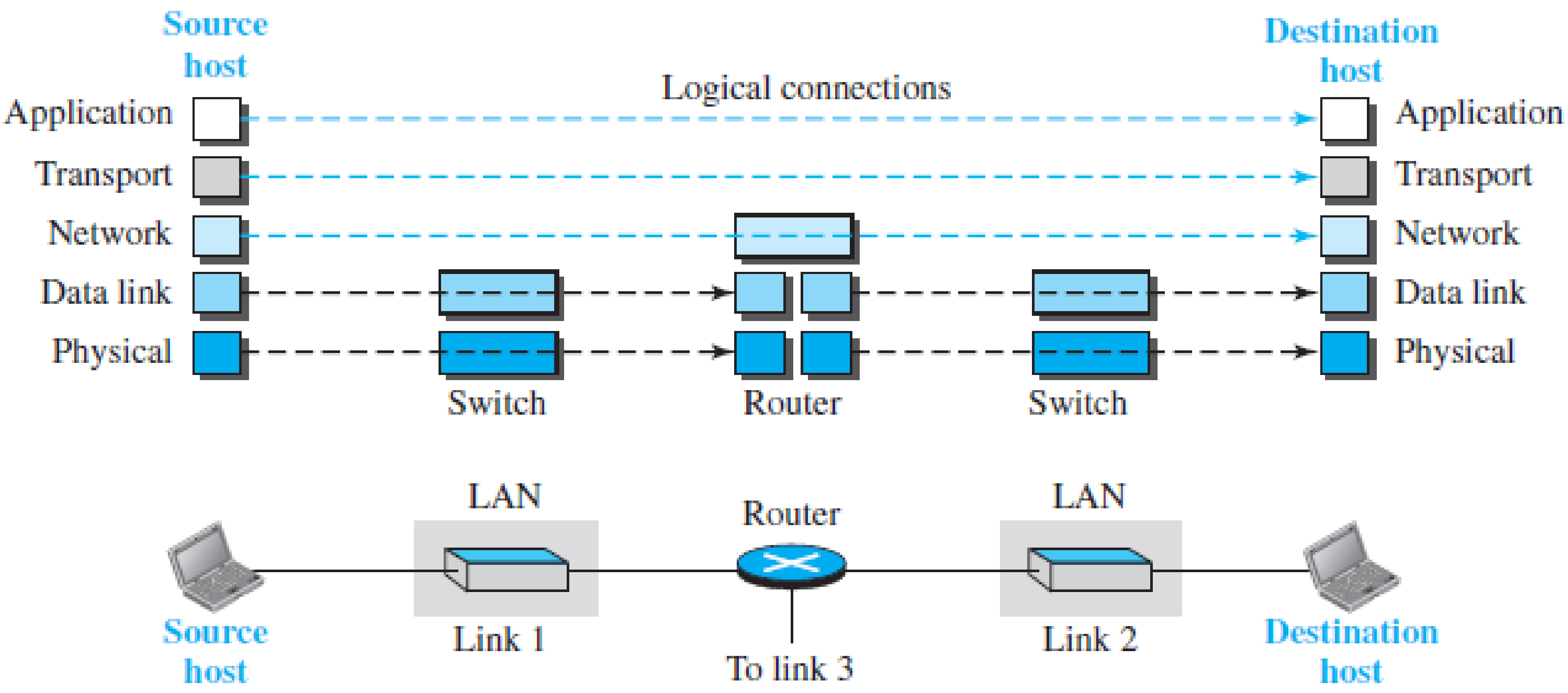
TCP/IP Protocol – Application Layer

- Application layer of TCP/IP is equivalent to session, presentation and application layers of OSI Model.
- It supports different protocols such as:
  - Simple Mail Transfer Protocol (SMTP)
  - File Transfer Protocol (FTP)
  - Hypertext Transfer Protocol (HTTP)
  - Simple Network Management Protocol (SNMP)
  - Domain Name Server (DNS)
  - Dynamic Host Configuration Protocol (DHCP)
  - And many more

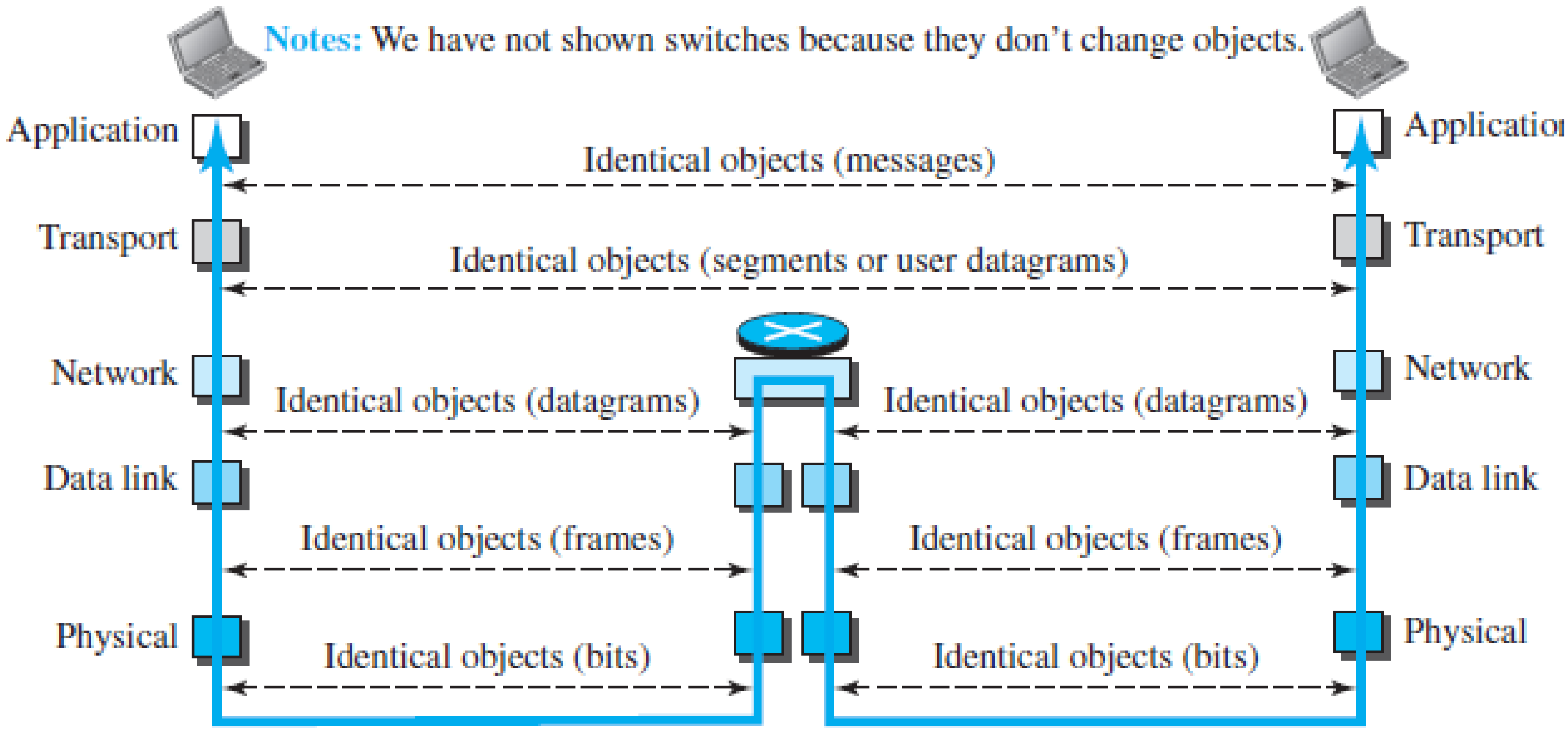
Communication Through the Internet



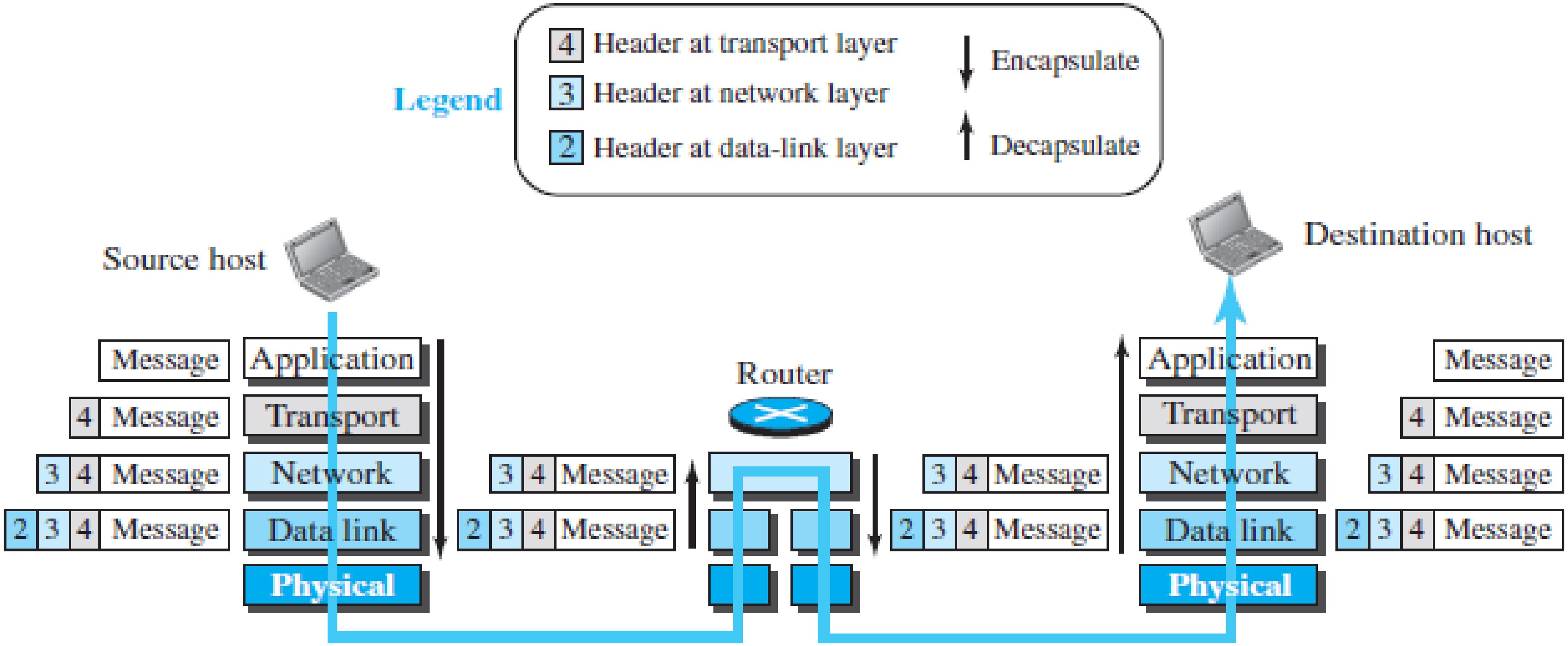
Logical Connections between layers of TCP/IP



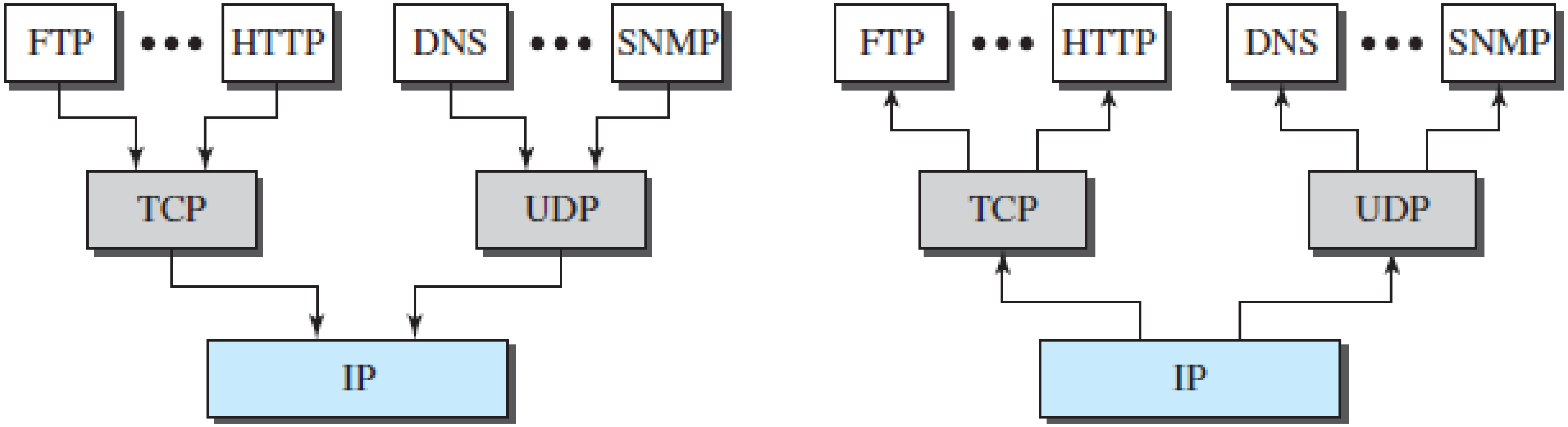
Identical Objects in the TCP/IP



Encapsulation and Decapsulation in TCP/IP



Multiplexing and Demultiplexing in TCP/IP

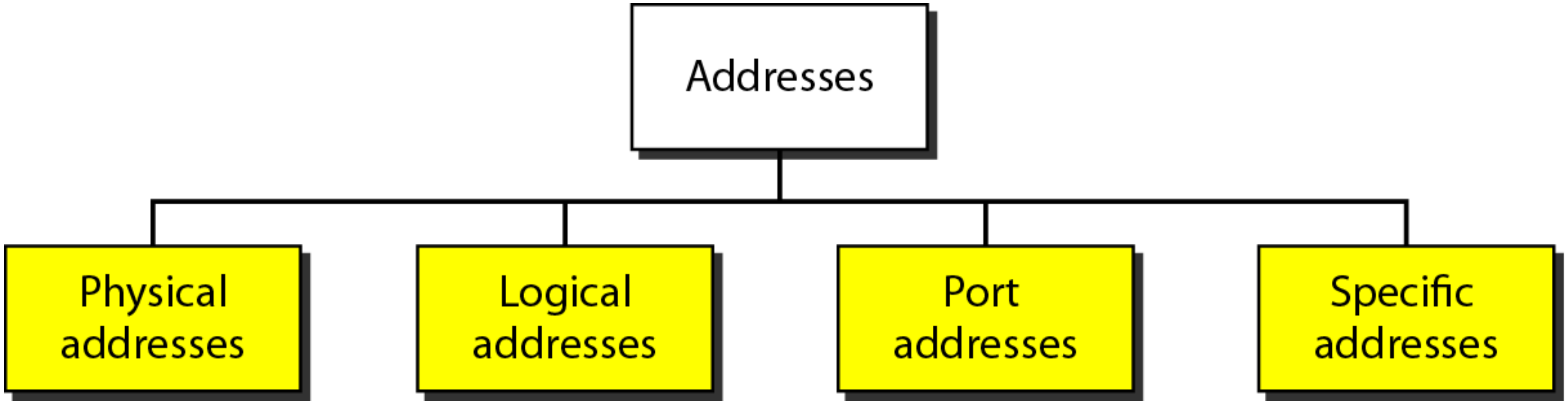


a. Multiplexing at source

b. Demultiplexing at destination

Addressing

- Four levels of addresses are used in an internet employing the TCP/IP protocols:
  - Physical Addresses
  - Logical Addresses
  - Port Addresses
  - Specific Addresses



Addressing (Conti…)

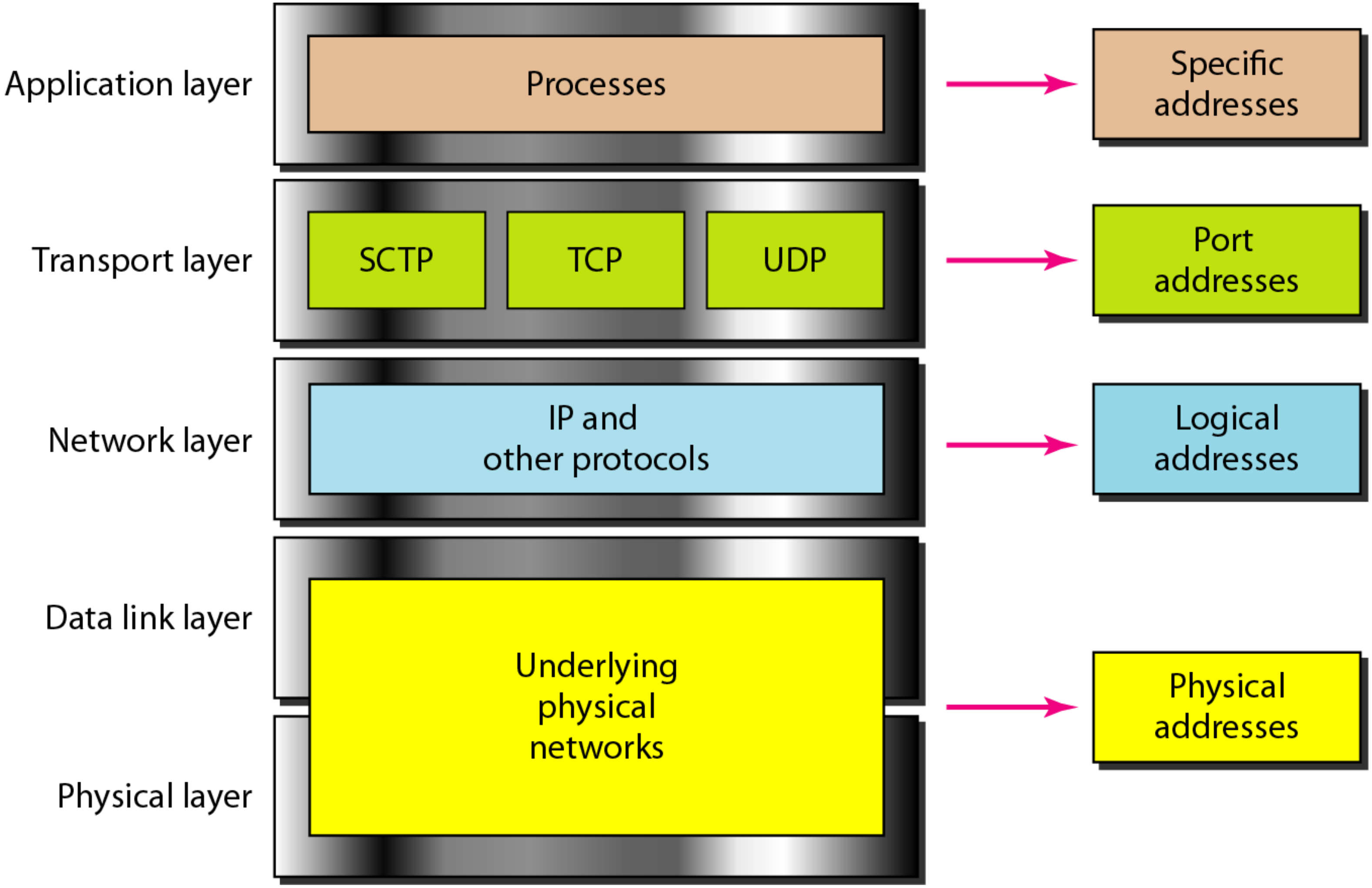


Figure 2.18 Relationship of layers and addresses in TCP/IP

Addressing – Physical Addresses

- Lowest level address, also known as link address or Media Access Control (MAC) address
- Defined by LAN or WAN
- Included in the frame by the data link layer
- Size and format vary depending on the network, e.g.:
  - Ethernet uses 6-bytes (48-bits) physical address imprinted on the network interface card (NIC)
  - LocalTalk (Apple) has 1-bye dynamic address that changes each time the station comes up

Addressing – Physical Addresses (Conti…)

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.

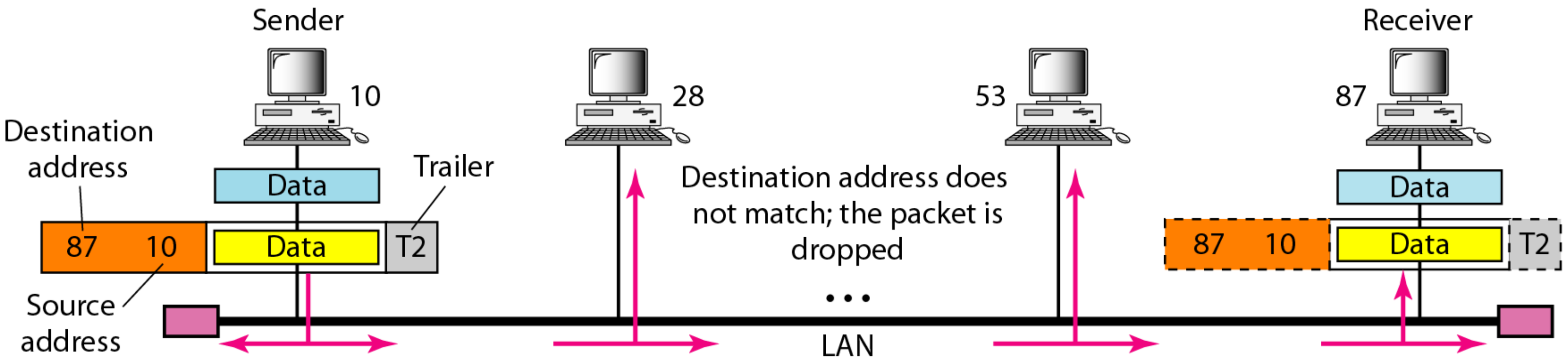


Figure 2.19 *Physical addresses*

Addressing – Physical Addresses (Conti…)

Example 2.2: 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.

Addressing – Logical Addresses

- Physical addresses are not suitable in an internetwork environment, where different networks can have different address format
- A universal addressing system is required where each host can be identified uniquely
- Logical addresses also known as IP addresses (32-bits) can uniquely define a host connected to the internet.
- No two publicly addressed and visible hosts on the internet can have the same IP address

Addressing – Logical Addresses (Conti…)

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.

Addressing – Logical Addresses (Conti…)

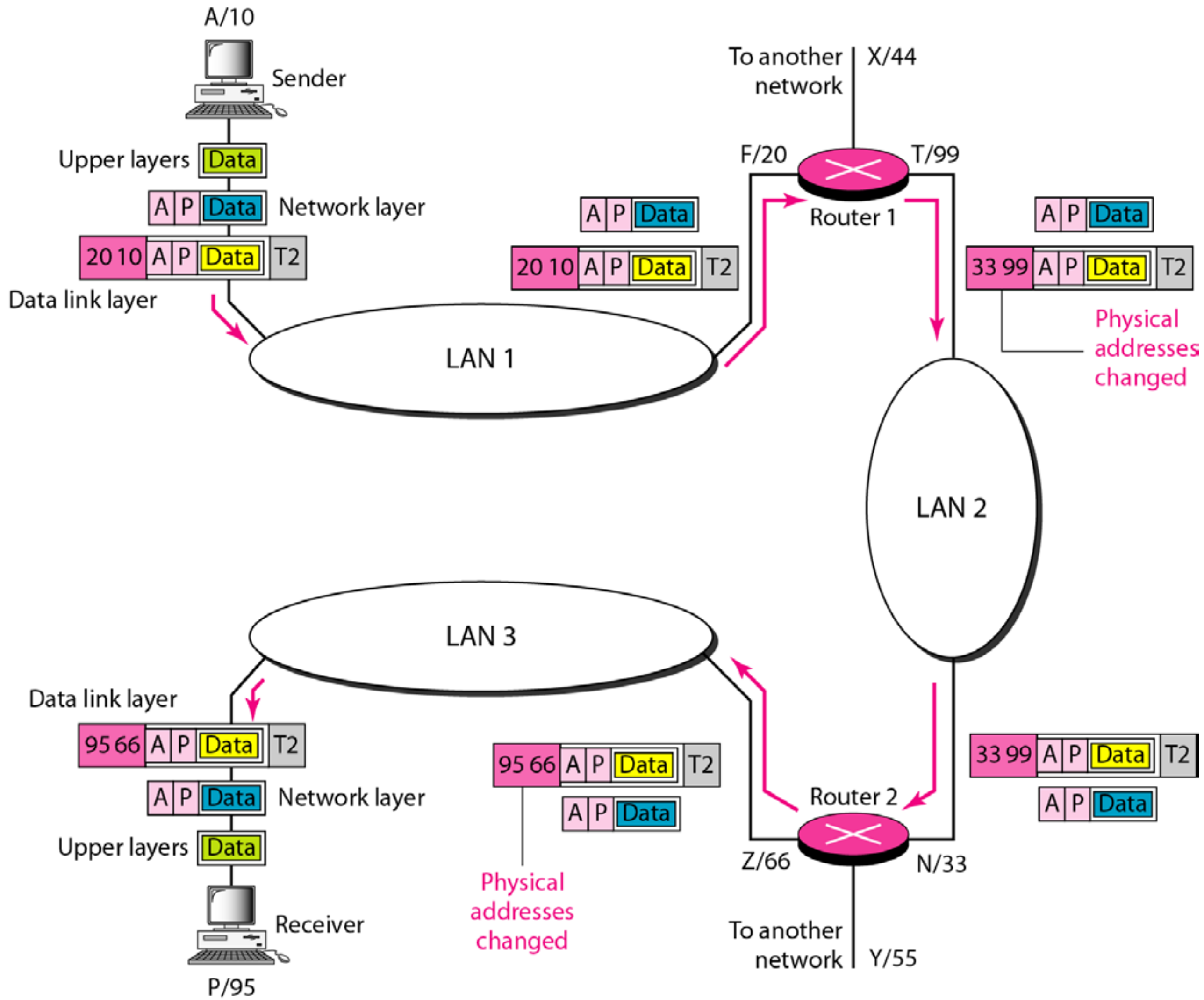


Figure 2.20 *IP addresses*

Note

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

Addressing – Port Addresses

- Computer can run multiple processes at the same time, e.g.:
  - Node A can communicate with node C using TELNET
  - At the same time, node A can communication with node B using FTP
- To receive the data simultaneously, there should be a method to label these processes
- In TCP/IP architecture, the label assigned to a process is called a port address.
- A port address in TCP/IP is 16-bits in length.

Addressing – Port Addresses (Conti…)

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.

Addressing – Port Addresses (Conti…)

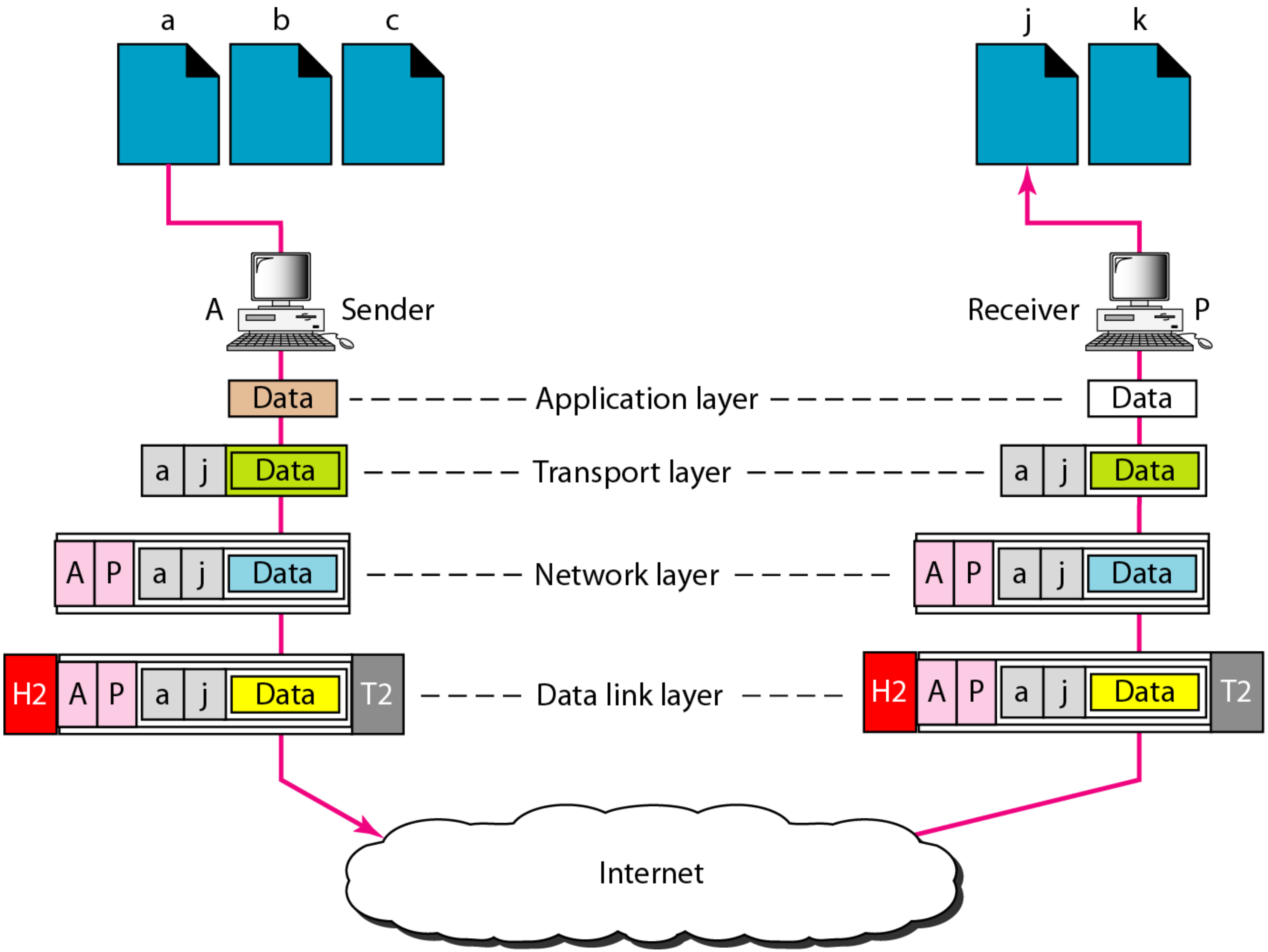


Figure 2.21 *Port addresses*

Addressing – Port Addresses (Conti…)

Note: Although physical addresses change from hop to hop, logical and port addresses remain the same from the source to destination.

Example 2.5: 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.

Addressing – Specific Addresses

- Some application have user-friendly addresses designed for specific address. Examples include:
  - The email address (e.g. javed@aup.edu.pk)
  - The Universal Resource Locator – URL (e.g. www.aup.edu.pk)
- These addresses get changed to the corresponding port and logical addresses by the sender node.