Network Models

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

Protocol

- Protocol is synonymous with rule and standards are agreed-upon rules.
- In computer networks, communication occurs between entities in different systems. An entity is anything capable of sending or receiving information. However, two entities can not simply send bit streams to each other and expect to be understood. For communication to occur, the entities must agree on a protocol.
- A protocol is a set of rules that govern data communications.
- A protocol defines what is communicated, how it is communicated, and when it is communicated.
- The key elements of a protocol are syntax, semantics, and timing.
- The term syntax refers to the structure of the data, meaning the order in which they are presented.
- For example, a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message itself.

Protocol

- The word semantics refers to the meaning of each section of bits.
- Semantics helps in interpreting a particular pattern and the action to be taken based on that interpretation.
- For example, an address identifies the route to be taken and the final destination of the message.

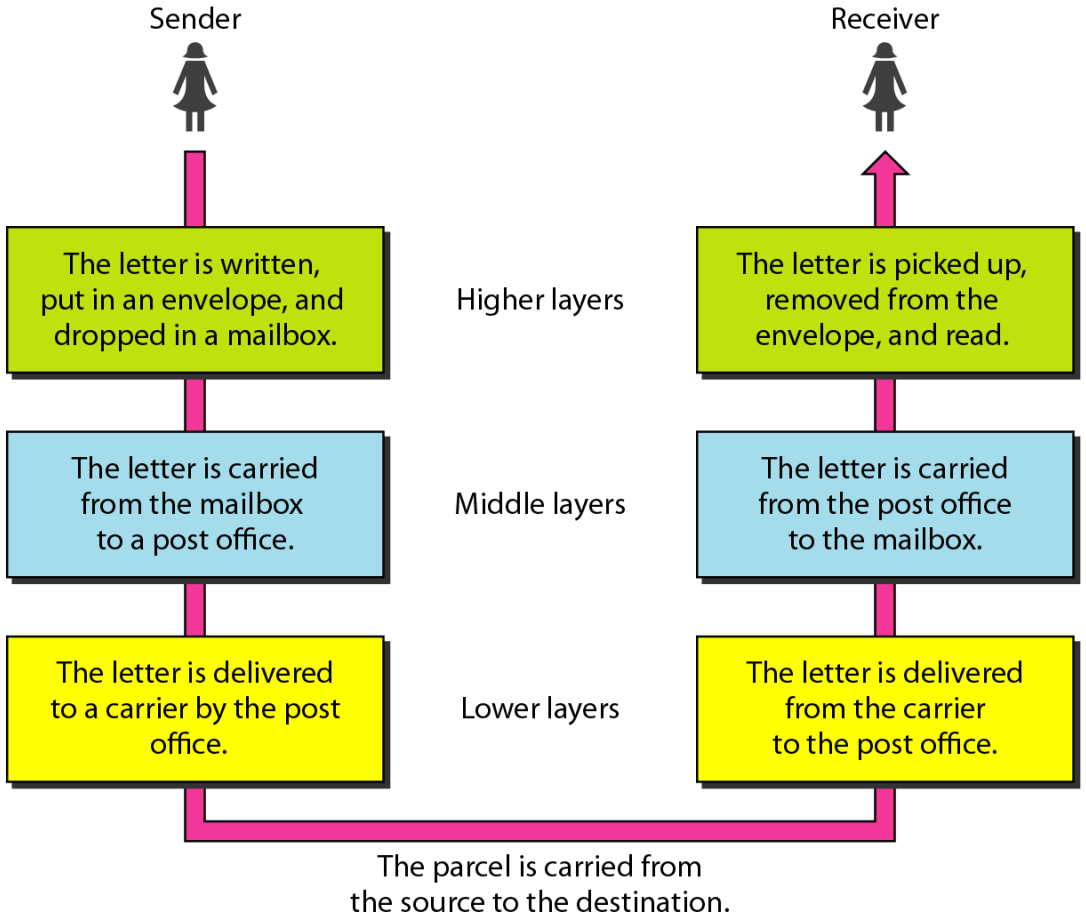
- The word timing refers to two characteristics, namely, when data should be sent and how fast they can be sent.
- For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

Layered Task - Example

Consider two friends are communicating through postal mail.

- The sender writes the letter, inserts the letter in an envelope, writes the sender and receiver addresses, and drops the letter in a mailbox.
- The letter is picked up by a letter carrier and delivered to the post office.
- The letter is sorted at the post office and a carrier transports the letter.
- The parcel is carried from the source to the destination by the carrier.
- At the Receiver Site, the carrier transports the letter to the post office.
- The letter is sorted and delivered to the recipient’s mailbox.
- The receiver picks up the letter, opens the envelope, and reads it.

Tasks involved in sending a letter



Each layer at the sending site uses the services of the layer immediately below it. The sender at the higher layer uses the services of the middle layer. The middle layer uses the services of the lower layer. The lower layer uses the services of the carrier.

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.*

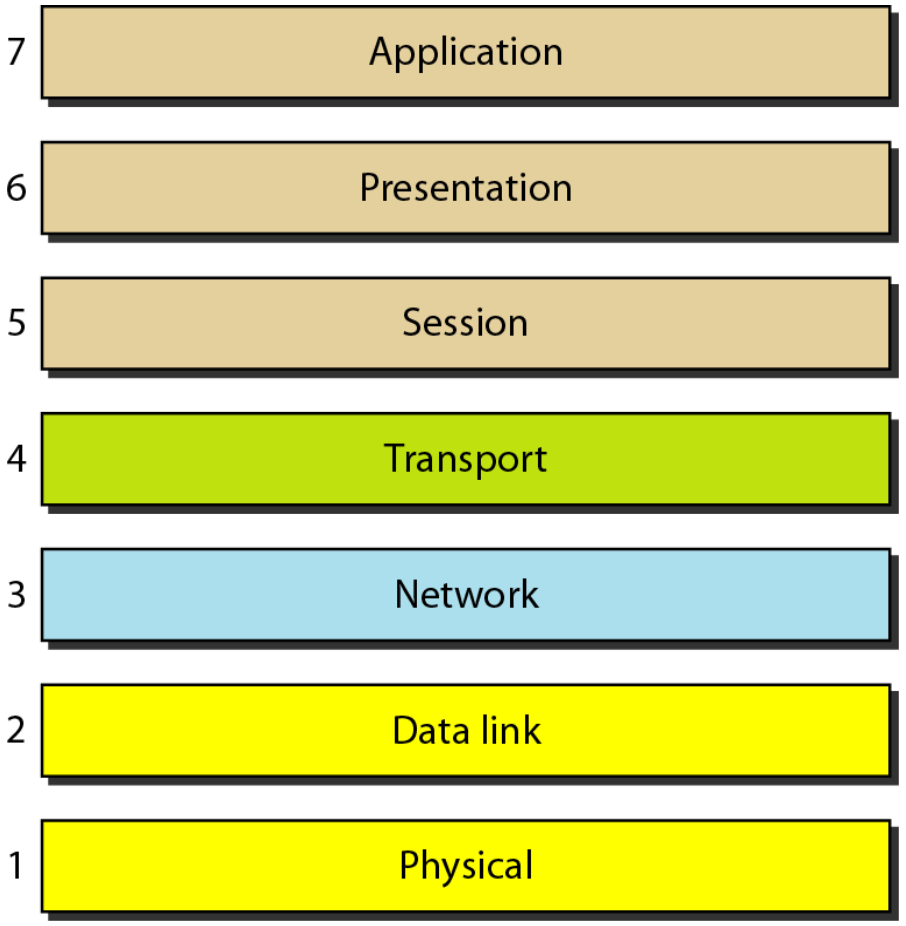
Topics discussed in this section:

Layered Architecture
Peer-to-Peer Processes
Encapsulation

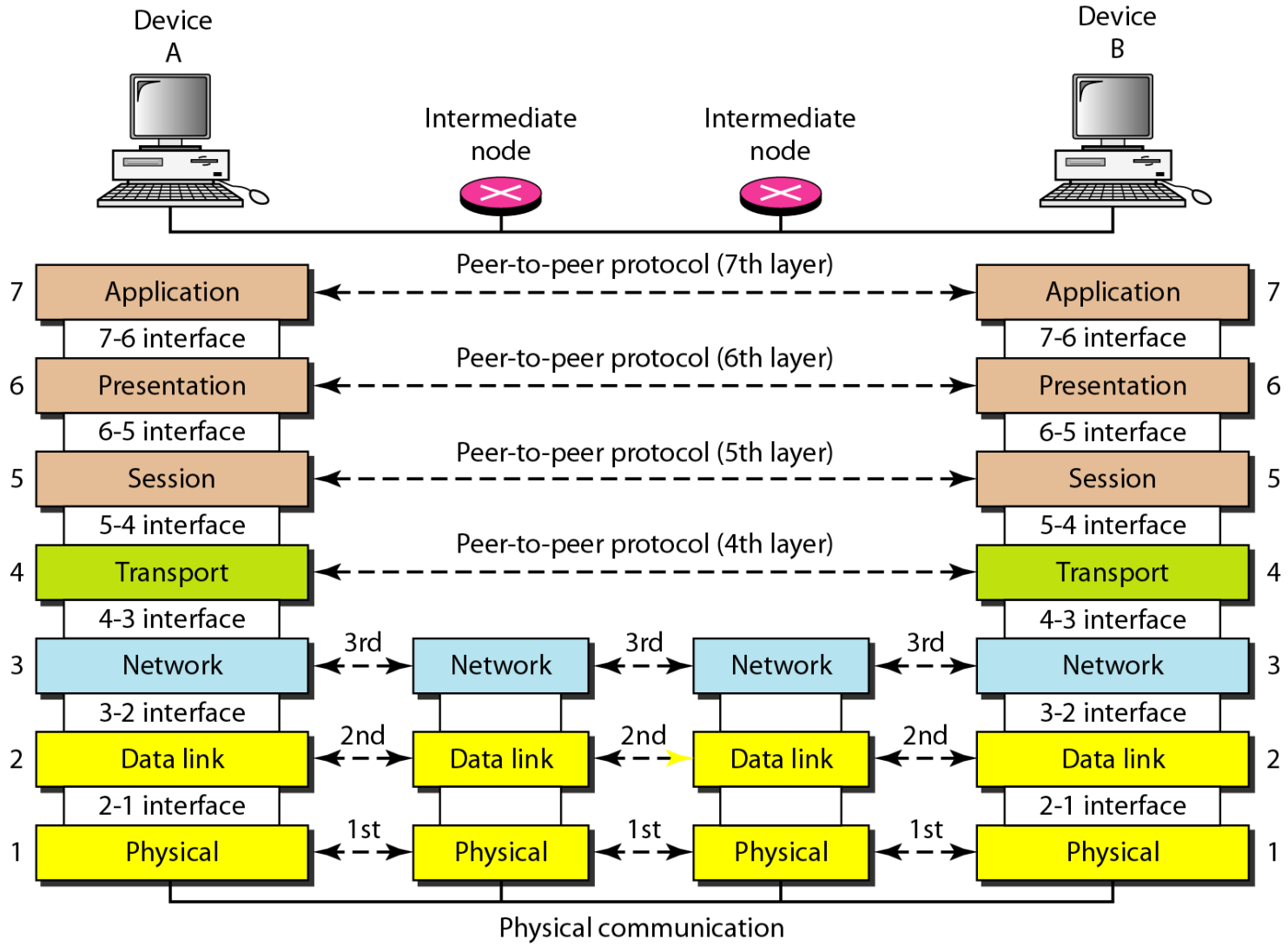
Seven layers of the OSI model

Within a single machine, each layer calls upon the services of the layer just below it. For example, Network Layer uses the services provided by Data Link Layer and provides services for Transport Layer.

Between machines, Network Layer on one machine communicates with Network Layer on another machine. Communication between machines is therefore a peer-to-peer process using the protocols appropriate to a given layer.



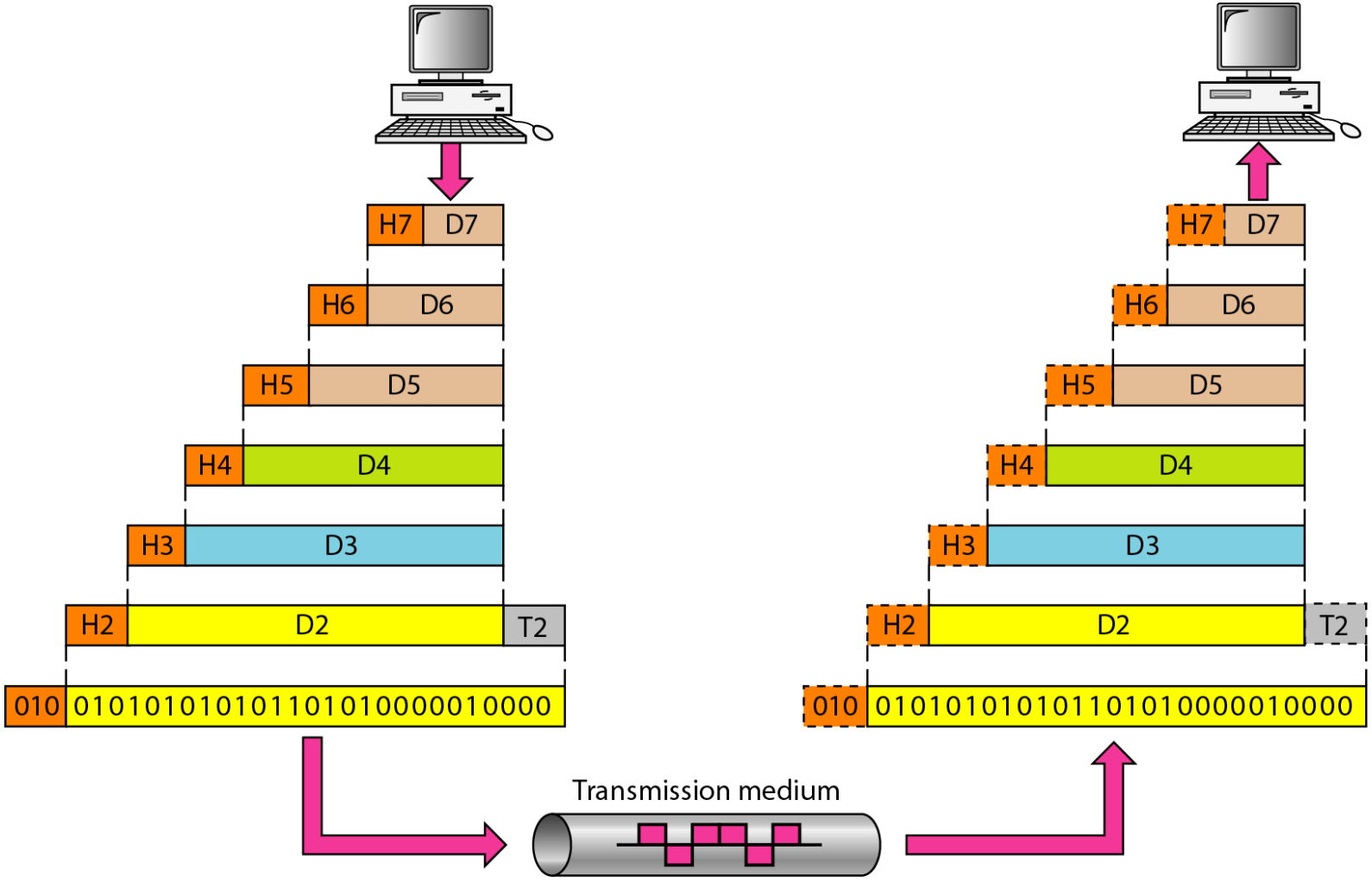
The interaction between layers in the OSI model



The interaction between layers in the OSI model

- The exchange of data moves down through the layers of the Sending device and moves upward through the layers of the Receiving device.
  - D7 means the data unit at layer 7, and H7 means the header at layer 7. Layer 7 represents Application layer. D6 means the data unit at layer 6. H6 means the header at layer 6 and so on.
- At each layer, a header is added to the data unit. Usually, the trailer is added only at layer 2 which represents Data Link layer. When the formatted data unit passes through the Physical layer, it is changed into an electromagnetic signal and transported along a Transmission medium.
- Upon reaching its destination, the signal passes into physical layer and is transformed back into digital form. The data units then move back up through the OSI layers.
- As each block of data reaches the next higher layer, the headers and trailers attached to it at the corresponding sending layer are removed, and actions appropriate to that layer are taken.
- By the time it reaches Layer 7, the message is again in a form appropriate to the application and is made available to the recipient.

An exchange using the OSI model



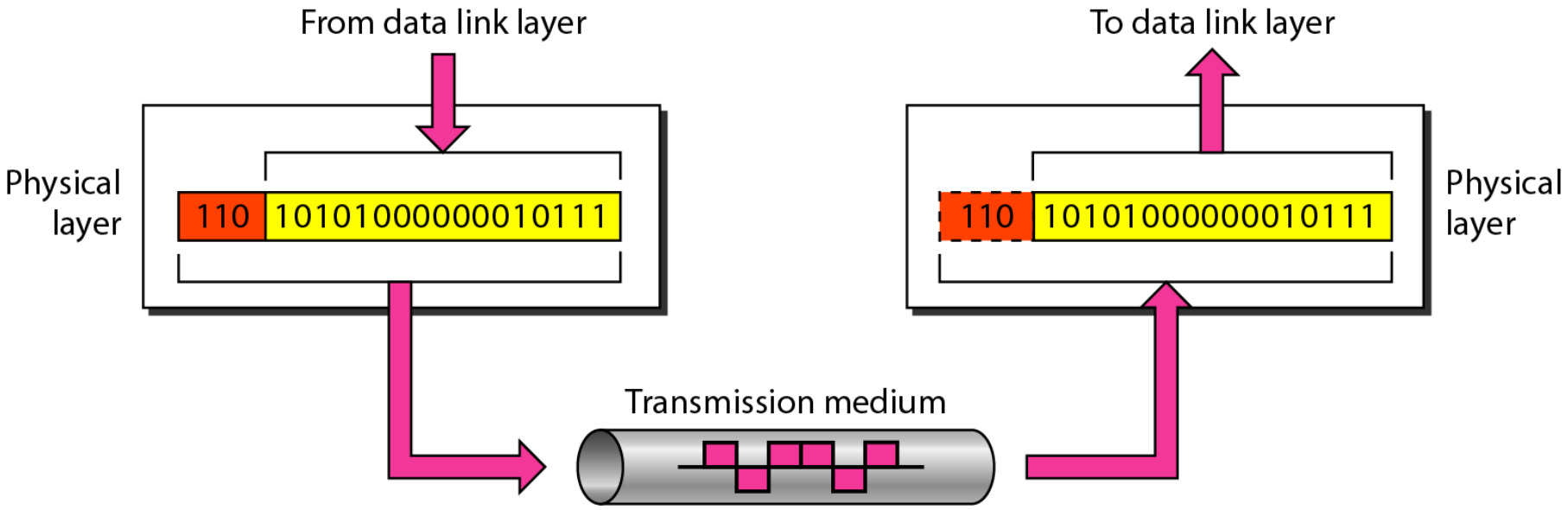
2-3 LAYERS IN THE OSI MODEL

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

Physical layer

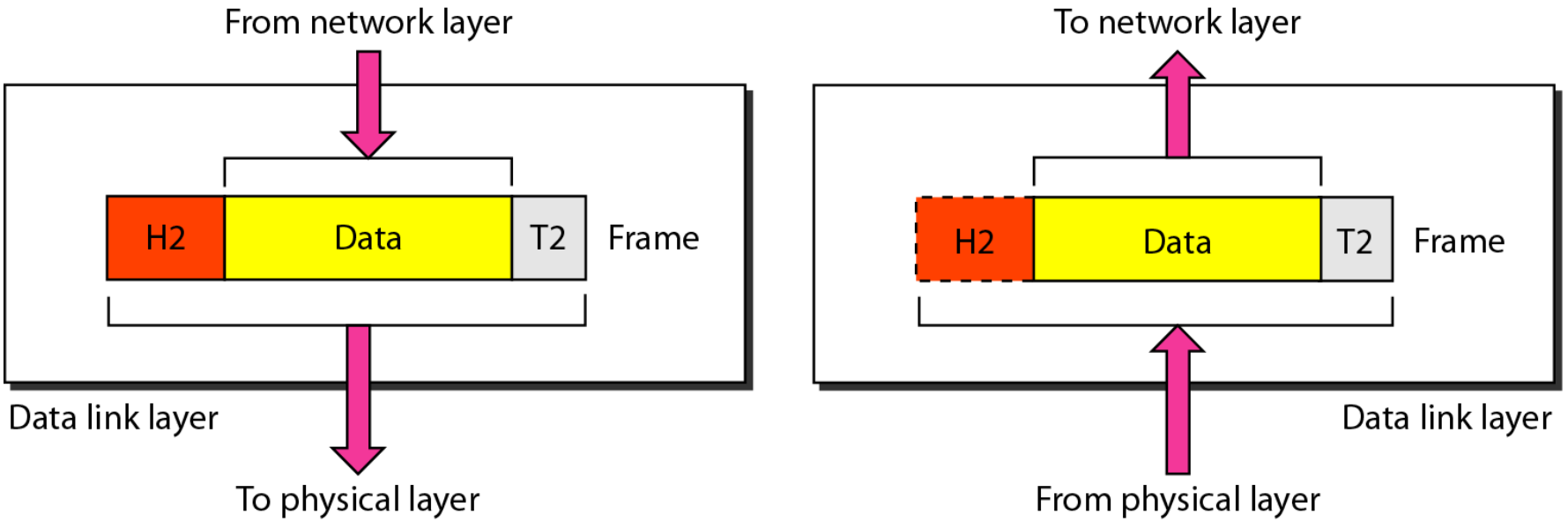


- The physical layer coordinates the functions required to carry a bit stream over a physical medium.
- At the sender's end, a data from the data link layer is encapsulated as a packet, after adding header at the physical layer. When the encapsulated packet passes through the physical layer, it is changed into an electromagnetic signal and transported along a Transmission medium.
- Upon reaching its destination, the signal is transformed back into digital form. The data units then move back up through the OSI layers.

Physical layer

- The physical layer is also concerned with the physical characteristics of interfaces and medium, representation of bits, data rate, synchronization of bits, line configuration, physical topology, transmission mode.
- The physical layer defines the characteristics of the interface between the devices and the transmission medium. It also defines the type of transmission medium.
- The physical layer data consists of a stream of bits with no interpretation. To transmit, bits must be encoded into electrical or optical signals.
- The physical layer defines the type of encoding. The number of bits sent each second is also defined by the physical layer. The sender and receiver not only must use the same bit rate but also must be synchronized at the bit level.
- The physical layer is concerned with the connection of devices to the media. Devices can be connected by different types of physical topologies.
- The physical layer also defines the direction of transmission between two devices, namely simplex, half-duplex, or full-duplex.

Data link layer

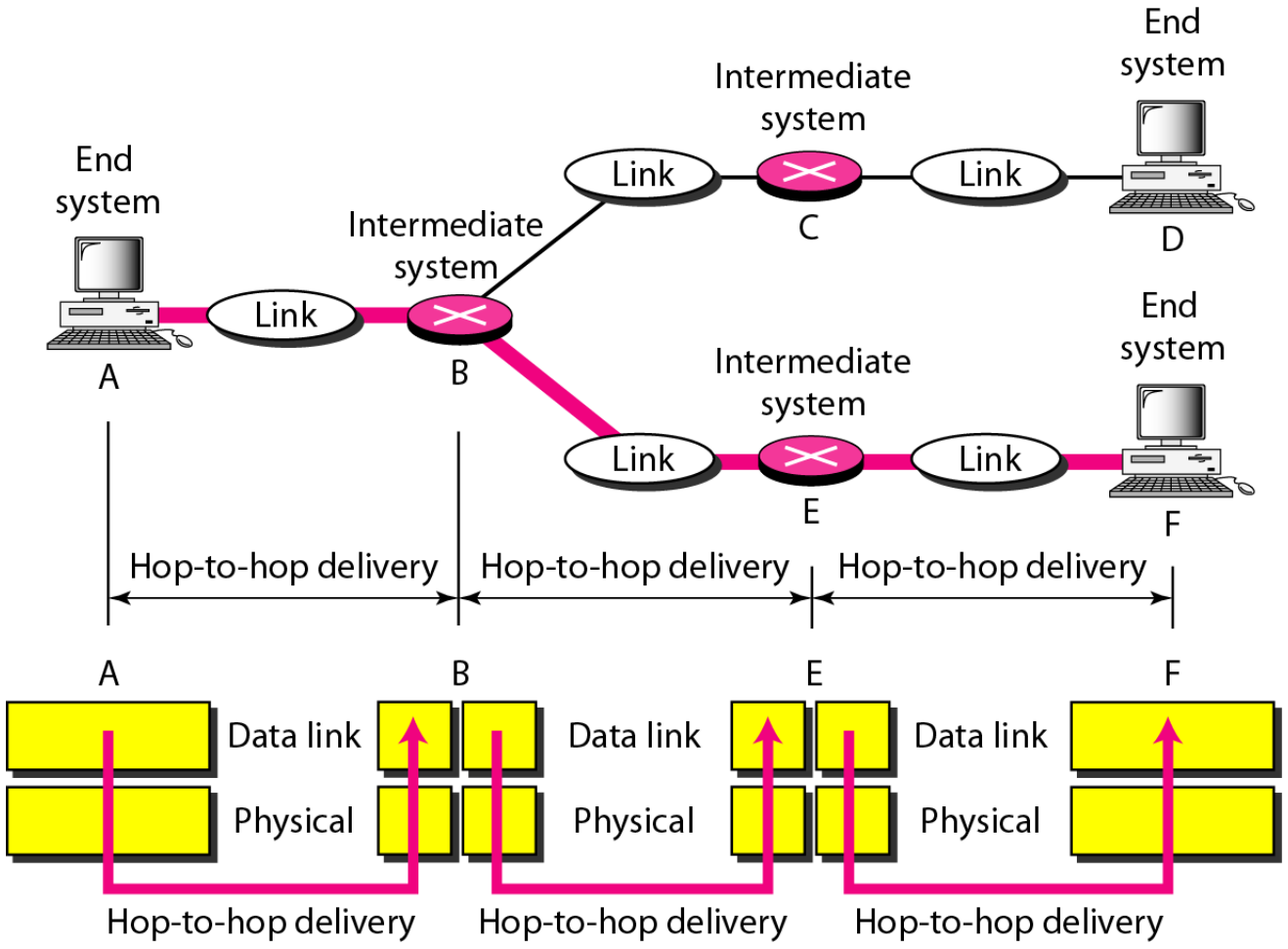


- The data link layer moves frames from one node to the next.
- It transforms the physical layer from a raw transmission facility to a reliable link.
- At this layer, a header H2 and a trailer T2 is added to the data unit. Upon reaching its destination, the data units then ascend through the OSI layers.
- As each block of data reaches the next higher layer, the headers and trailers attached to it at the corresponding sending layer are removed, and actions appropriate to that layer are taken.

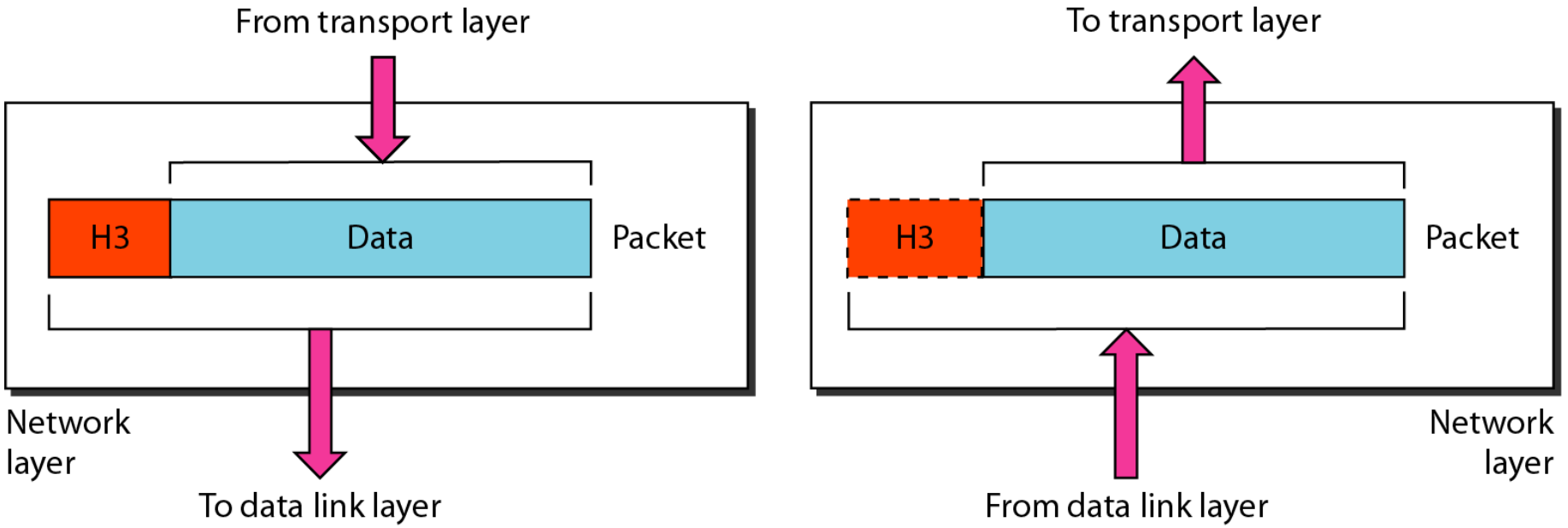
Data link layer

- The responsibilities of the data link layer include framing, physical addressing, flow control, error control, and access control. The data link layer divides the stream of bits received from the network layer into manageable data units called frames. If frames are to be distributed to different systems on the network, the data link layer adds a header and a trailer to the frame to define the sender and receiver of the frame.
- If the rate at which the data are absorbed by the receiver is less than the rate at which data are transmitted by the sender, the data link layer imposes a flow control mechanism to avoid overwhelming the receiver.
- The data link layer adds reliability to the physical layer by adding mechanisms to detect and retransmit damaged or lost frames. Error control is normally achieved through a trailer added to the end of the frame. When two or more devices are connected to the same link, data link layer protocols are necessary to determine which device has control over the link at any given time.

Hop-to-hop delivery



Network layer

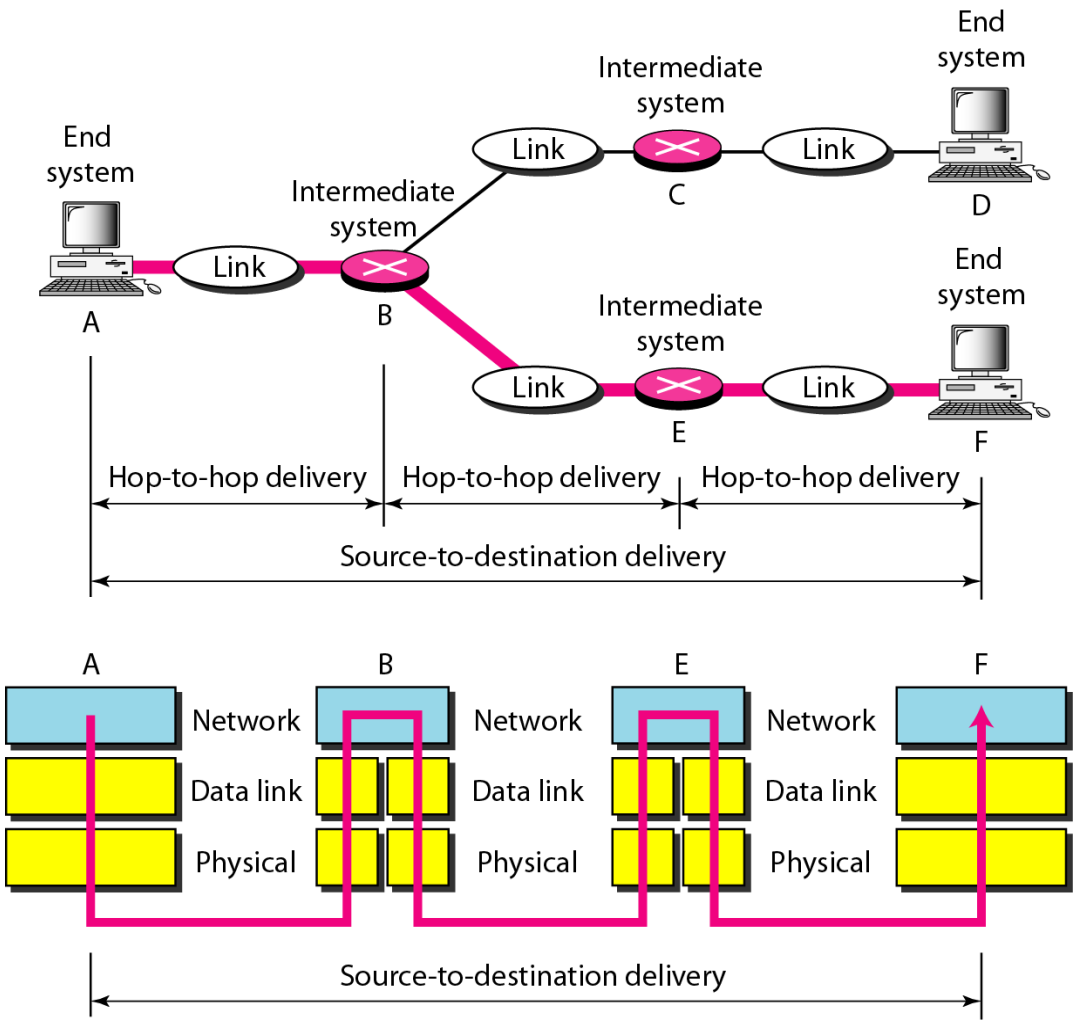


- The network layer is responsible for the delivery of individual packets from the source to the destination.
- At this layer, a header H3 is added to the packet, and then descends to Data Link layer.
- Upon reaching its destination, the header attached to it at the corresponding sending layer is removed, and then the data unit ascends to the Transport layer.

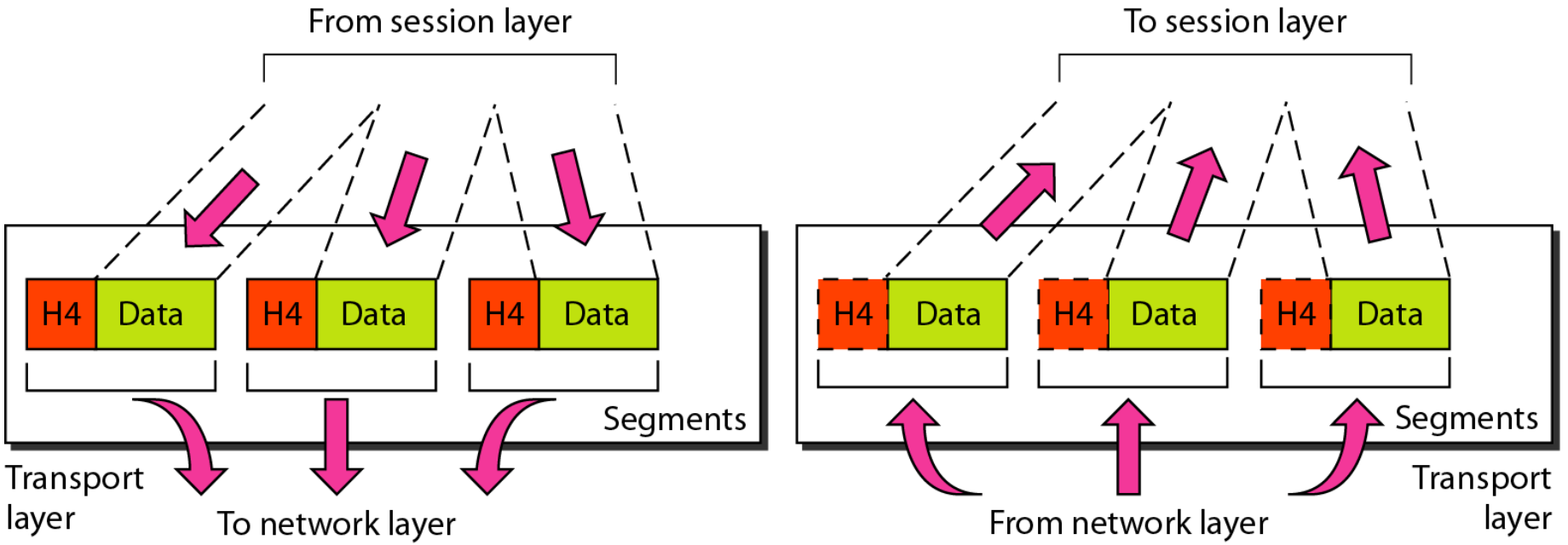
Network layer

- The data link layer oversees the delivery of the packet between two systems on the same network, whereas, the network layer delivers packet between two systems connected across different networks.
- If two systems are connected to the same link, there is usually no need for a network layer.
- However, if the two systems are attached to different networks with connecting devices between the networks, there is often a need for the network layer to accomplish source-to-destination delivery.
- One of the main responsibilities of the network layer is to add a header to the packet coming receiver and from the upper layer that includes the logical addresses of the sender.
- The other responsibility is to provide routing mechanism.
- When independent networks are connected to create internetworks, the connecting devices, called routers or switches, route or switch the packets to their final destination.

Source-to-destination delivery

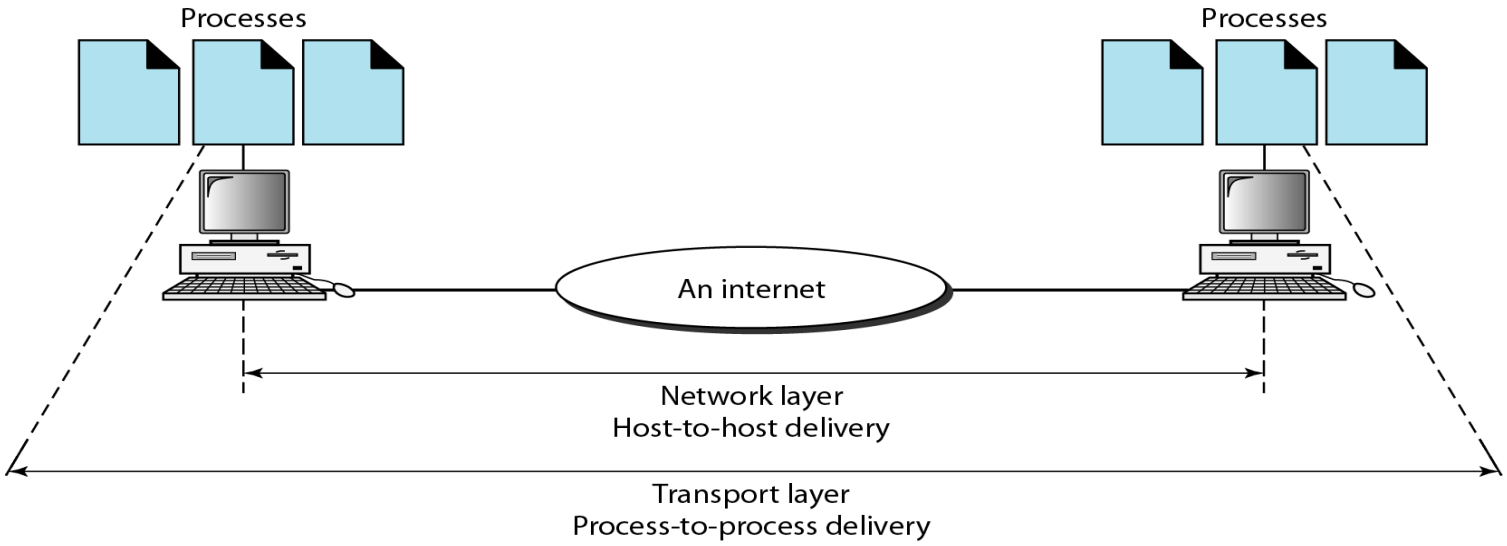


Transport layer



- The transport layer is responsible for the delivery of a message from one process to another.
- A process is an application program running on a host.
- At this layer, a header H4 is added to the segments and then segments descend to Network layer.
- Upon reaching its destination, the header attached to the segments is removed, and then the data unit ascends to the Transport layer.

Reliable process-to-process delivery of a message



- While the network layer oversees source-to-destination delivery of individual packets, it does not recognize any relationship between those packets.
- It treats each one independently, as though each piece belonged to a separate message.
- The transport layer, on the other hand, ensures that the whole message arrives intact and in order.
- The responsibilities of the transport layer include service- point addressing, segmentation and reassembly, connection control, flow and error control.

Reliable process-to-process delivery of a message

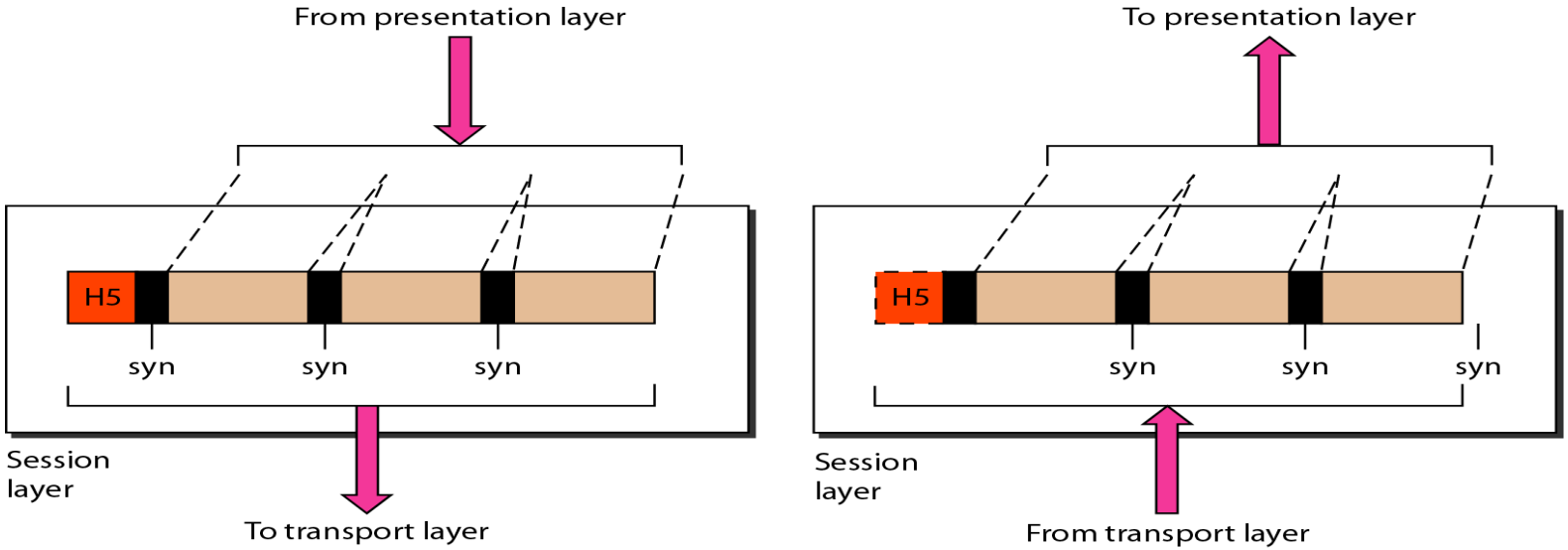
- The transport layer header must include a type of address called a service-point address or port address, for delivering specific processes between computers.
- The network layer gets each packet to the correct computer and the transport layer gets the entire message to the correct process on that computer.
- Data is divided into transmittable segments, with each segment containing a sequence number.
- These numbers enable the transport layer to reassemble the message correctly upon arriving at the destination and to identify and replace packets that were lost in transmission.
- The transport layer can be either connectionless or connection-oriented.

Reliable process-to-process delivery of a message

- A connectionless transport layer treats each segment as an independent packet and delivers it to the transport layer at the destination machine.

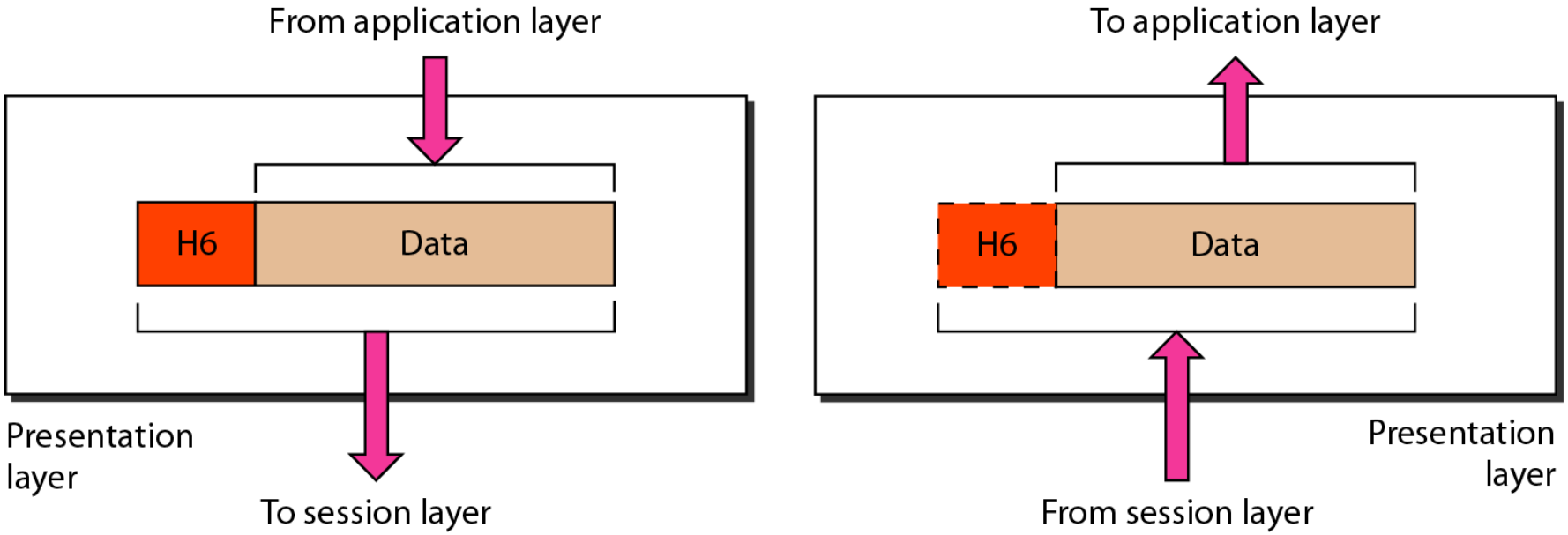
- A connection-oriented transport layer makes a connection with the transport layer at the destination machine first before delivering the packets.
- After all the data are transferred, the connection is terminated. Like the data link layer, the transport layer is responsible for flow and error control.
- The sending transport layer makes sure that the entire data arrives at the receiving transport layer without error.
- Error correction is usually achieved through retransmission.

Session layer



- Between each segment, synchronization points are inserted and then descended to transport layer.
- The session layer is the network dialog controller.
- It establishes, maintains, and synchronizes the interaction among communicating systems.
- The session layer allows a process to add checkpoints, or synchronization points, to a stream of data.

Presentation layer

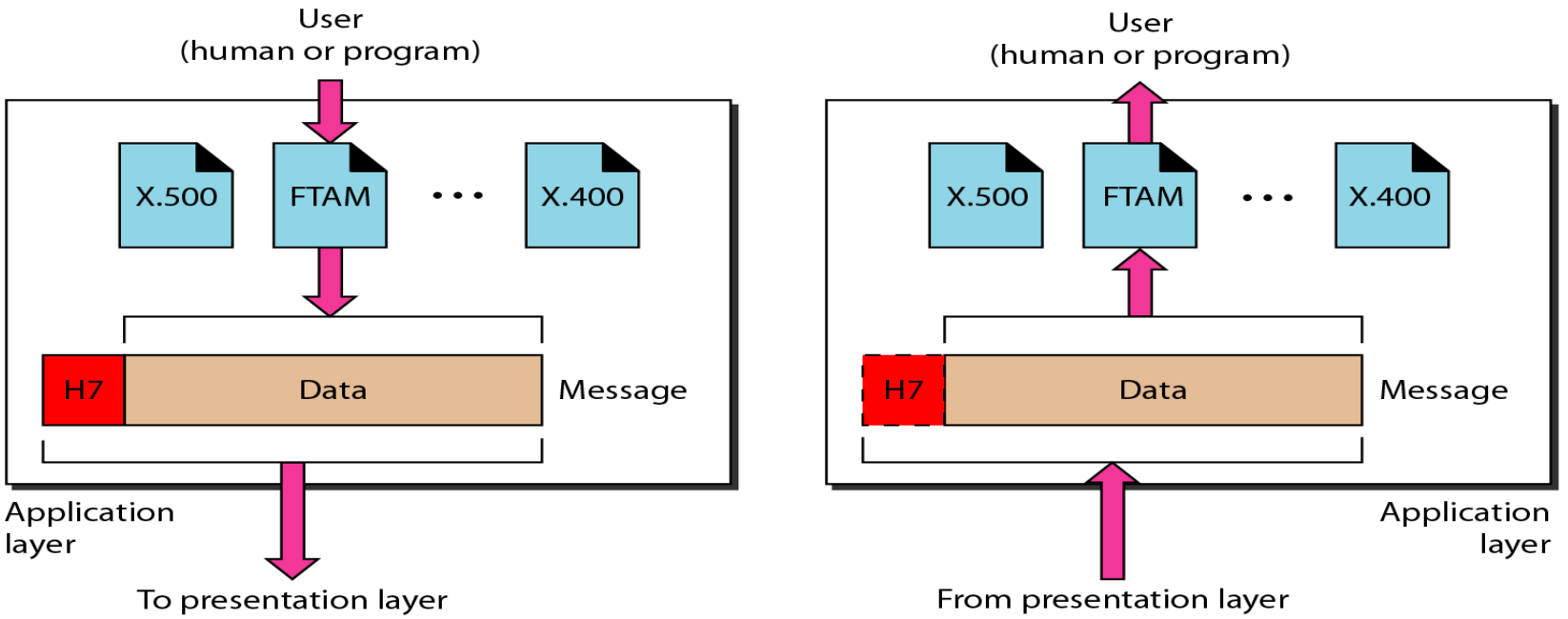


- The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems.
- Syntax refers to the order in which data is presented.
- Semantics helps in interpreting a particular pattern and the action to be taken based on that interpretation.
- The responsibilities of the presentation layer include translation, encryption, and compression.

Presentation layer

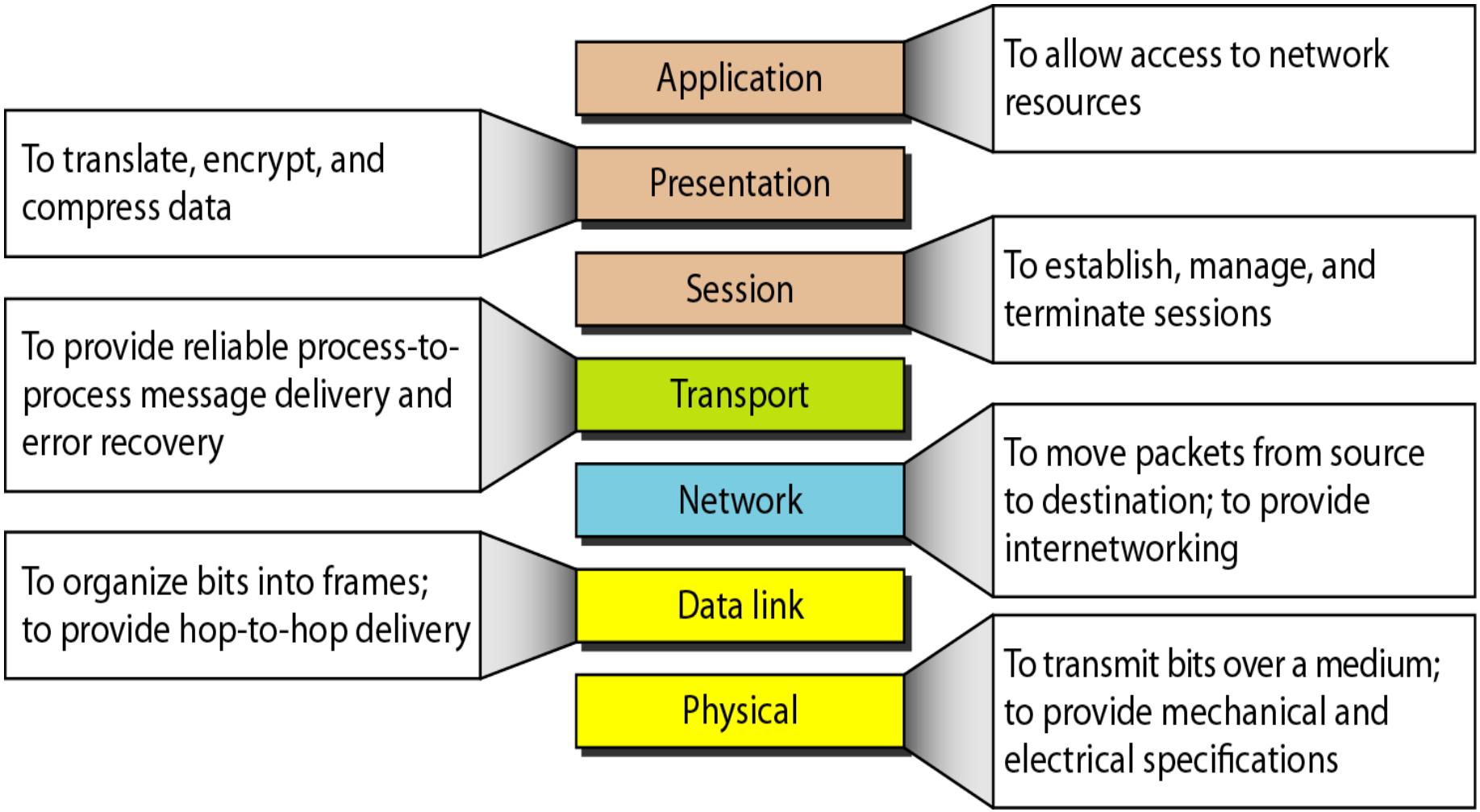
- The processes of running programs in two systems are usually exchanging information in the form of character strings, numbers, and so on.
- The information must be changed to bit streams before being transmitted.
- Because different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding methods.
- The presentation layer at the sender, changes the information from its sender-dependent format into a common format.
- The presentation layer at the receiver, changes the common format into its receiver-dependent format.
- To carry sensitive information, a system must be able to ensure privacy.
- Encryption means that the sender transforms the original information to another form and sends the resulting message out over the network.
- Decryption reverses the original process to transform the message back to its original form.
- Data compression reduces the number of bits contained in the information. Data compression becomes particularly important in the transmission of multimedia such as text, audio, and video.

Application layer



- The application layer is responsible for providing services to the user.
- The application layer enables the user, whether human or software, to access the network, by providing distributed information services.
- The data is created by the sender with the help of user interfaces and other support services.
- The services provided by the application layer include Network virtual terminal, File transfer, access, and management, Mail services, Directory services, etc.

Summary of layers



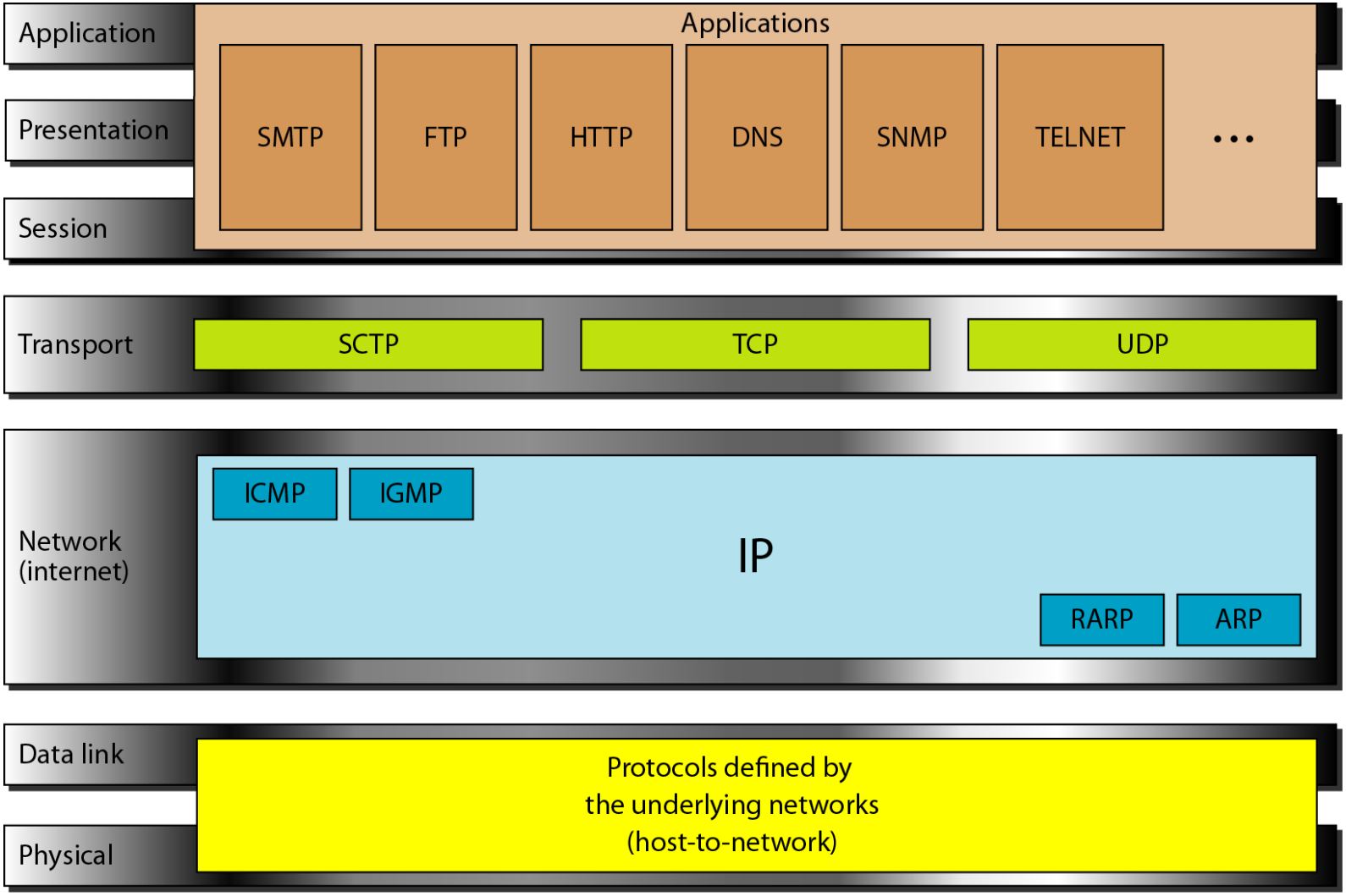
TCP/IP PROTOCOL SUITE

*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



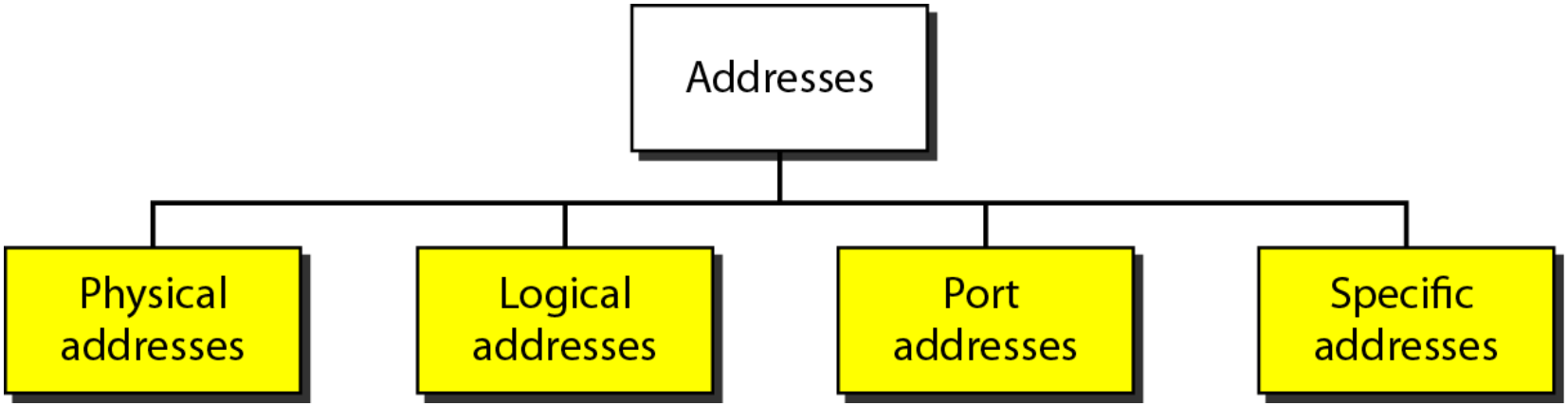
ADDRESSING

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

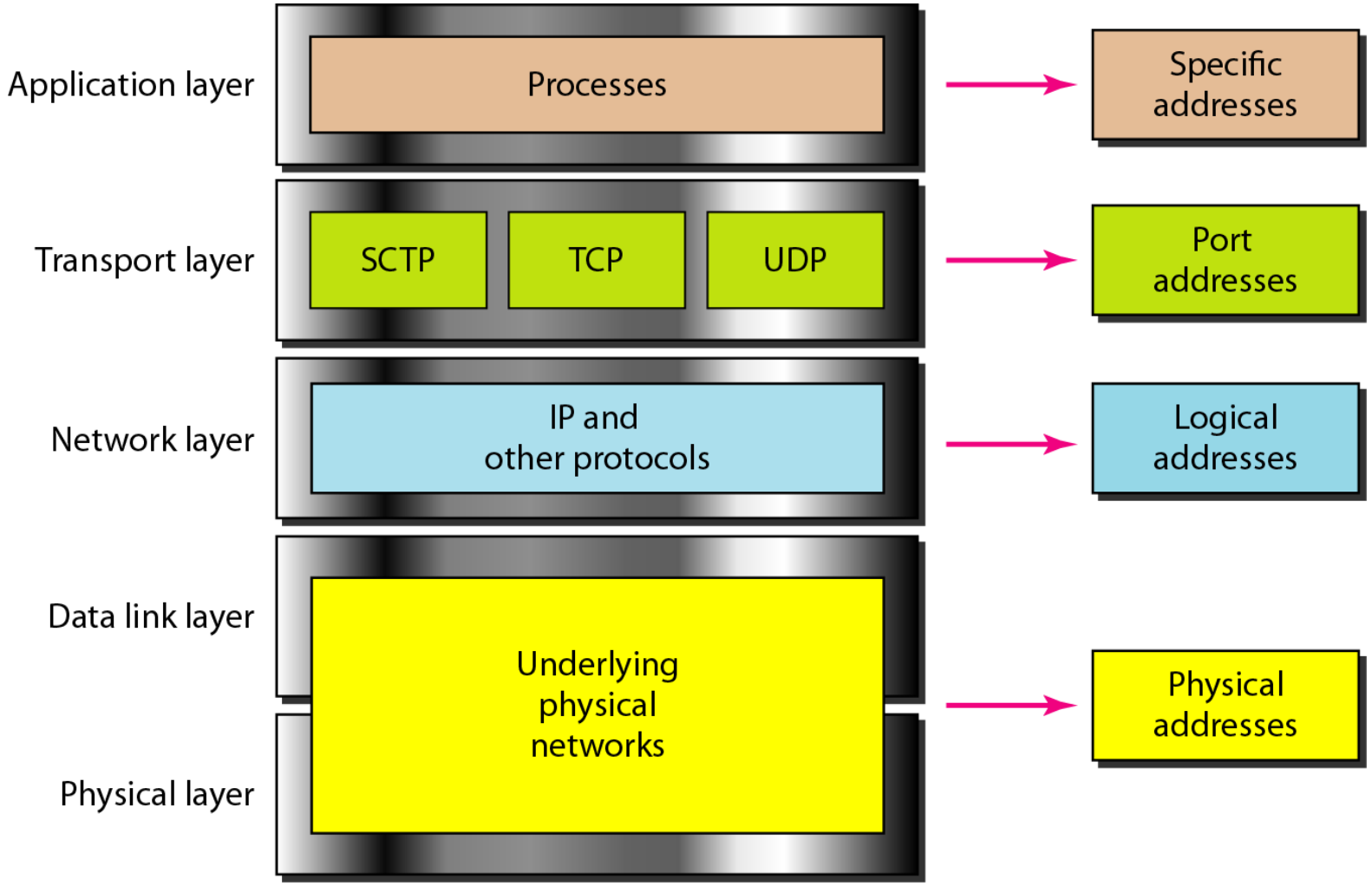
Topics discussed in this section:

Physical Addresses
Logical Addresses
Port Addresses
Specific Addresses

Addresses in TCP/IP

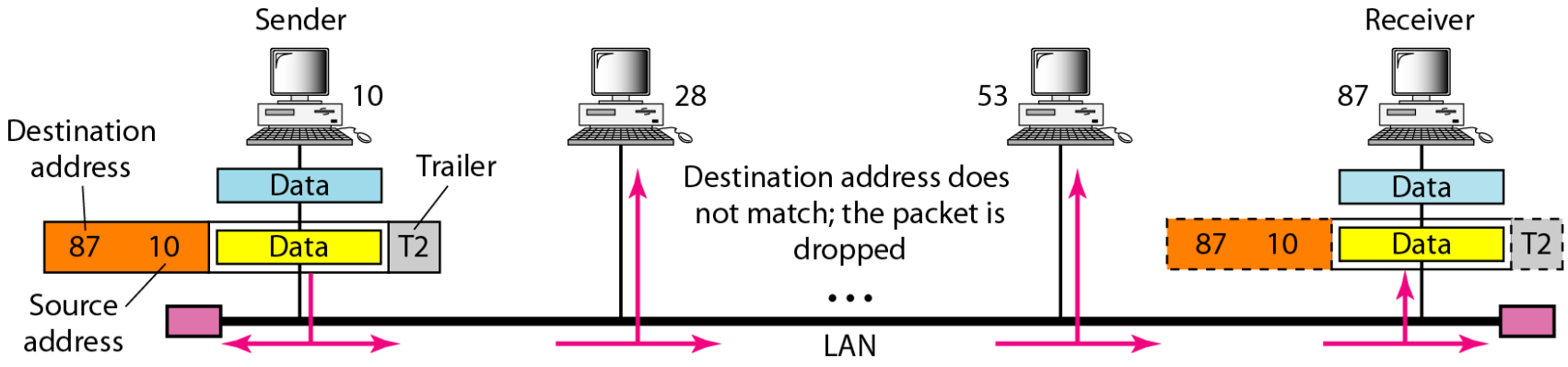


Relationship of layers and addresses in TCP/IP



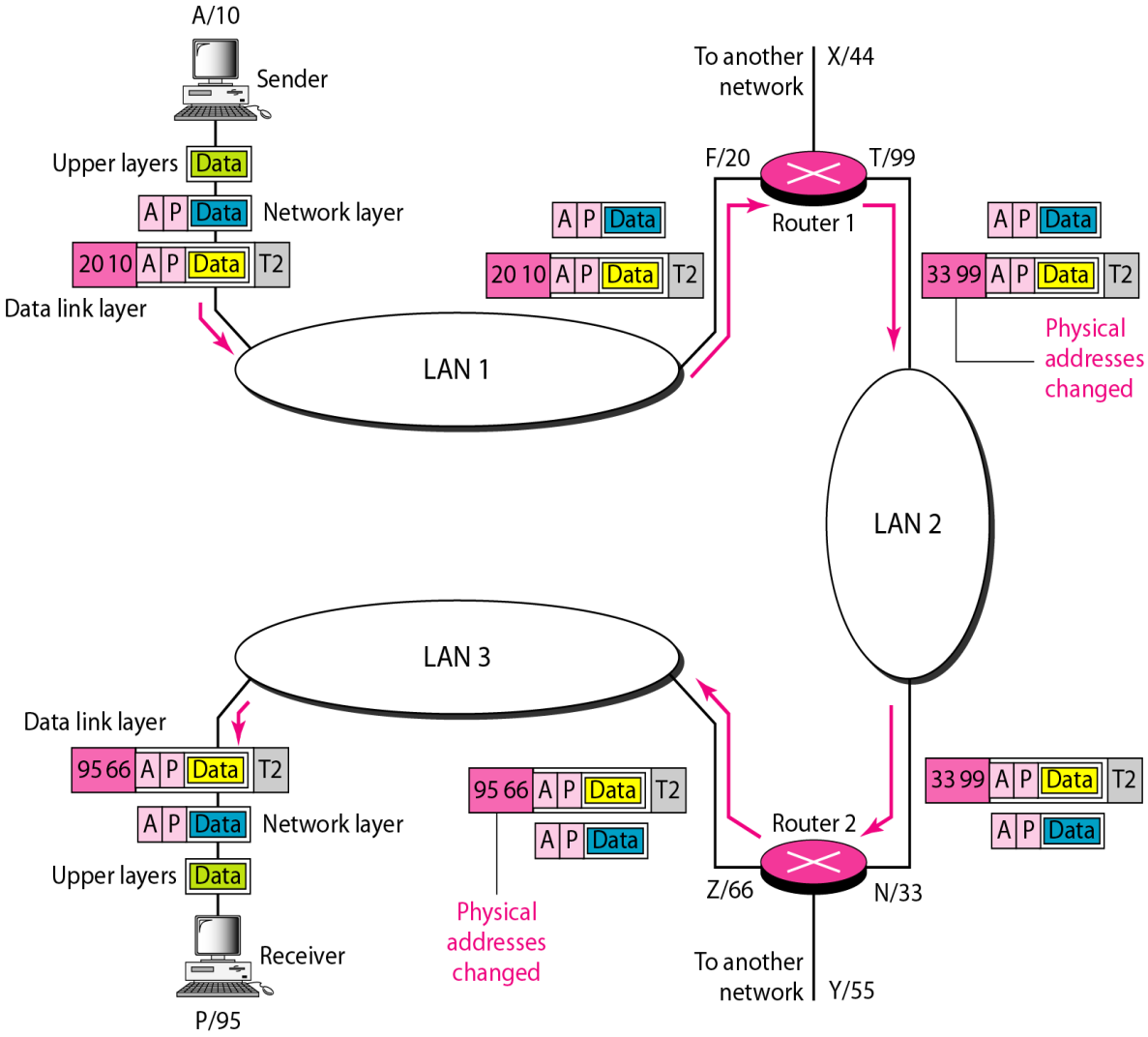
Example 1

In 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 (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.



Example 2

Figure 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.



Example 3

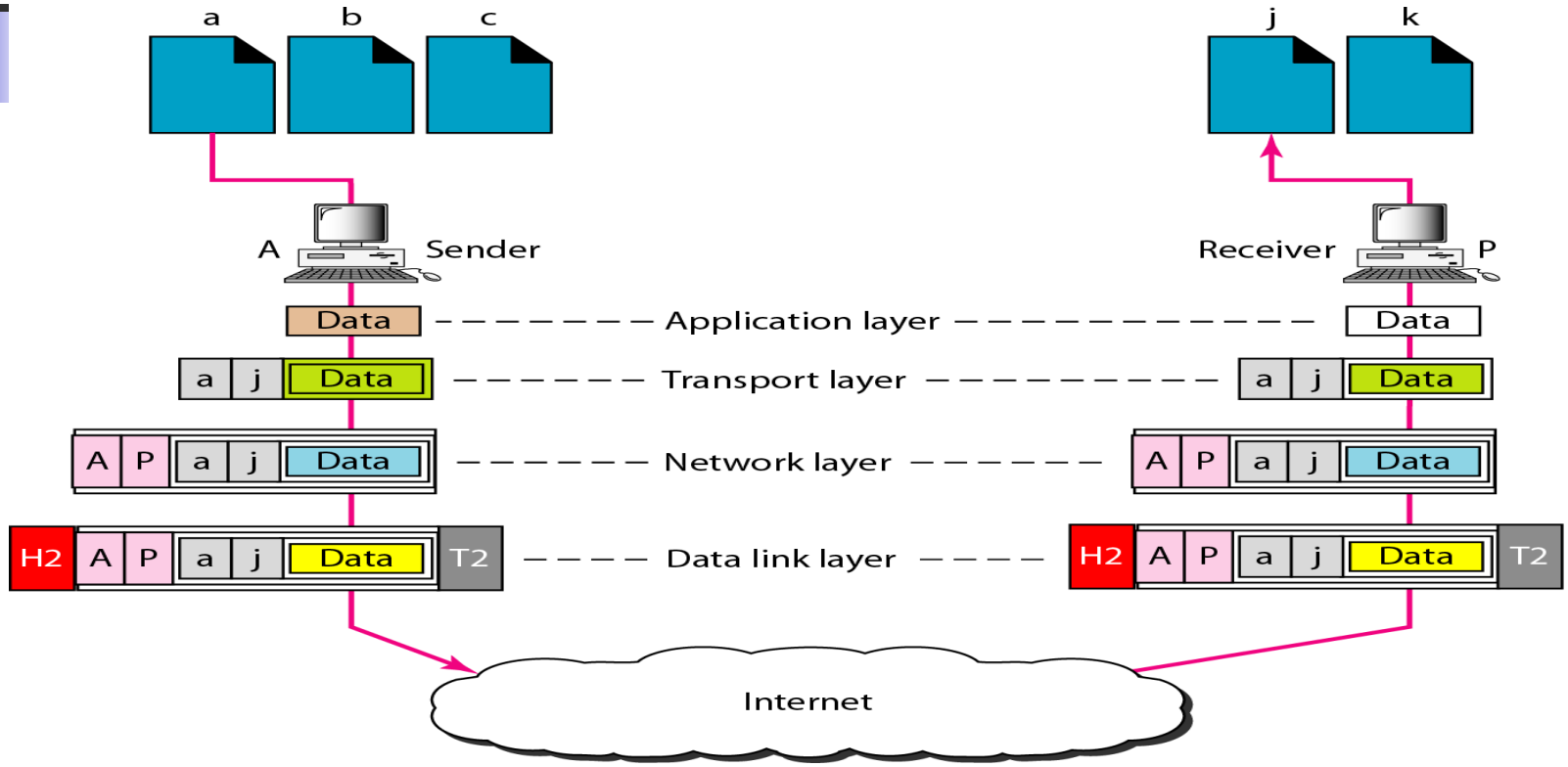


Figure shows two computers communicating via the Internet. The sending computer is running three processes at this time with port addresses a, b, and c. The receiving computer is running two processes at this time with port addresses j and k. Process a in the sending computer needs to communicate with 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.