Chapter 2: Network Models

The OSI Model

- Open Systems Interconnection (OSI).
- Developed by the International Organization for Standardization (ISO).
- It was first introduced in the late 1970s. An open system is a set of protocols that allows any two different systems to communicate regardless of their underlying architecture.
- Model for understanding and developing computer-to-computer communication architecture that is flexible, robust and interoperable.

- The purpose of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hard-ware and software
- It is not a protocol.
- Divides network architecture into seven layers.

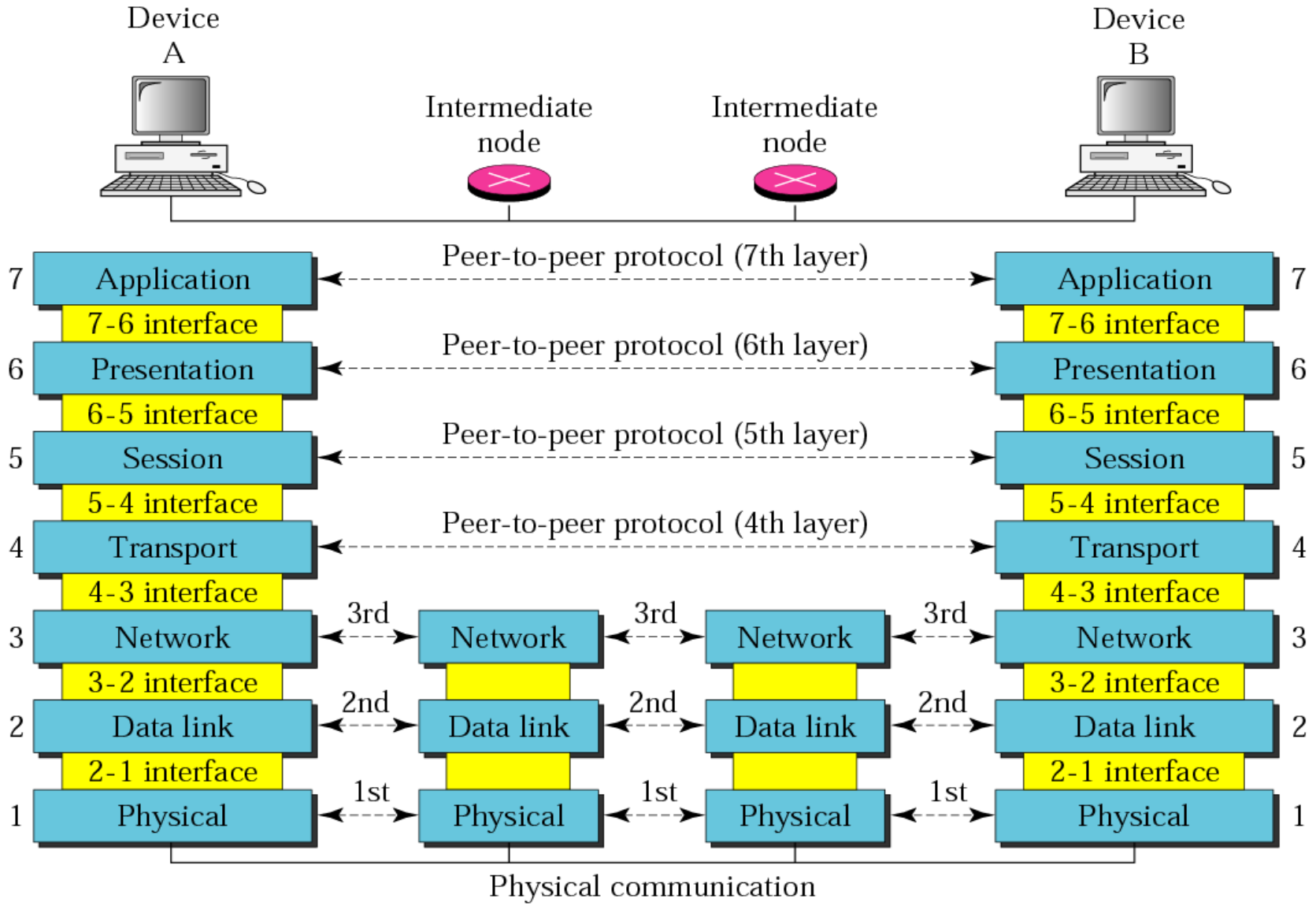
OSI cont.

- 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
- Changes in one layer should not require changes in other layers
- Layer 1,2,3 are the network support layer, deals with the physical aspects of moving data from one device to another.
- Layer 5,6,7 are the user support layer, allow the interoperability among unrelated software.
- Layer 4 ensures that what the lower layer have transmitted is in a form that the upper layers can use.

OSI layer

- Application layer
- Presentation layer
- Session layer
- Transport layer
- Network layer
- Data Link layer
- Physical layer
- a message is sent from device A to device B. As the message travels from A to B, it may pass through many intermediate LAYESRS.

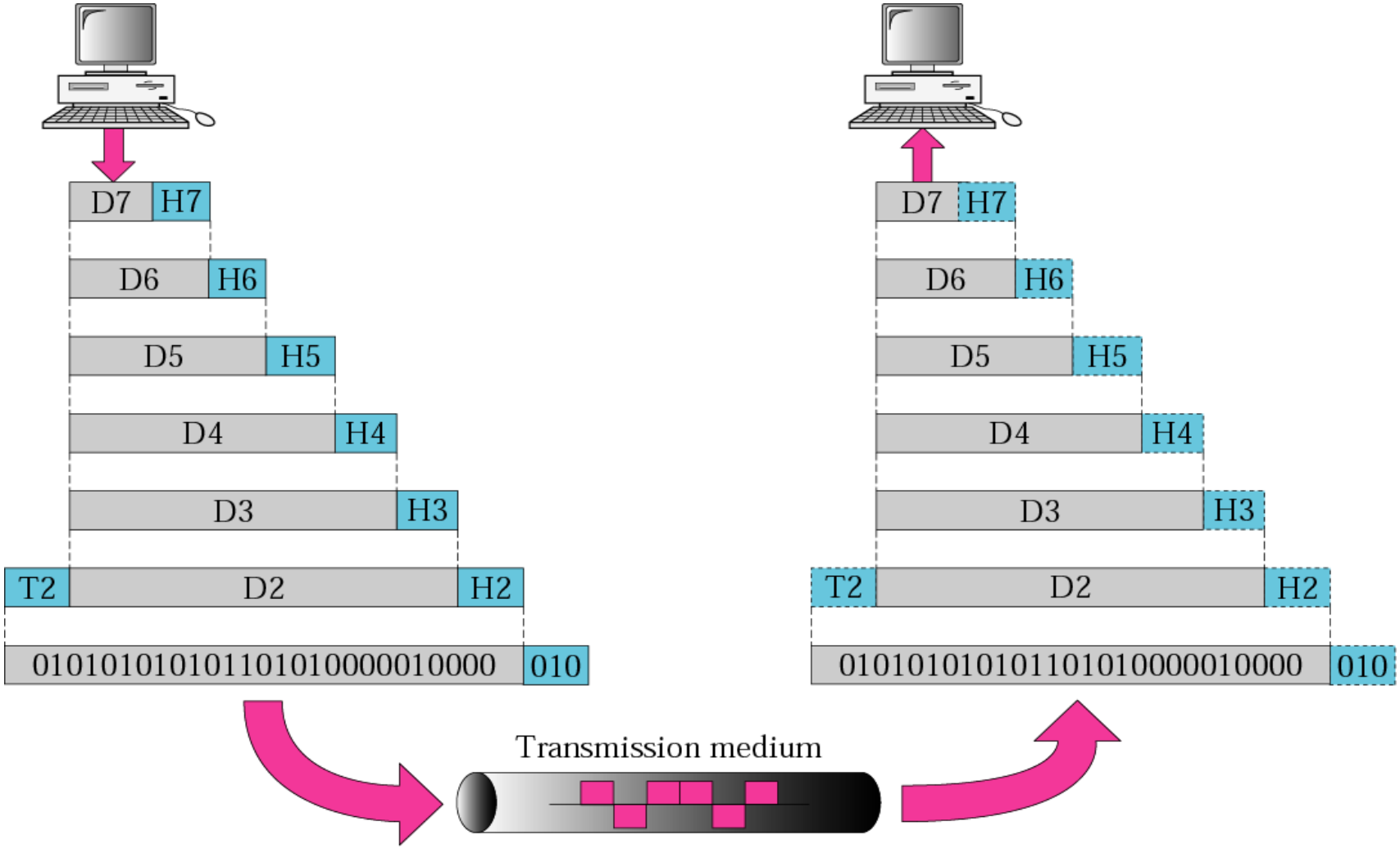
OSI layer


Device A
Device B
Intermediate node
Intermediate node
Peer-to-peer protocol (7th layer)
Peer-to-peer protocol (6th layer)
Peer-to-peer protocol (5th layer)
Peer-to-peer protocol (4th layer)
7 Application
7-6 interface
6 Presentation
6-5 interface
5 Session
5-4 interface
4 Transport
4-3 interface
3 Network
3-2 interface
2 Data link
2-1 interface
1 Physical
3rd
2nd
1st
Physical communication

Peer to peer process

- At the physical layer, communication is direct: In Figure 2.3, device A sends a stream
- of bits to device B (through intermediate nodes). At the higher layers, however, communication must move down through the layers on device A, over to device B,
- 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.

An exchange using the OSI model



- Interfaces Between Layers
  - It passes a data and network information between a adjacent layers.

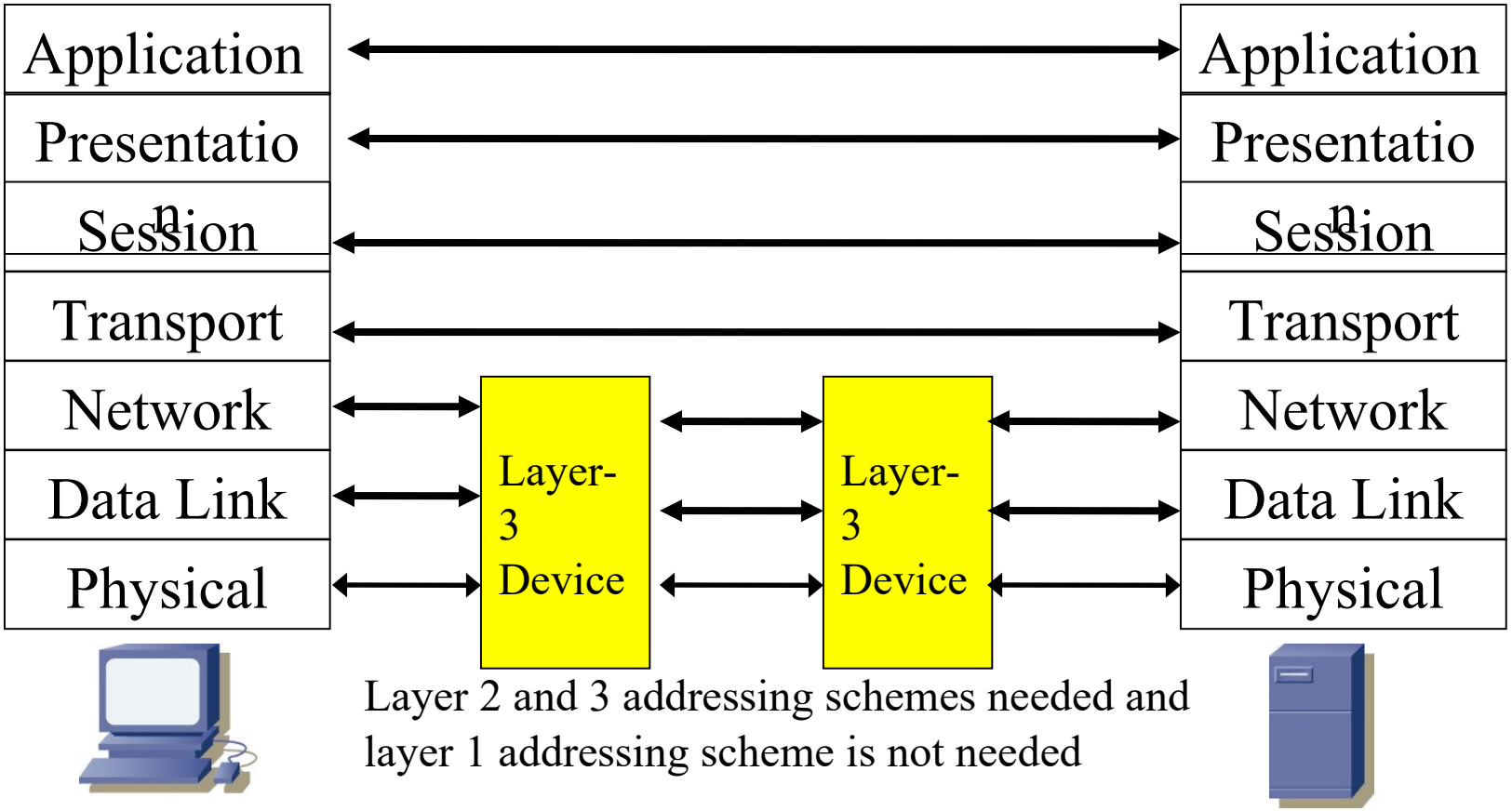
Protocol Data Units (PDU)

- At each layer, protocols are used to communicate
- Control information is added to user data at each layer
- For example, the transport layer may fragment user data
- Each fragment has a transport header added
  - Destination Address
  - Sequence number
  - Error detection code
- This creates a *transport protocol data unit (TPDU)*

Organization of the Layers

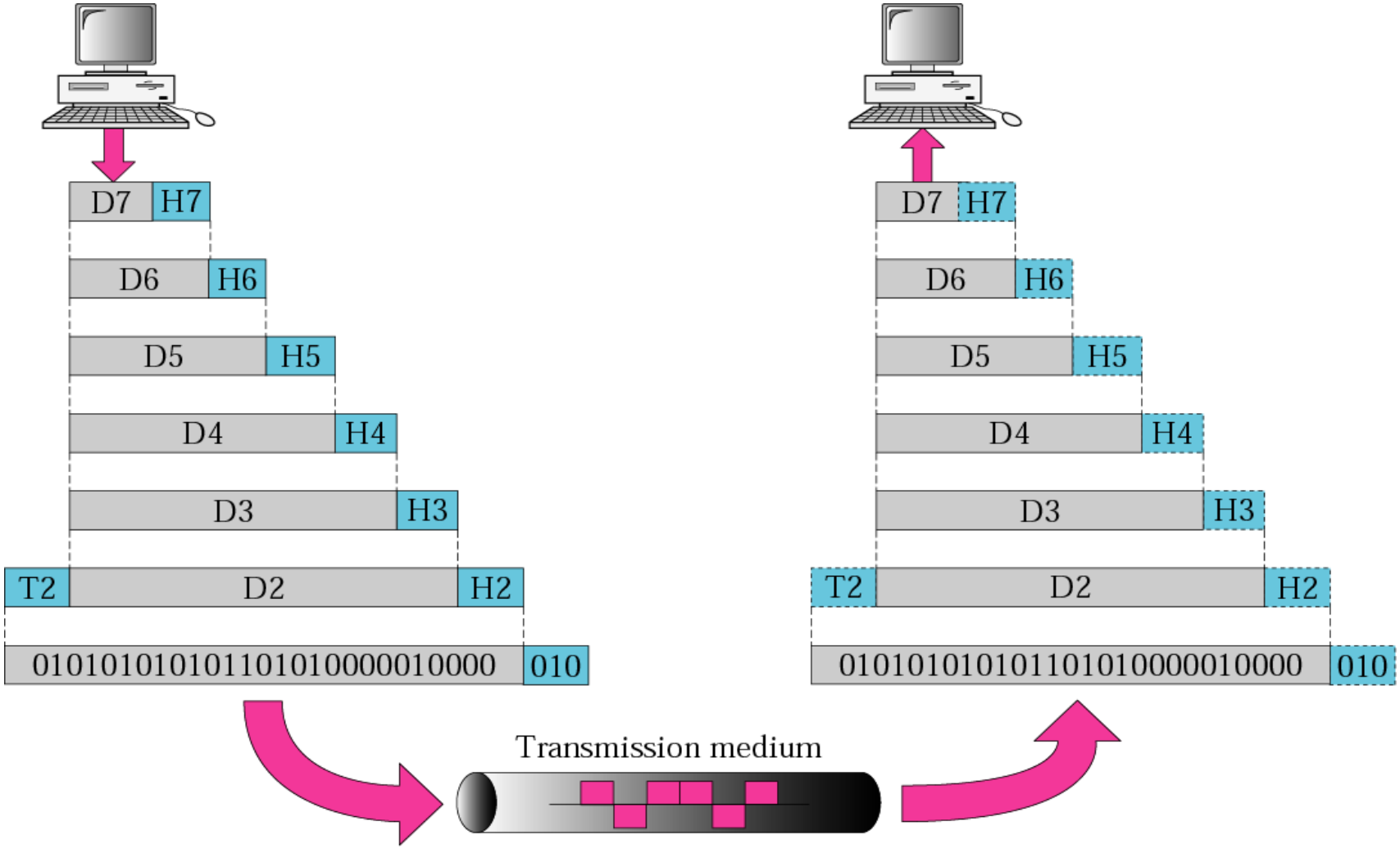
- The seven layers can be thought of as belonging to three subgroups.
- Layers I, 2, and 3-physical, data link, and network-are the network support layers; they deal with the physical aspects of moving data from one device to another (such as electrical
- specifications, physical connections, physical addressing, and transport timing and reliability).
- Layers 5, 6, and 7-session, presentation, and application-can be thought of as the user support layers; they allow interoperability among unrelatedsoftware systems
- Layer 4, the transport layer, links the two subgroups and ensures that what the lower layers have transmitted is in a form that the upper layers can use

Layer 1,2,3



Layer 2 and 3 addressing schemes needed and layer 1 addressing scheme is not needed

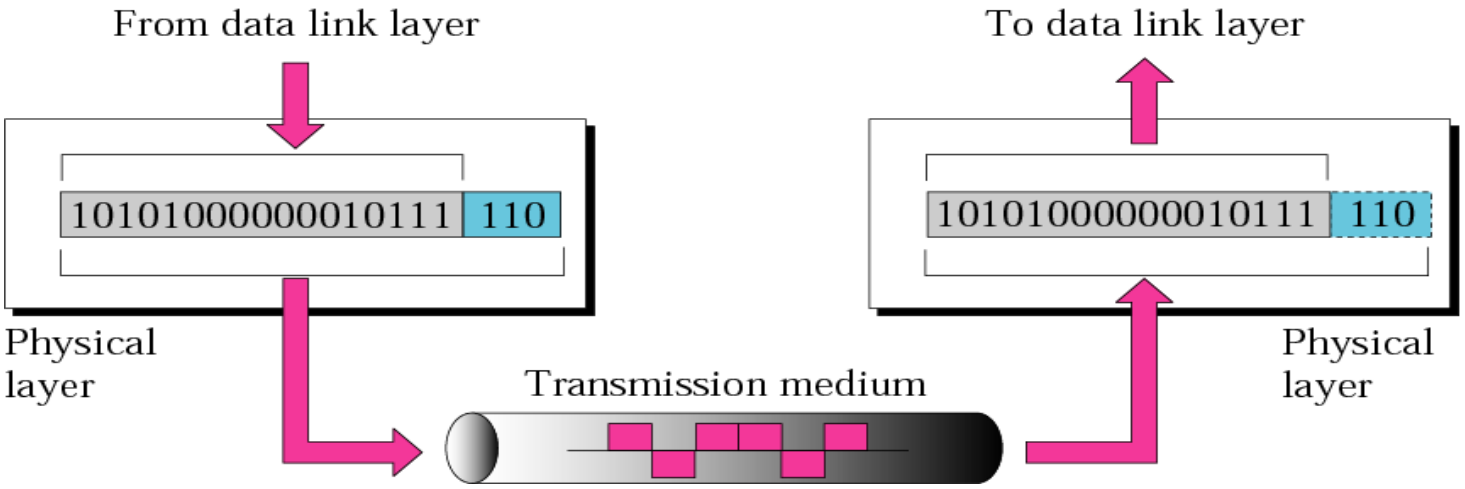
An exchange using the OSI model

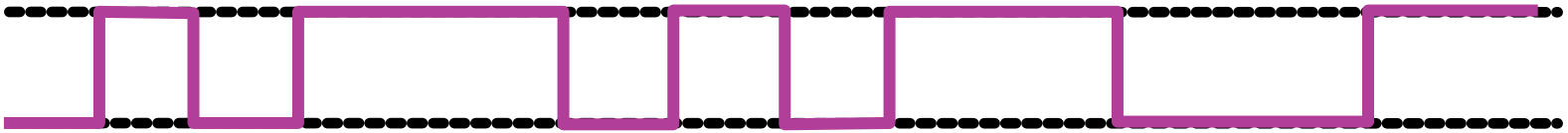


Layer 1: Physical Layer

- Responsible of:
  - Transmitting individual bits from one to the next node.
  - It also defines the procedures and functions that physical devices and interfaces have to perform for transmission
  - It deal with Physical characteristics of interface and media. It also defines the type of transmission medium
  - Representation of bits: a stream of bit(0s,1s),
  - Data rate : number of bit sent at each second is defined by this layer.
  - Synchronize of bits : he sender and receiver not only must use the same bit rate but also must be synchronized at the bit level

Physical Layer cont.





Physical Layer cont.

- Line configuration
  - In a point-to-point configuration, two devices are connected through a dedicated link.
  - In a multipoint configuration, a link is shared among
- Physical topology
  - It defines how devices are connected to
  - make a network.
- Transmission mode
  - The physical layer also defines the direction of transmission between two devices: simplex, half-duplex, or full-duplex.

Layer 2: Data Link layer

Responsible of:

Moving frames from one hop (node) to the next.

1. Framing: divided the stream of bits received from the network layer manageable data units called frames.

2. Physical address (MAC address). :

It adds the header to the frame to define the sender and receiver of the frame. If frame is intended for a system outside the sender network , the receiver address is the address of the device that connect the network to next network.

2. Flow control :

3. Flow Control :

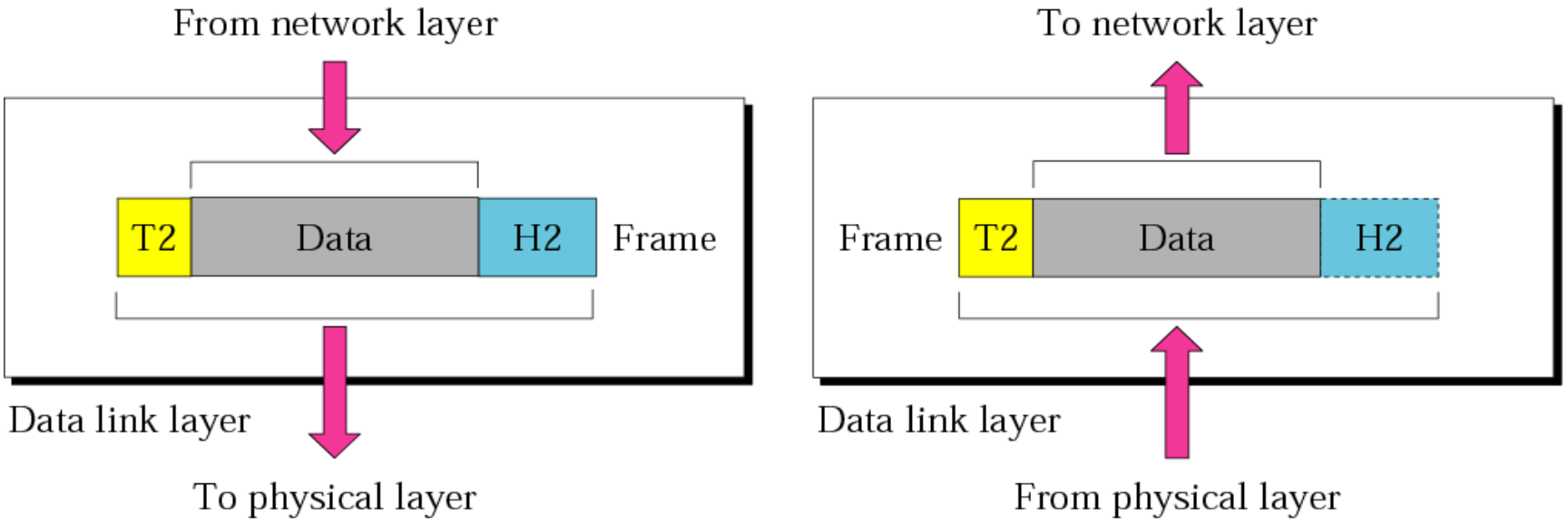
If the rate at which the data are absorbed by the receiver is less than the rate at which data are produced in the sender , it applies the data flow control mechanism to avoid over whelming the receiver.

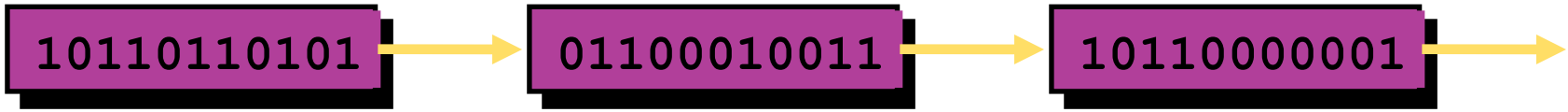
4. Error Control :

Data link layer adds reliability to the physical layer by adding mechanisms to detect and retransmit damage or lost frames.

Error control is normally achieved through a trailer added to the end of the frame.

Data Link layer cont.





Hop to hop delivery:

Communication at data link layer occurs between two adjacent nodes.

To send data frame from A to F. three partial deliveries are made.

A send data frame to datalink layer at B(router)

B sends a new frame to the datalink layer at E.

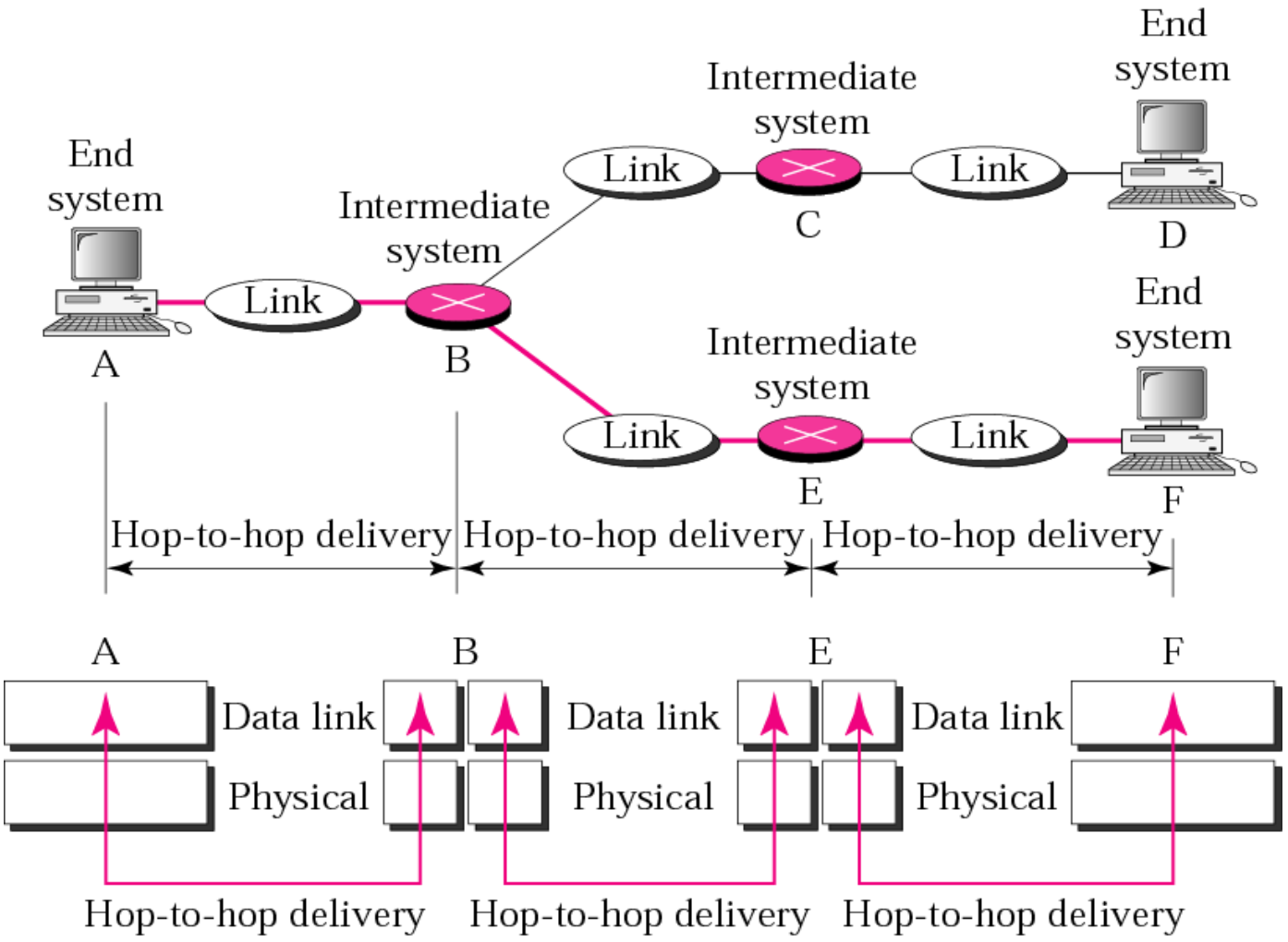
E sends a new frame to data link layer at F.

Frame that are exchanged between the nodes have different headers value.

For e.g data frame from A to B . has B as a destination address,

e.g data frame from B to E . has E as destination address.

Hop-to-Hop delivery



Layer 3: Network Layer

- Responsible for source to destination delivery of a packet across multiple network whereas the data link layer deliver the frames between two system in same network.
- If two systems connected to the same link , no need for network layer.
- The network layer is responsible:
  - The delivery of individual packets from the original source to the final destination .
  - Logical addressing: if the packet passes the network boundary we need another addressing system to help (source to destination) connection. Network layer adds header to the packet coming from the upper layer
  - It includes the logical address of sender and receiver

Routing :

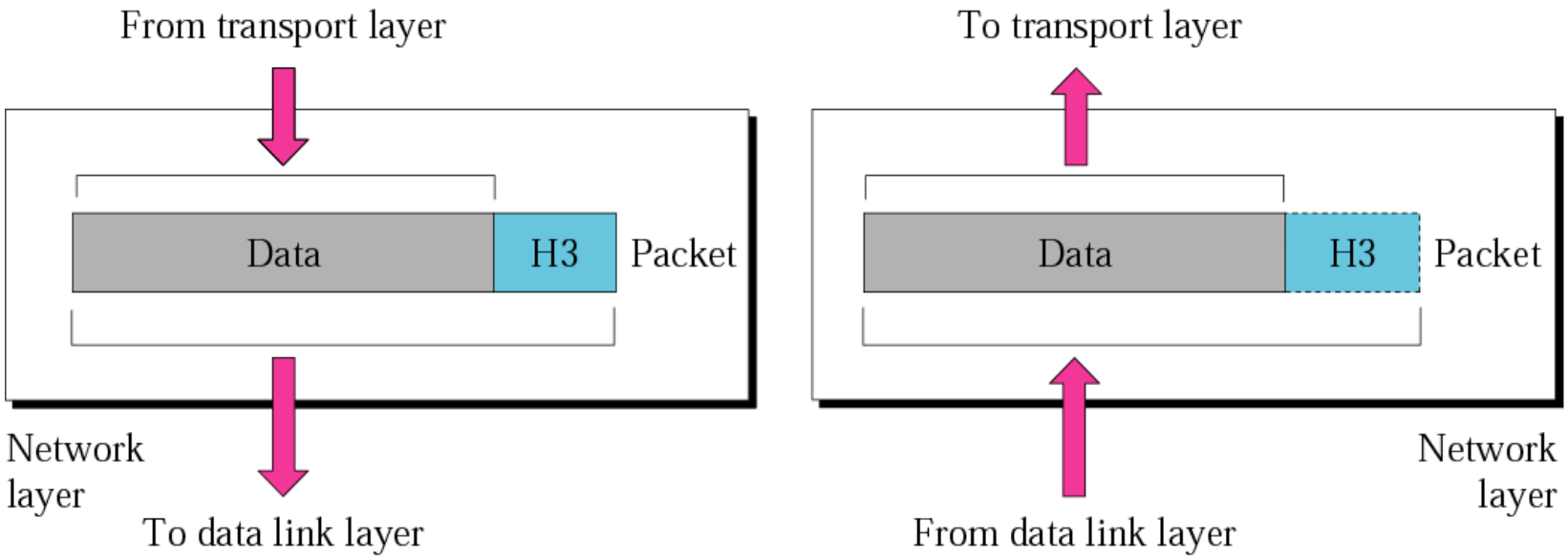
when independent networks or links are connected to create intemetworks(network of networks) or a large network, the connecting devicesroute or switch the packet to final destination.

Source-to-destination delivery (End-to-End).

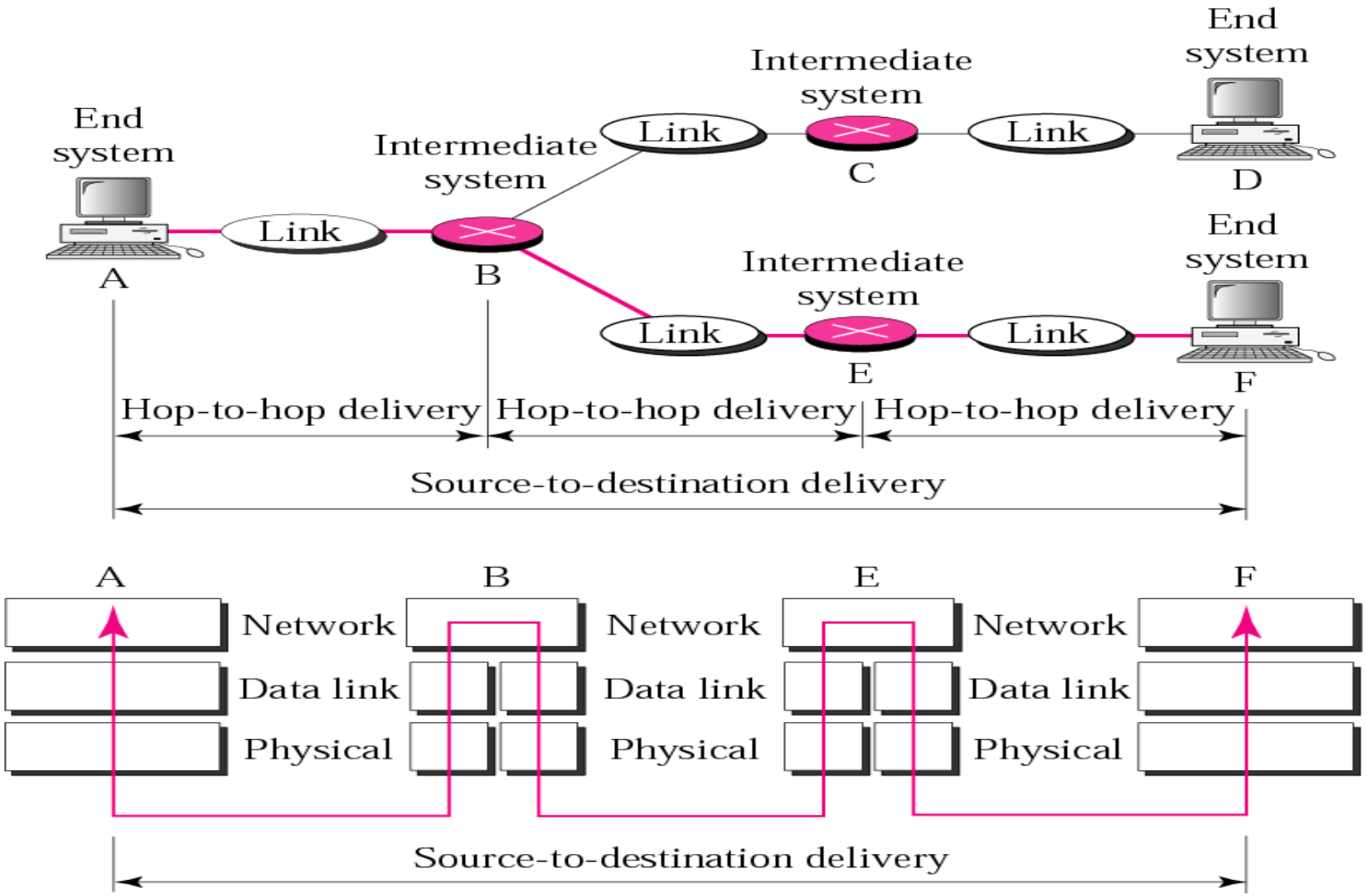
A send packet to B . When the packet arrives at B , the router make a decision based on final destination.

Router B is using routing table to find the next router E.

Network Layer cont.



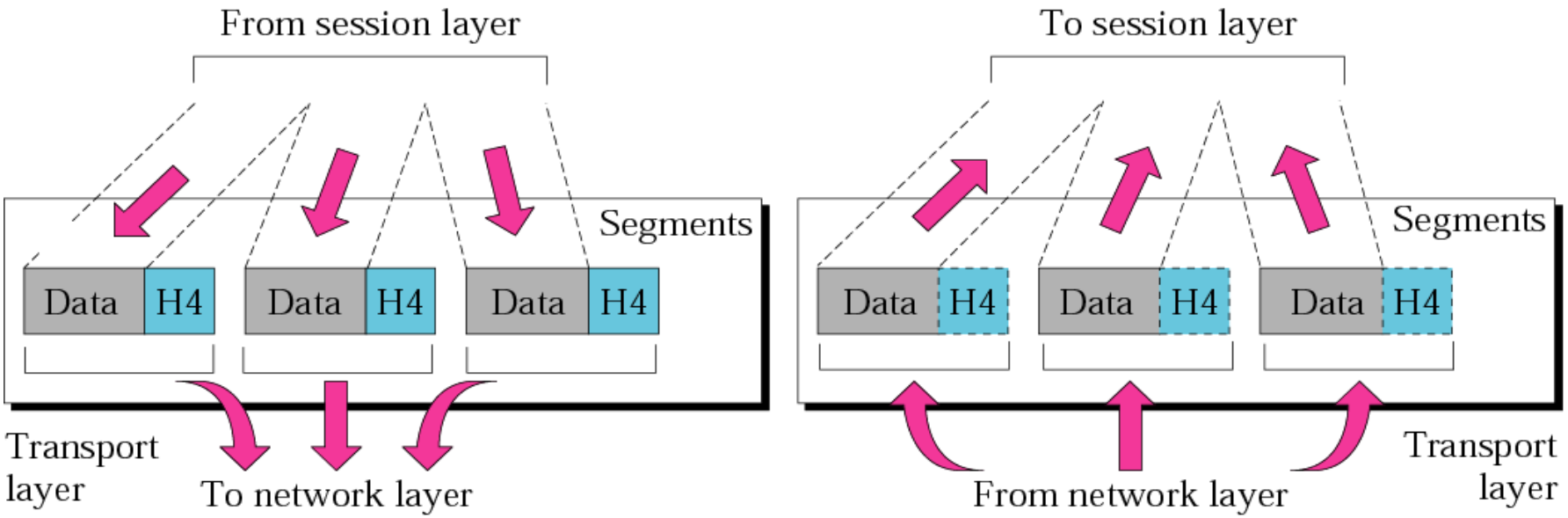
Source-to-Destination delivery



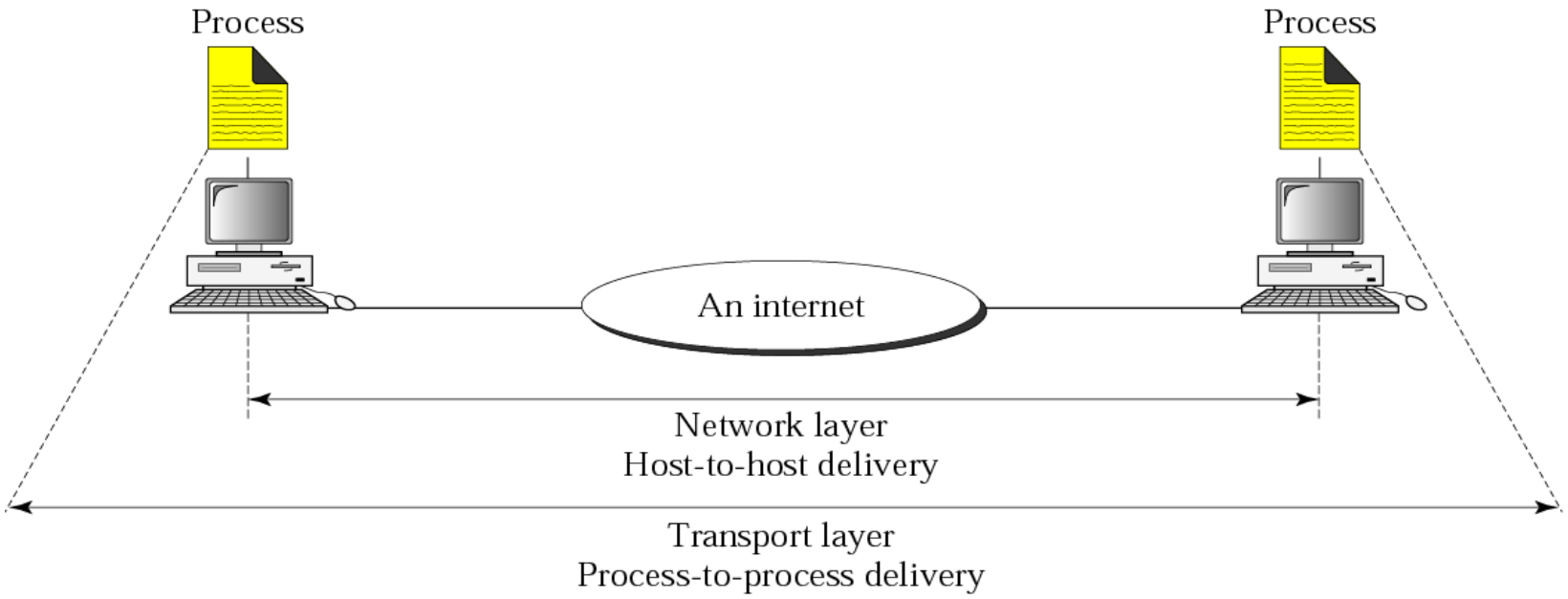
Layer 4: Transport Layer

- Transport layer is responsible for process to process delivery of entire message.
- process is an application program running on a host. Whereas the network layeroversees 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, whether or not it does.
- The transport layer, ensures that the whole message arrives intact and in order, overseeing both error control and flow control at the source-to-destination level

Transport Layer cont.



Reliable process-to-process delivery of a message



- The transport layer is responsible for:
  - **Service point or Port a**ddressing
  - Computers often run several programs at the sametime. For this reason, source-to-destination delivery means delivery not only from one computer to the next but also from a specific process (running program) on one computer to a specific process (running program) on the other
  - The transportlayer header must therefore include a type of address called a service-pointaddress (or port address).

- The network layer gets each packet to the correct computer; the transport layer gets the entire message to the correct process on computers
- **Segmentation and reassembly** : a message is divided into transmittable segments each segment containing a sequence no.
- These numbers enable the trans-port layer to reassemble the message correctly upon arriving at the destination and to identify and replace packets that were lost in transmission.

Transport layer cont.

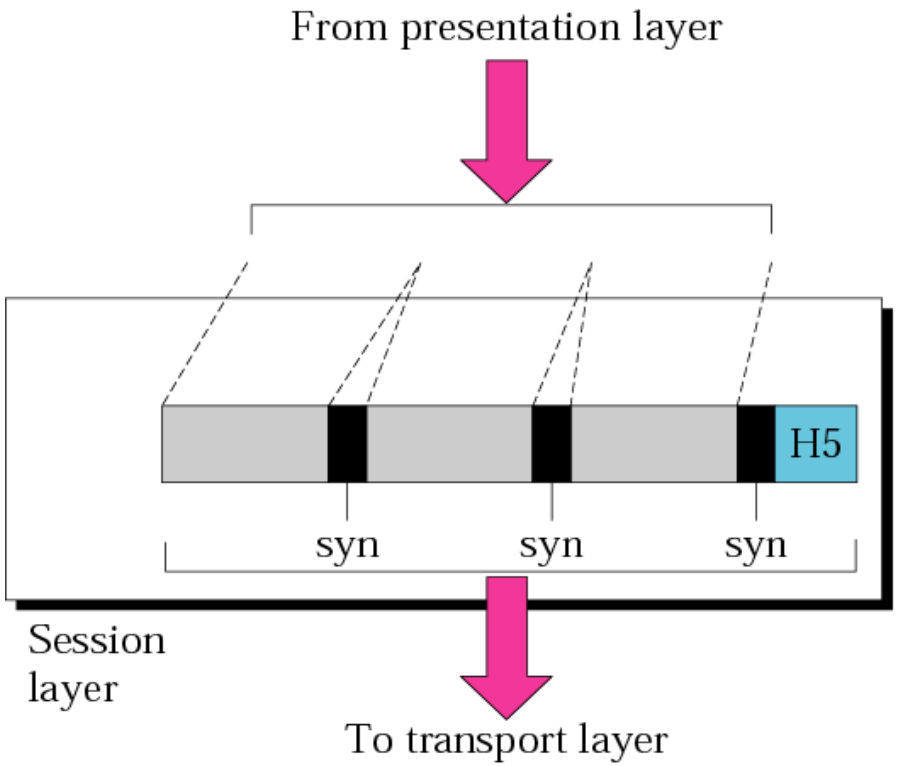
- **Connection Control**: connection oriented or connectionless.
- A connectionless transport layer treats each segment as an independent packet and delivers it to the transport layer at the destination machine. In Connection oriented once all packets transfer then connection will be terminate. (connection between source to destination transport layers)
- **Flow control** : layer responsible for flow control
- Error control : The sending transport layer makes sure that the entire message arrives at the receiving transport layer without error
- (damage, loss, or duplication).

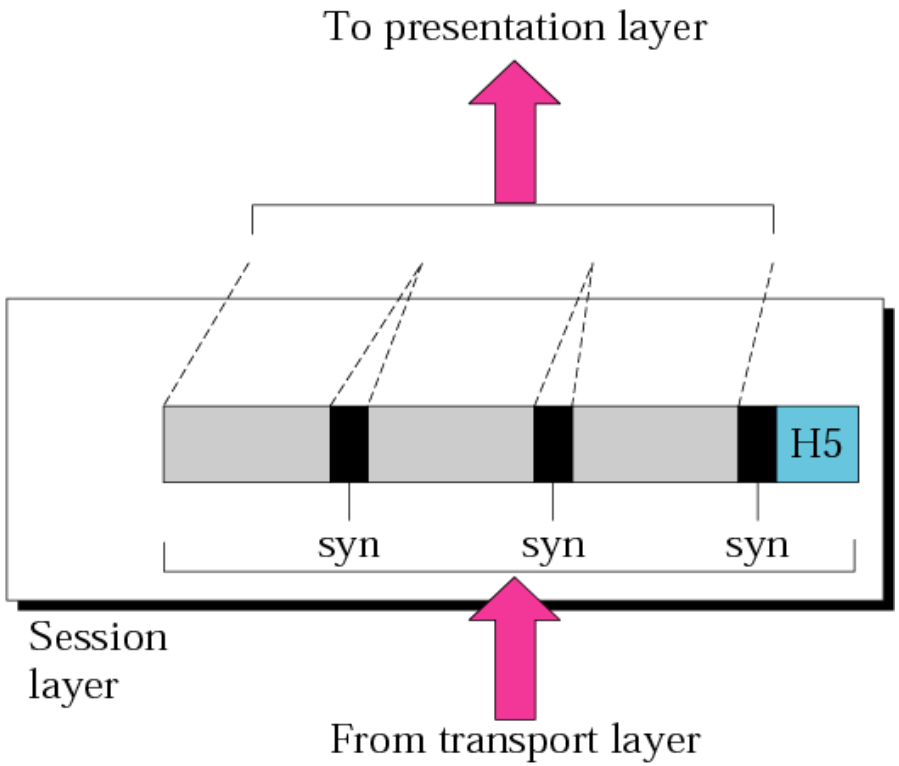
Layer 5: Session Layer

- Dialog control: design to establish, maintain, and synchronize the interaction between communicating systems.
  - It allows the communication between two processes to take place in either half-duplex (one way at a time) or full-duplex (two ways at a time) mode.
- Synchronization: it allows a process to add checkpoints or synchronization points to a data stream.

  if a system is sending a fileof 2000 pages, it is advisable to insert checkpoints after every 100 pages to ensure that each 100-page unit is received and acknowledged independently.

Session Layer cont.

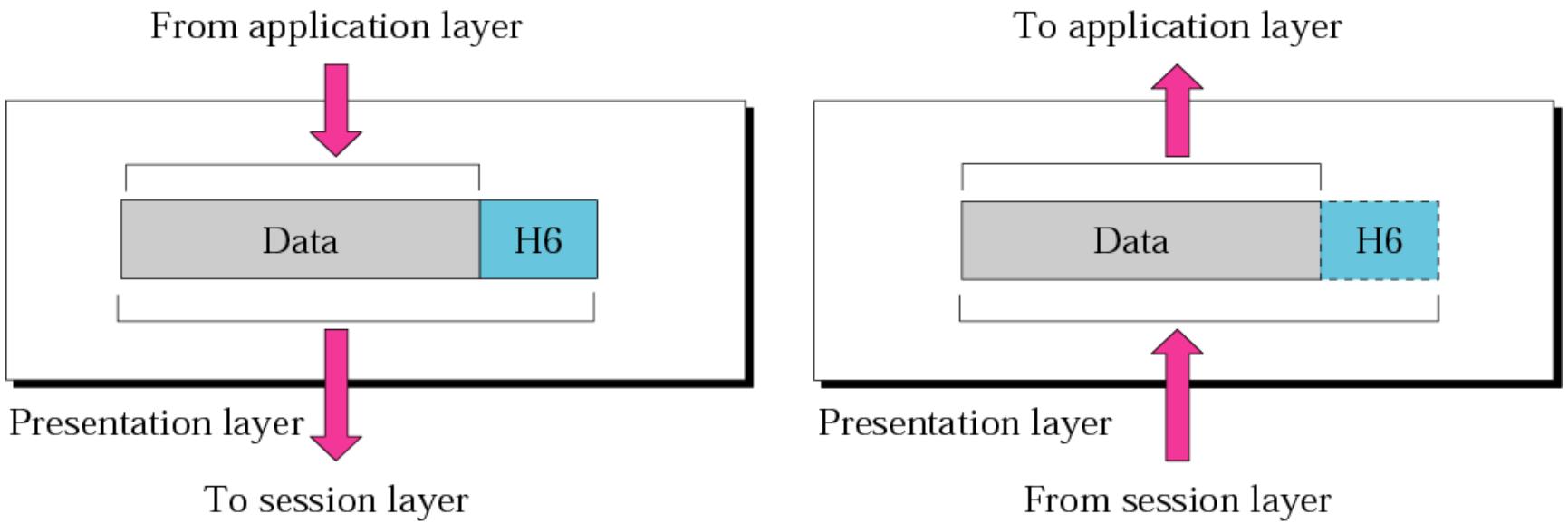




Layer 6 :Presentation Layer

- Design to the handle the syntax and semantic of the information exchanged between 2 systems.
- And design for data translation, encryption, decryption, and compression.
- Translation : different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding methods.
- Compression : Data compression becomes particularly important in the transmission of multimedia such as text, audio, and video.

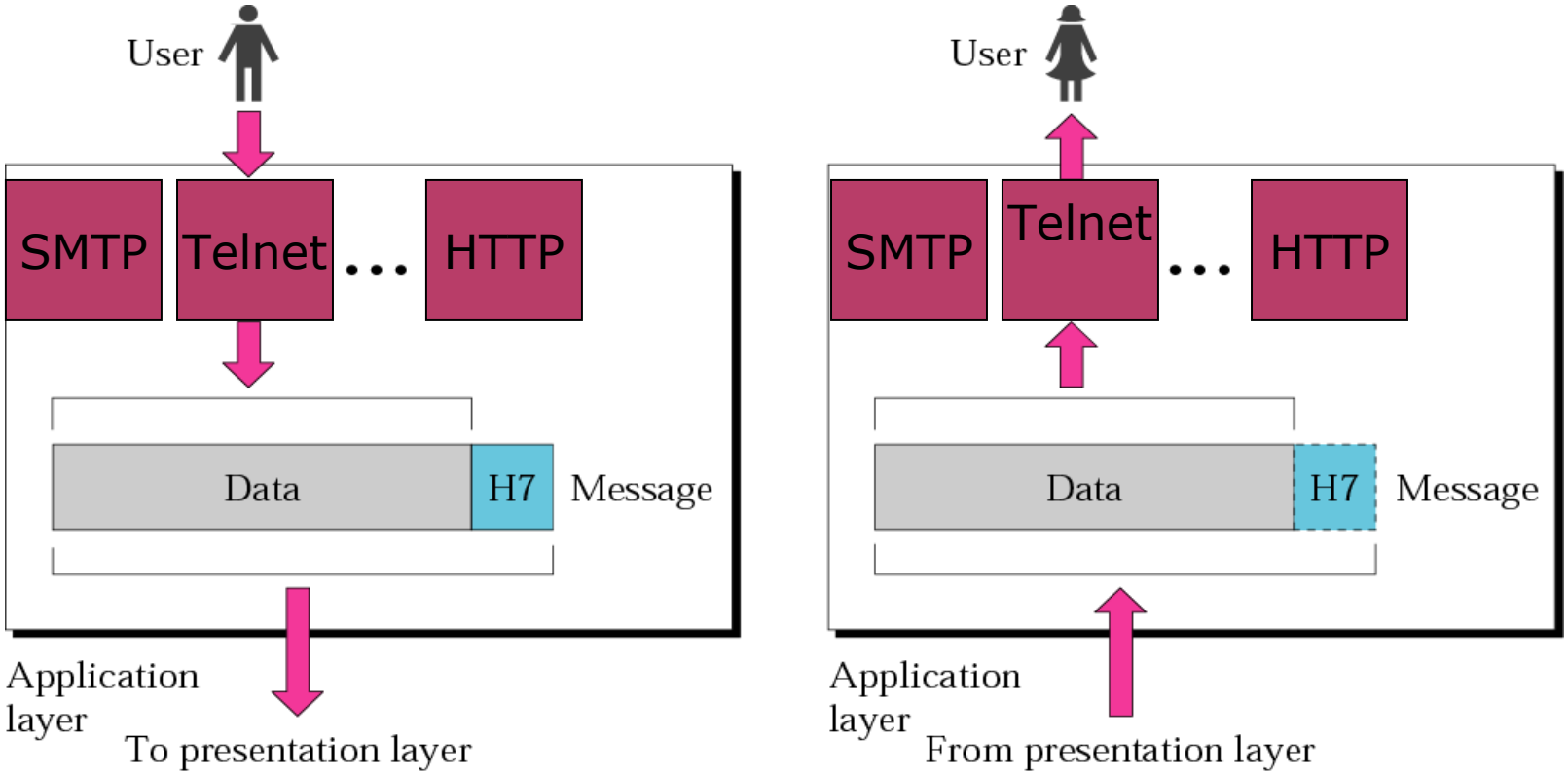
Presentation Layer cont.



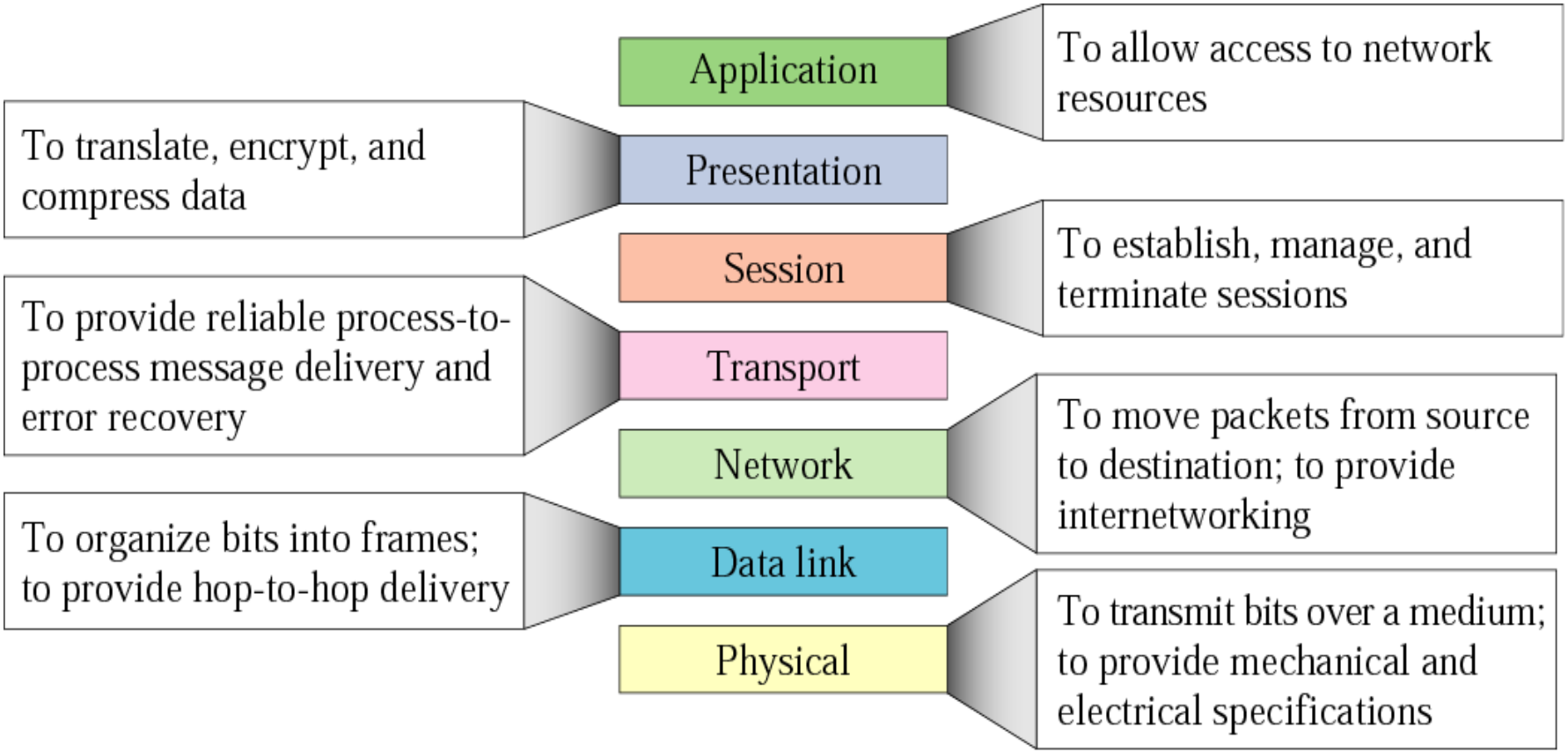
Layer 7: Application Layer

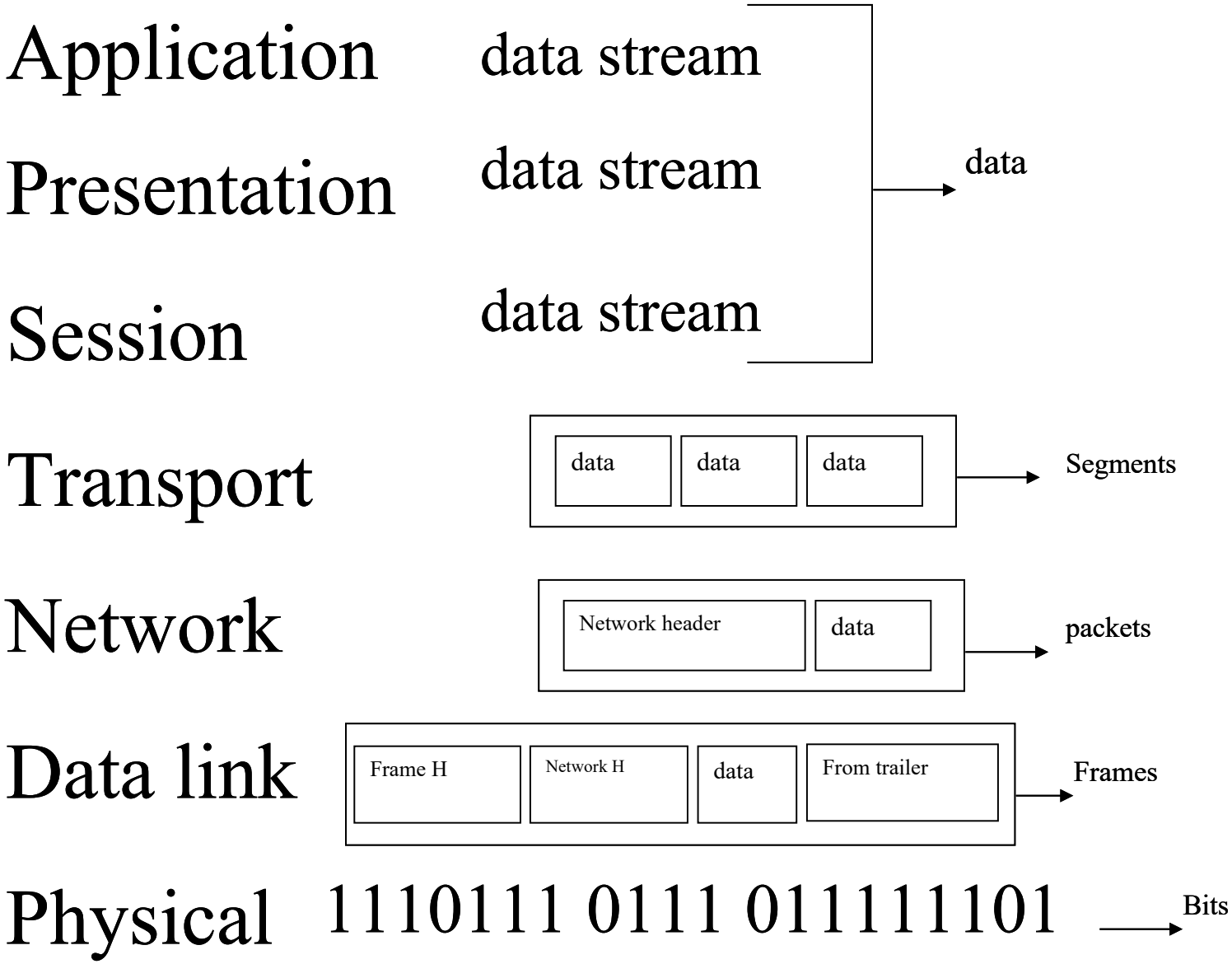
- The application layer is responsible for providing services to the user.
- Mail services
- File transfer, access and management
- Remote log-in or network virtual terminal
- Accessing the World Wide Web
- Directory service

Application Layer cont.



Summary

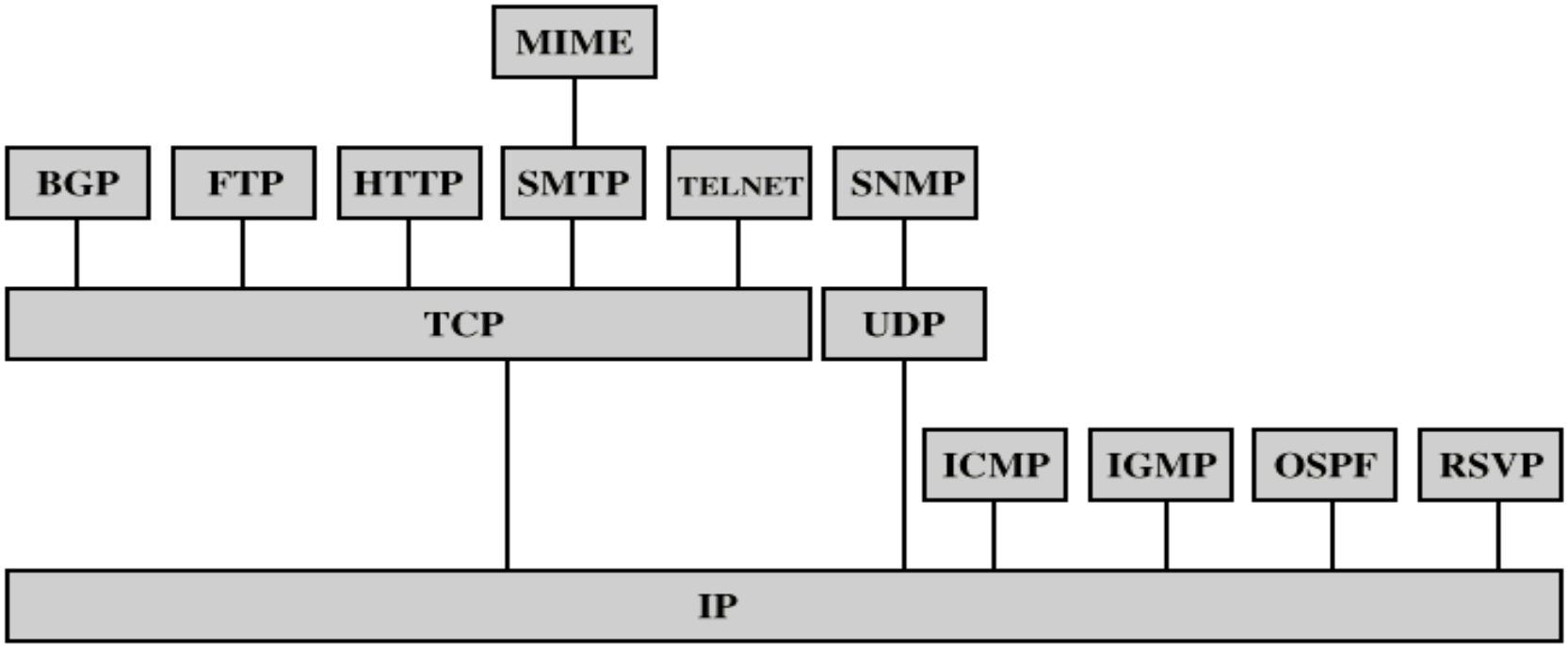

Application
To allow access to network resources
To translate, encrypt, and compress data
Presentation
Session
To establish, manage, and terminate sessions
To provide reliable process-to-process message delivery and error recovery
Transport
Network
To move packets from source to destination; to provide 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


Application
data stream
Presentation
data stream
Session
data stream
data
Transport
data
data
data
Segments
Network
Network header
data
packets
Data link
Frame H
Network H
data
From trailer
Frames
Physical
1110111 0111 011111101
Bits

TCP/IP Protocol Suite

- The TCP/IP protocol suite is a hierarchical protocol , made of five layers:
  - Physical layer
  - Data link layer
  - Network layer
  - Transport layer
  - Application layer.

Some Protocols in TCP/IP Suite



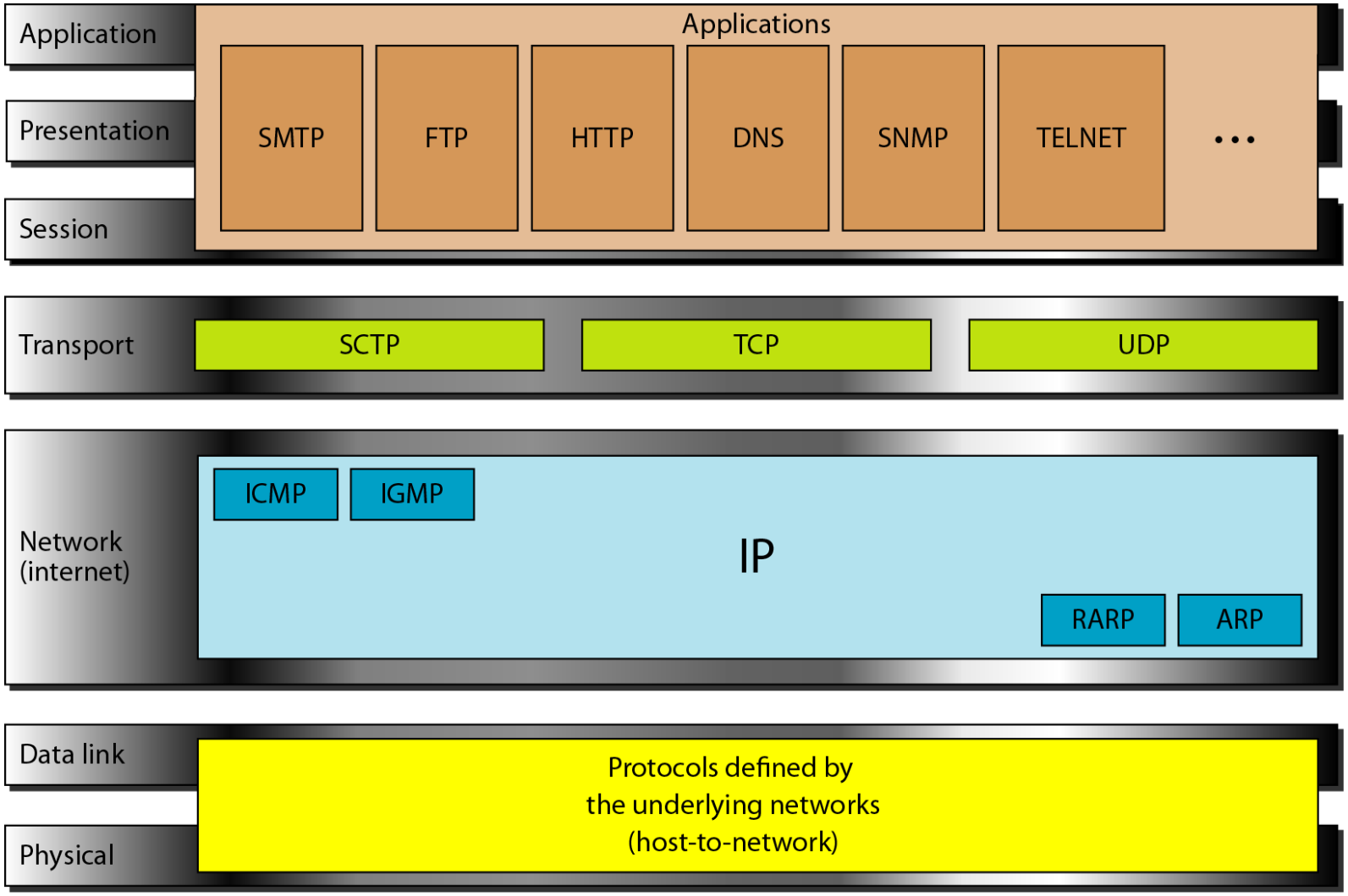
BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension

OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

TCP/IP PROTOCOL SUITE

- The layers in the TCP/IP protocol suite do not exactly match those in the OSI model.
- 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 and OSI model



- Network Layer

Internetworking Protocol (IP)

  - IP transports data in packets called datagrams, each of which is transported sepa-rately. Datagrams can travel along different routes and can arrive out of sequence or beduplicated.
  - IP does not keep track of the routes and has no facility for reordering data-grams once they arrive at their destination.
- ARP
  - ARP is used to find the physical address of the node when its Internet address is known.
- internet Control Message Protocol
  - ICMP sends query and error reporting messages back to sender

Internet Group Message Protocol

The Internet Group Message Protocol (IGMP) is used to facilitate the simultaneous transmission of a message to a group of recipients.

Transport Layer

- Traditionally the transport layer was represented in TCP/IP by two protocols: TCP and UDP.
- UDP and TCP are transport level protocols responsible for delivery of a message from a process (running program) to another process

TCP : TCP is a reliable stream transport protocol. The term stream,

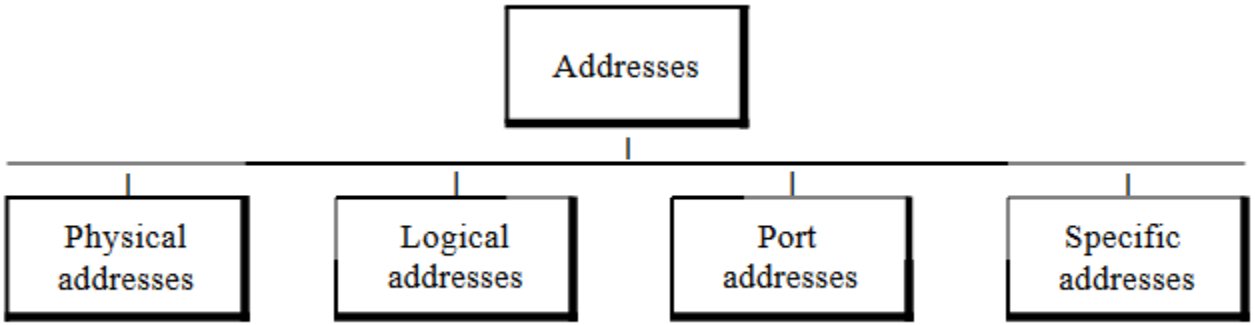
in this con-text, means connection-oriented: A connection must be established between both ends of a transmission before either can transmit data.

TCP divides a stream of data into smaller

units called segments. Each segment includes a sequence number for reordering after receipt, together w

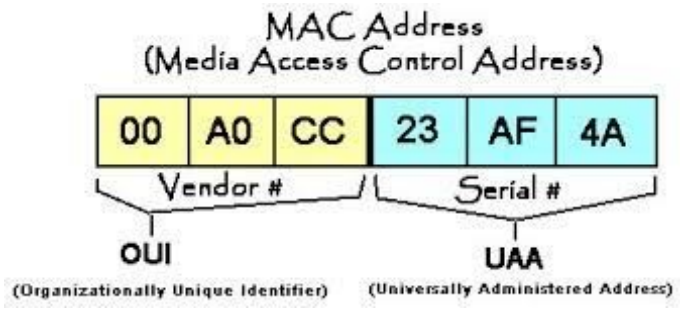
ADDRESSING

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

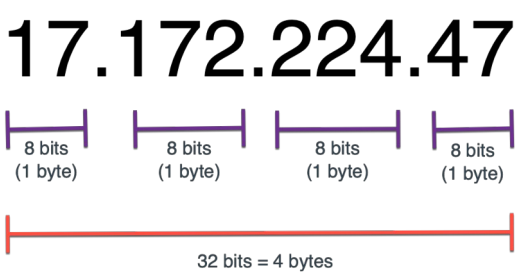


- Each address is related to a specific layer in the TCPIIP architecture

co_sci@yahoo.com) and the Universal Resource Locator (URL) (for example, www.mhhe.com).



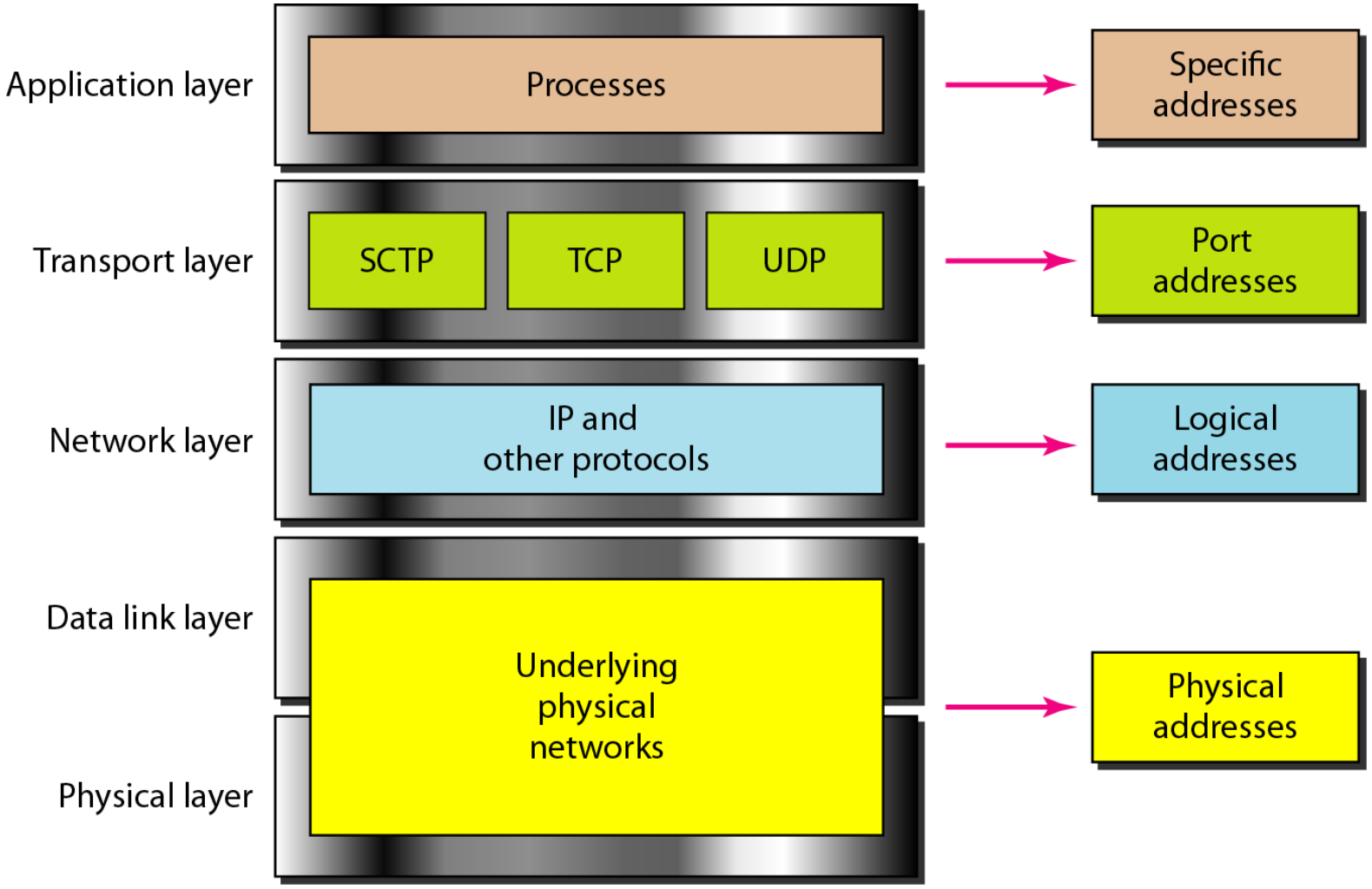
IPv4 Address Example



Logical address

Physical Address

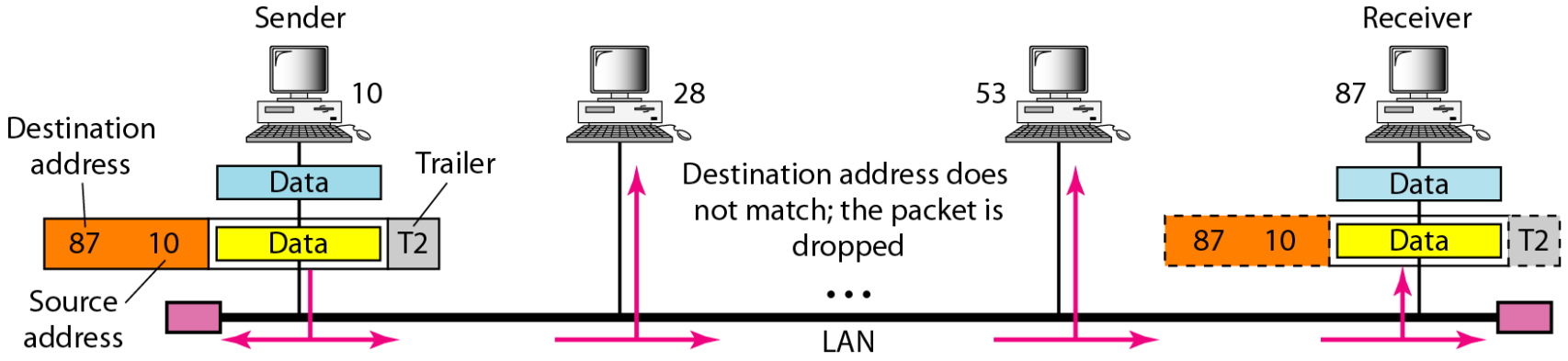
Relationship of layers and addresses in TCP/IP



SCTP: Stream Control Transmission Protocol
TCP: Transmission Control Protocol
UDP: User Datagram Protocol

Example 2.1

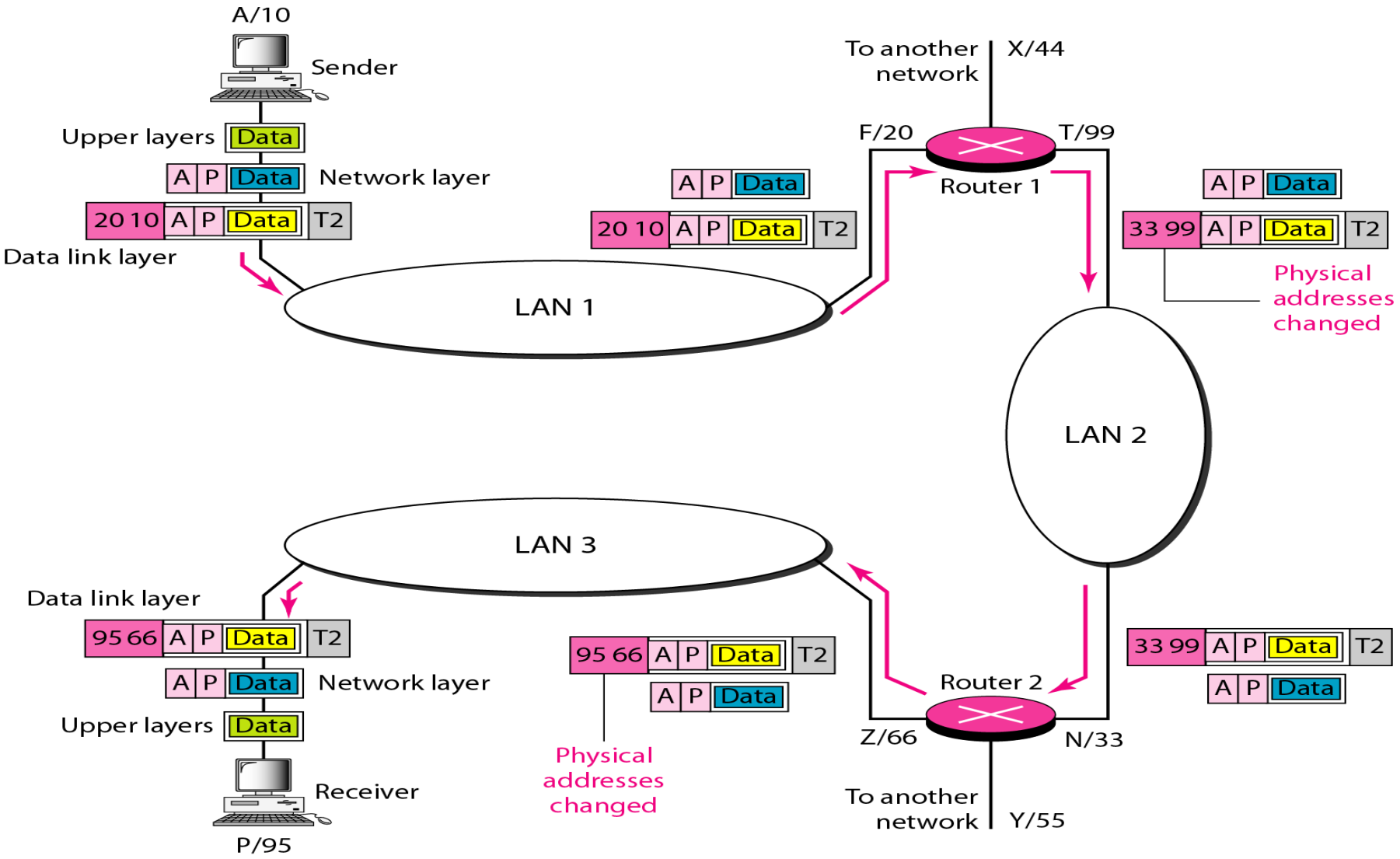
- In Figure 2.19 a node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link (bus topology LAN).
- As the figure shows, the computer with physical address 10 is the sender, and the computer with physical address 87 is the receiver.



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.

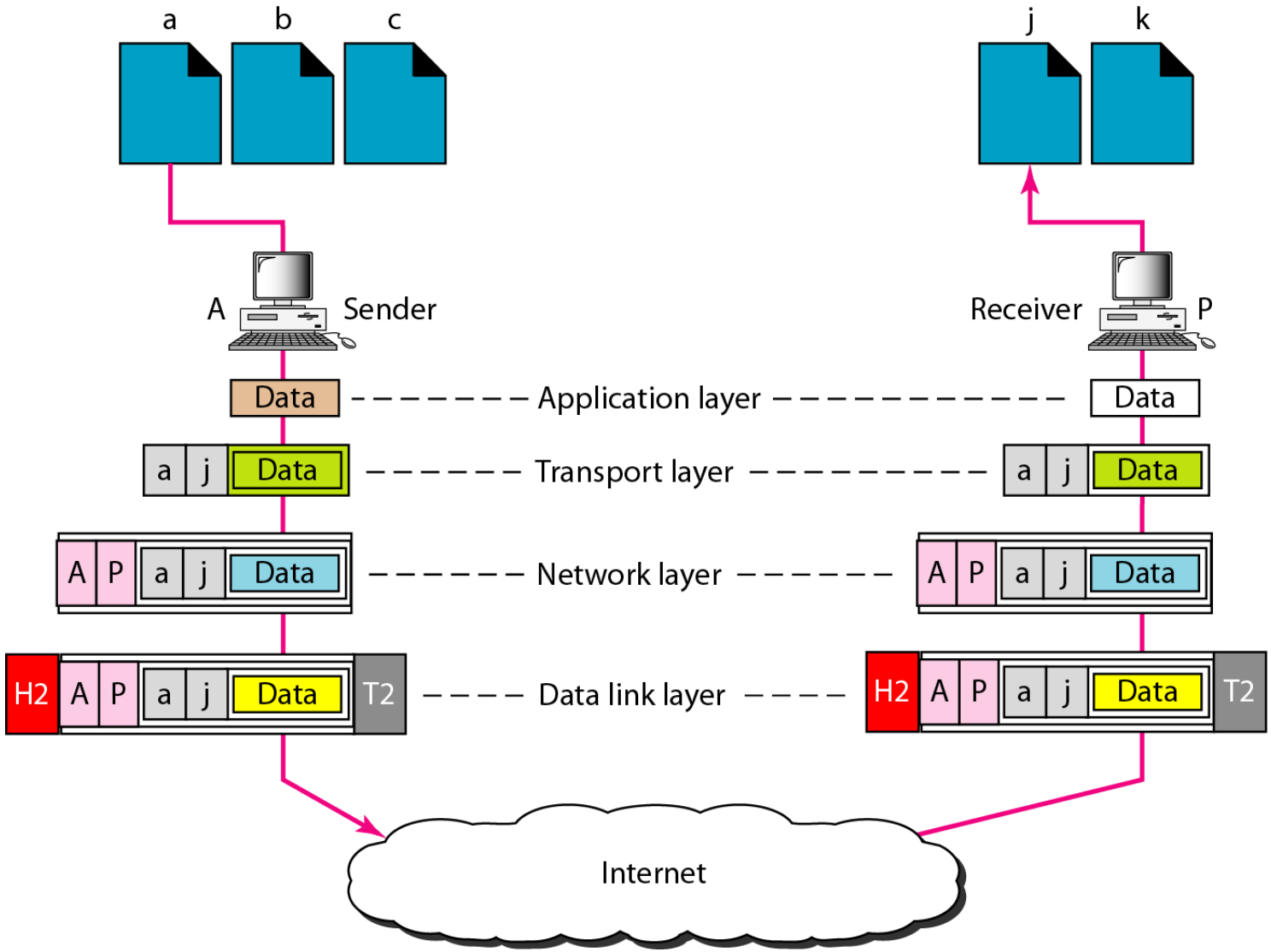
Figure 2.20 *IP addresses*



Example 2.4

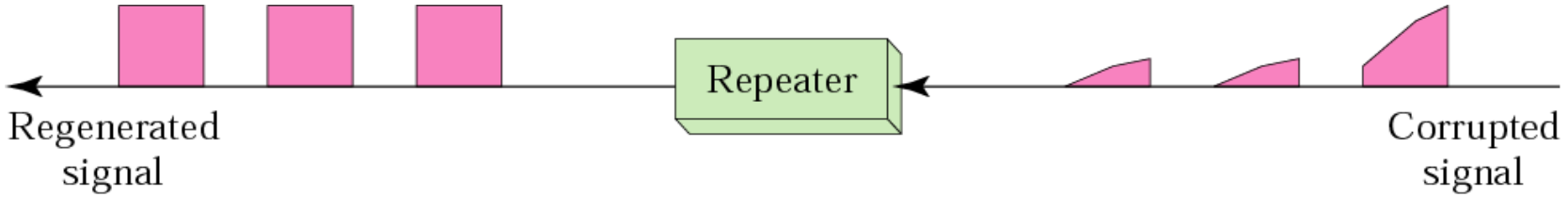
- Figure 2.21 shows two computers communicating via the Internet.
- The sending computer is running three processes at this time with port addresses a, b, and c. The receiving computer is running two processes at this time with port addresses j and k.
- Process a in the sending computer needs to communicate 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*

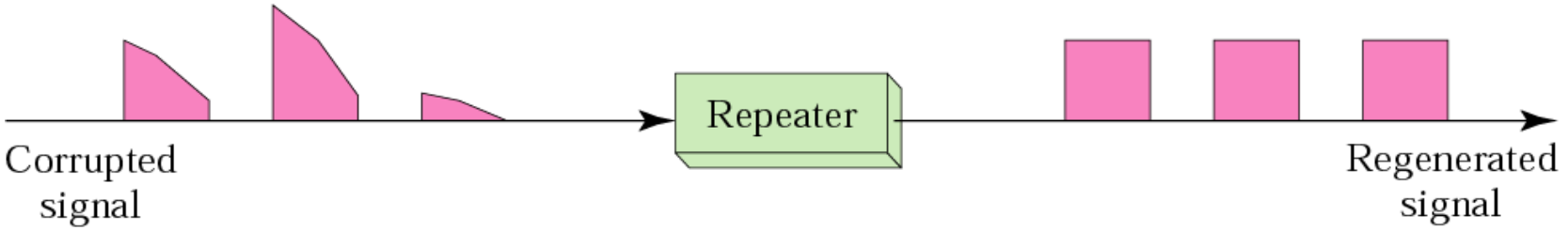


Network Devices

- Modem: a device that modulates a digital signal onto analog signal for transmission over telephone lines.
- Repeater: Re-generates the signal again.



a. Right-to-left transmission.



b. Left-to-right transmission.

DEVICES :

1. **Hub**

- A distributor that has a lot of ports which connected to computers, works on physical layer
- Uses broadcast transmission
- Used to transmit the signal to each port to respond from which the signal was received

2. **Switches**

- Like a hub but it transmit packets to its destination, works in Data Link Layer.
- Uses broadcast, unicast and multicast transmission
- Used to enable the connection establishment and connection termination on the basis of need.

3. **Bridge,** it is used to connect two similar LANs.
4. **Routers**, choose the best path to transmit the packet.
5. **Gateway**, it is use to connect two deferent LANs and connect different application protocols.
6. **Repeaters**, repeats signals that travels via long distance

Network devices With Layer

Layers	Network Devices
Application Layer	Application gateway
Transport Layer	Transport gateway
Network Layer	Router and gateway
Data link layer	Bridge and Switch
Physical Layer	Repeater, Hub and Modem.