Introduction

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.

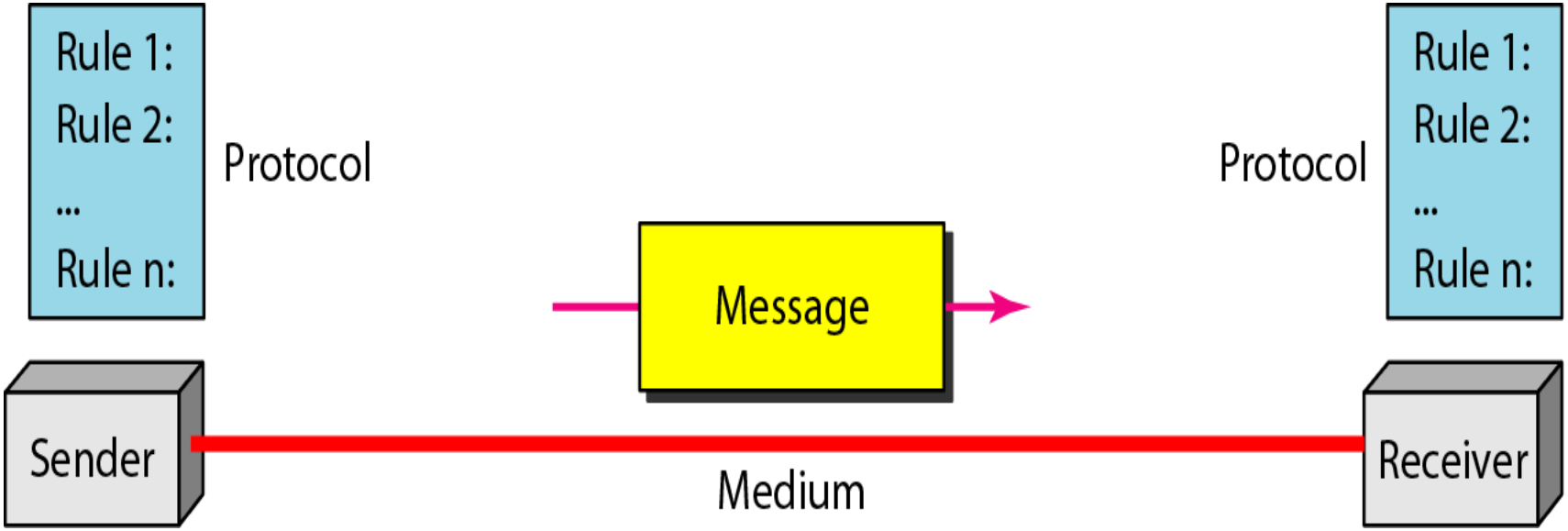
- Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable or may be wireless.

Effectiveness of Data Communication

Four Fundamental Characteristics

- Delivery
- Accuracy
- Timeliness - -*real time*
- Jitter

Components of a Data Communication System

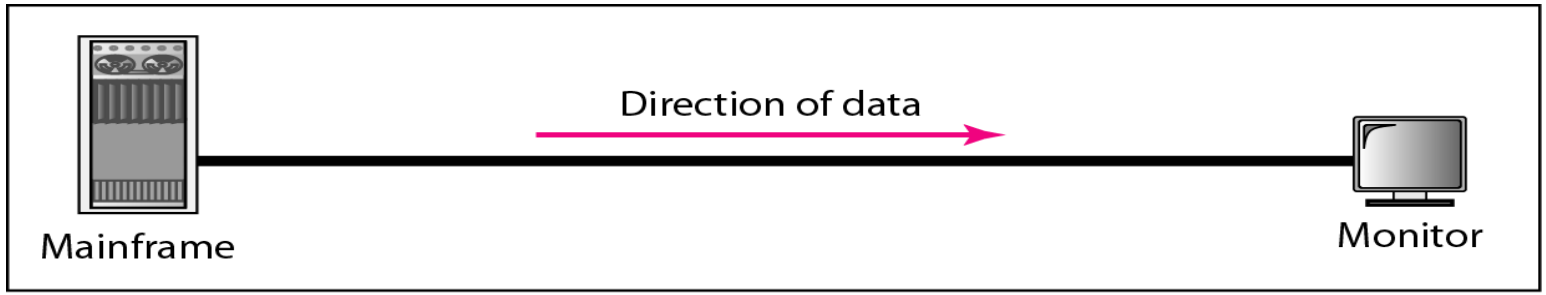


Continue…

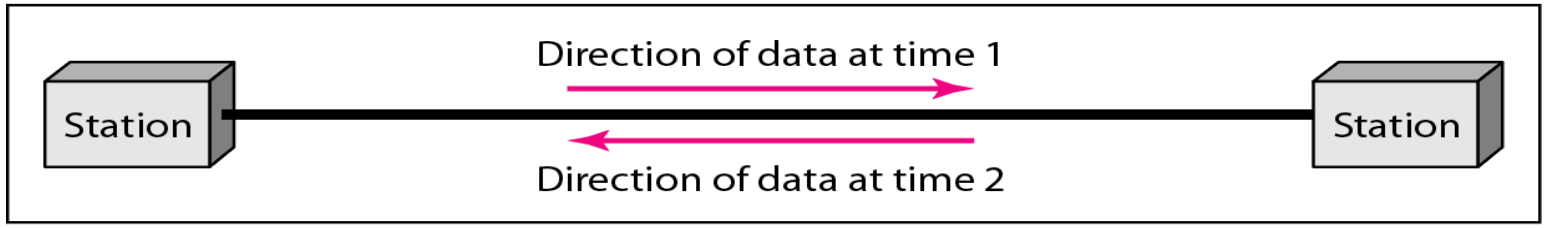
Five Components:

- Message- ***Text, Number, Image, Audio, Video***
- Sender
- Receiver
- Transmission Medium
- Protocol

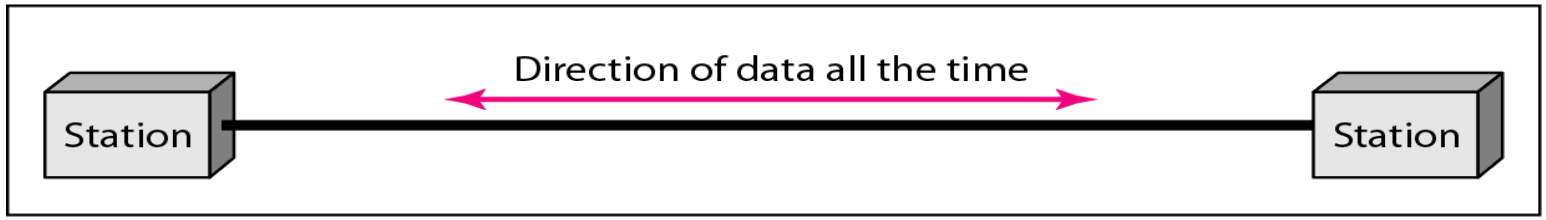
Data flow (Simplex, Half-duplex, and Full-duplex



a. Simplex



b. Half-duplex



c. Full-duplex

NETWORKS

- A network is a set of devices (often referred to as 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.

- A link can be a cable, air, optical fiber, or any medium which can transport a signal carrying information.

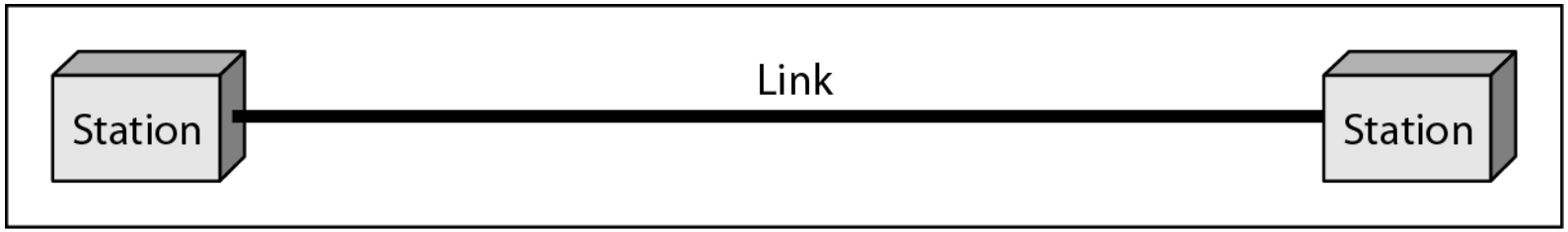
Network Criteria

- Performance
  - Depends on Network Elements- Transmit time, Response Time, Number of users, type of transmission medium, hardware, software.
  - Measured in terms of Delay and Throughput
- Reliability
  - Failure rate of network components.
  - Time to recover from a failure.
  - Measured in terms of availability/robustness
- Security
  - Data protection against corruption/loss of data due to:
    - Errors
    - Malicious users/ Unauthorized access.

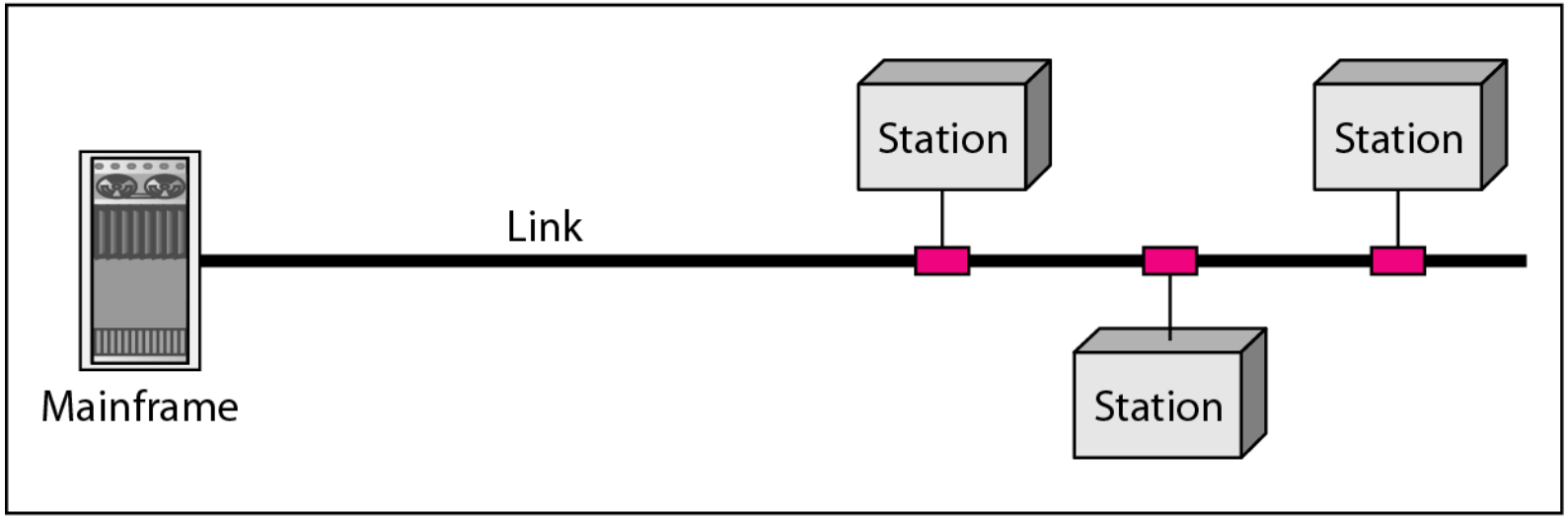
Physical Structures

- Type of Connection
  - Point to Point - single transmitter and receiver
  - Multipoint - multiple recipients of single transmission
- Physical Topology
  - Connection of devices
  - Type of transmission - unicast, mulitcast, broadcast

Types of connections: point-to-point and multipoint



a. Point-to-point



b. Multipoint

Uses of Computer Network

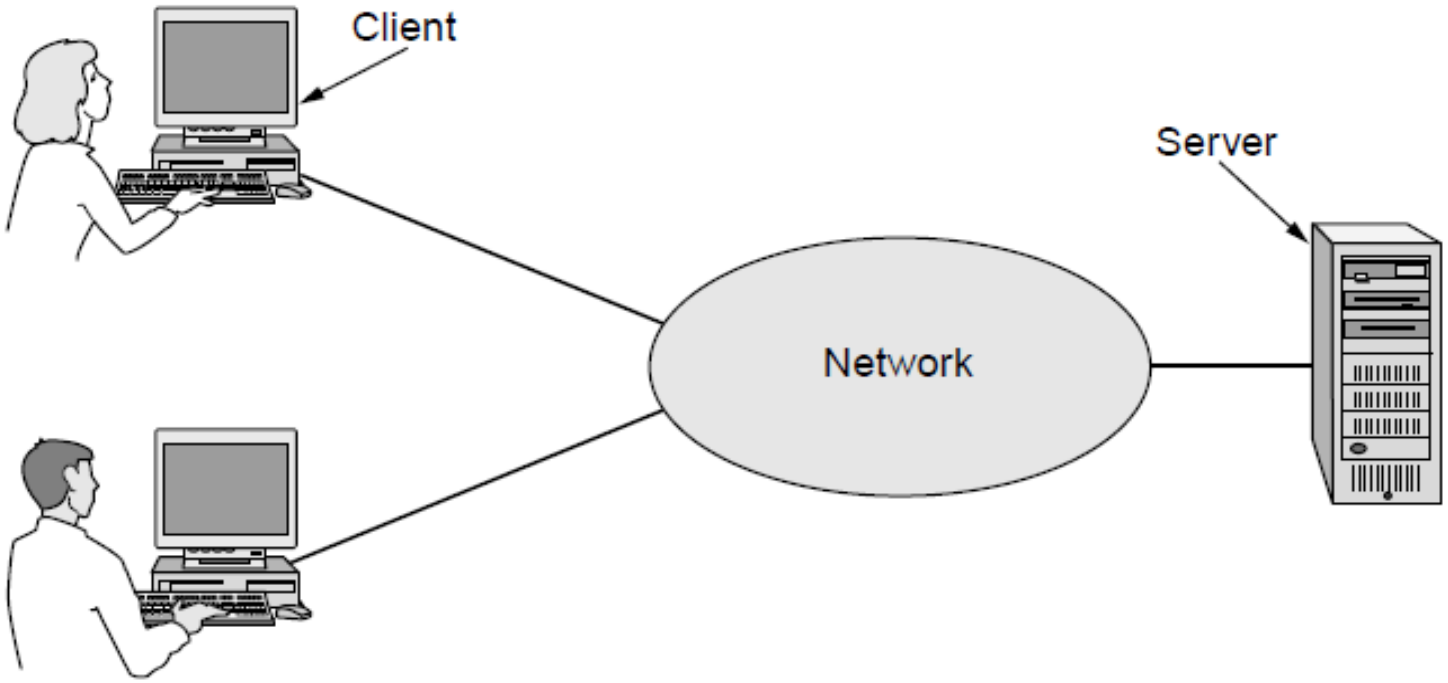
- Business Applications
- Home Applications
- Mobile Users
- Social Issues

Business Applications

- Resource sharing such as printers and storage devices

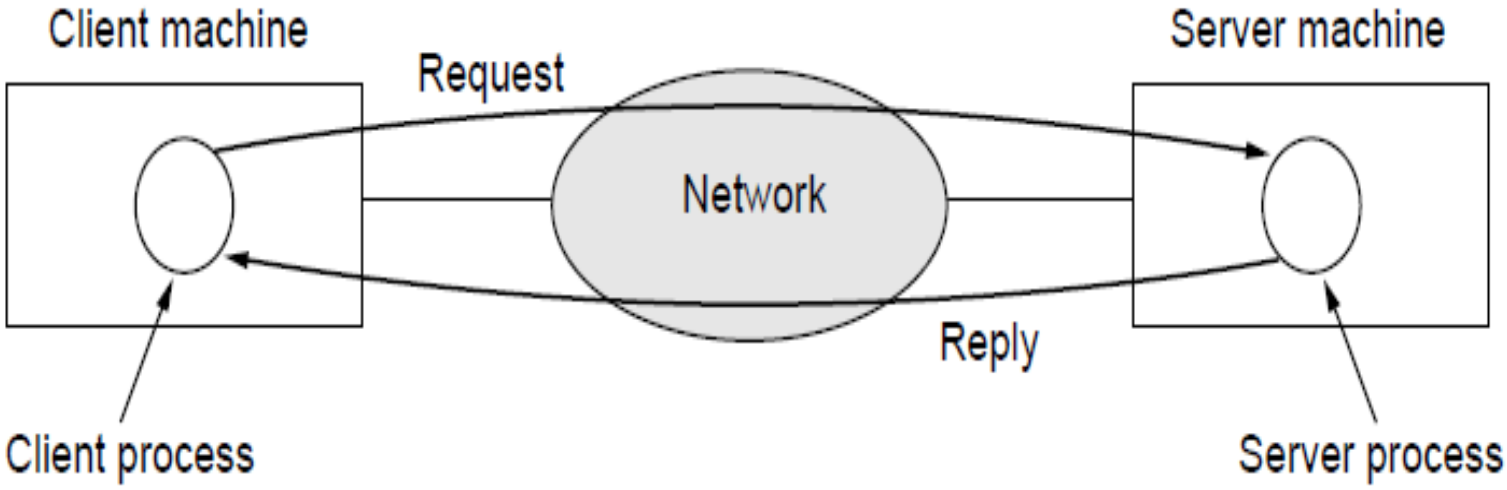
- Exchange of information by means of e-Mails and FTP

Business Applications (1)



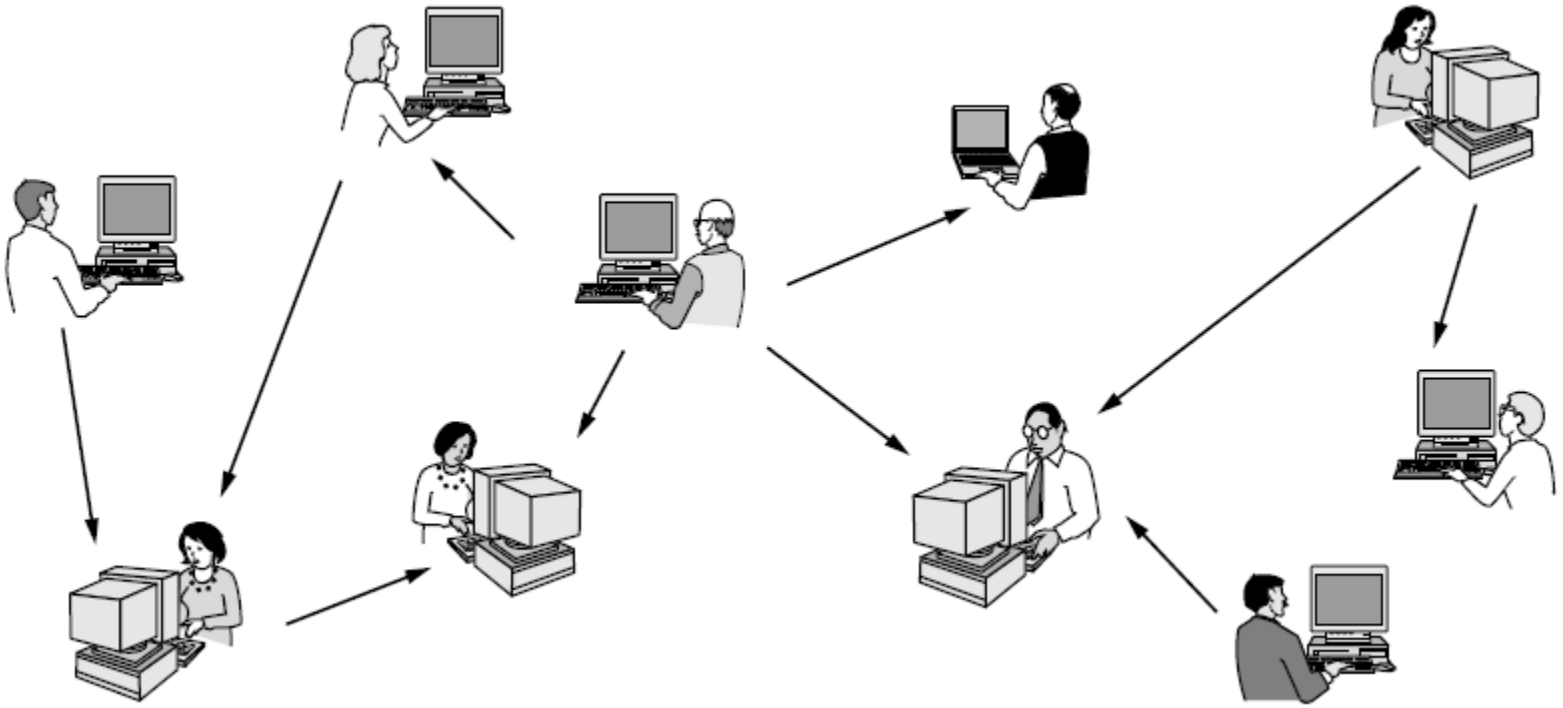
A network with two clients and one server

Business Applications (2)



The client-server model involves requests and replies

Home Applications (1)



In a peer-to-peer system there are no fixed clients and servers.

Home Applications (2)

Some forms of e-commerce

Tag	Full name	Example
B2C	Business-to-consumer	Ordering books online
B2B	Business-to-business	Car manufacturer ordering tires from supplier
G2C	Government-to-consumer	Government distributing tax forms electronically
C2C	Consumer-to-consumer	Auctioning second-hand products online
P2P	Peer-to-peer	Music sharing

Mobile Users

Combinations of wireless networks and mobile

Wireless	Mobile	Typical applications
No	No	Desktop computers in offices
No	Yes	A notebook computer used in a hotel room
Yes	No	Networks in unwired buildings
Yes	Yes	Store inventory with a handheld computer

Social Issues

- Network neutrality
- Digital Millennium Copyright Act
- Profiling users
- Phishing

PROTOCOLS

- A protocol is synonymous with rule. It consists of a set of rules that govern data communications. It determines what is communicated, how it is communicated and when it is communicated.
- The key elements of a protocol are
  - Syntax
  - Semantics
  - Timing

Elements of a Protocol

- Syntax
  - Structure or format of the data
  - Indicates how to read the bits - field delineation
- Semantics
  - Interprets the meaning of the bits
  - Knows which fields define what action
- Timing
  - When data should be sent and what
  - Speed at which data should be sent or speed at which it is being received.

Types of Network

- **Wired Networks**
- high bandwidth
- low bandwidth variability
- can listen on wire
- high power machines
- high resource machines
- low delay
- connected operation

-No Mobility.

- **Mobile Networks**
- low bandwidth
- high bandwidth variability
- hidden terminal problem
- low power machines
- low resource machines
- higher delay
- disconnected operation

Mobility.

The End

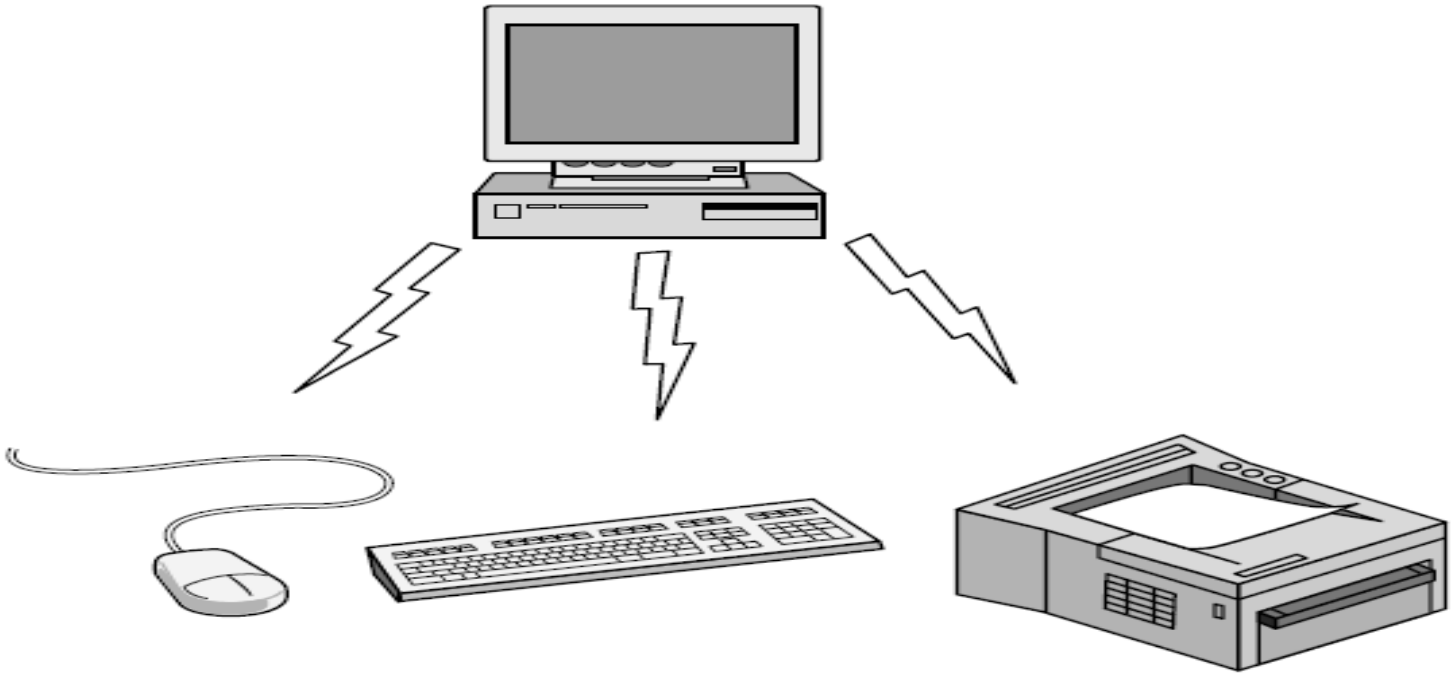
Network Hardware and its Topologies

CSE306

Categories of Networks

- Personal area networks
- Local Area networks
- Metropolitan Area networks
- Wide Area networks
- Wireless Networks
- Home Networks
- Internetworks- The Internet

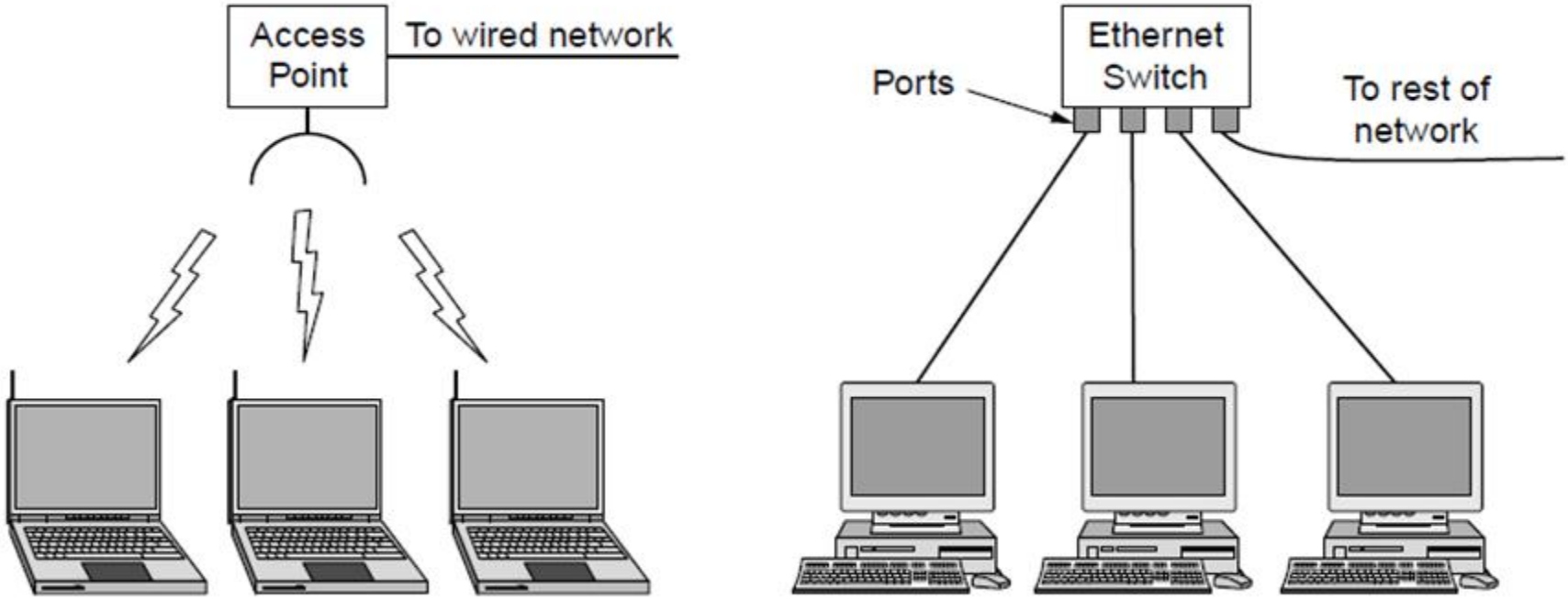
Personal Area Network



Bluetooth PAN configuration

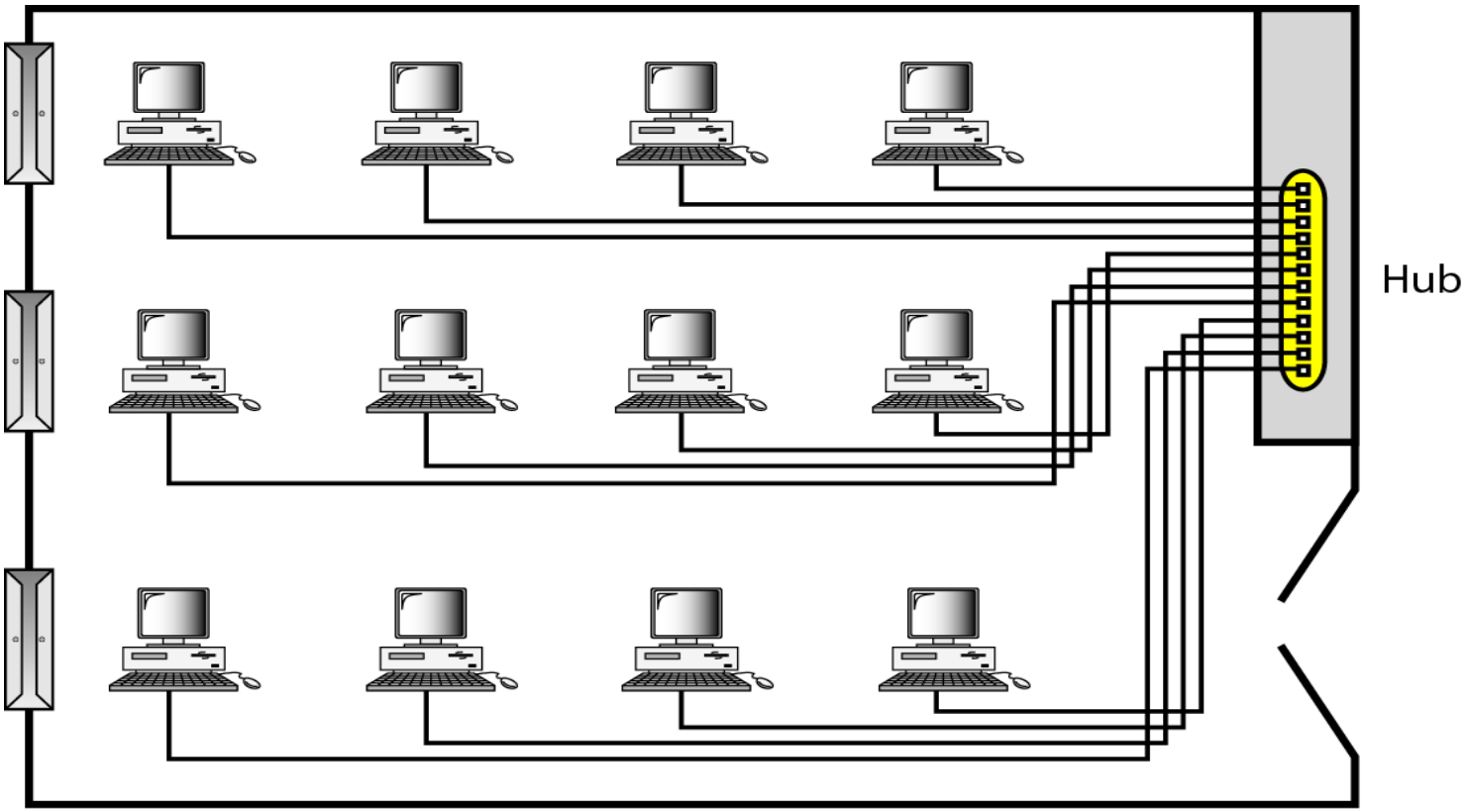
Local Area Networks (LANs)

- Short distances
- Designed to provide local interconnectivity



Wireless and wired LANs. (a) 802.11. (b) Switched Ethernet.

Isolated LAN connecting 12 computers to a hub in a closet

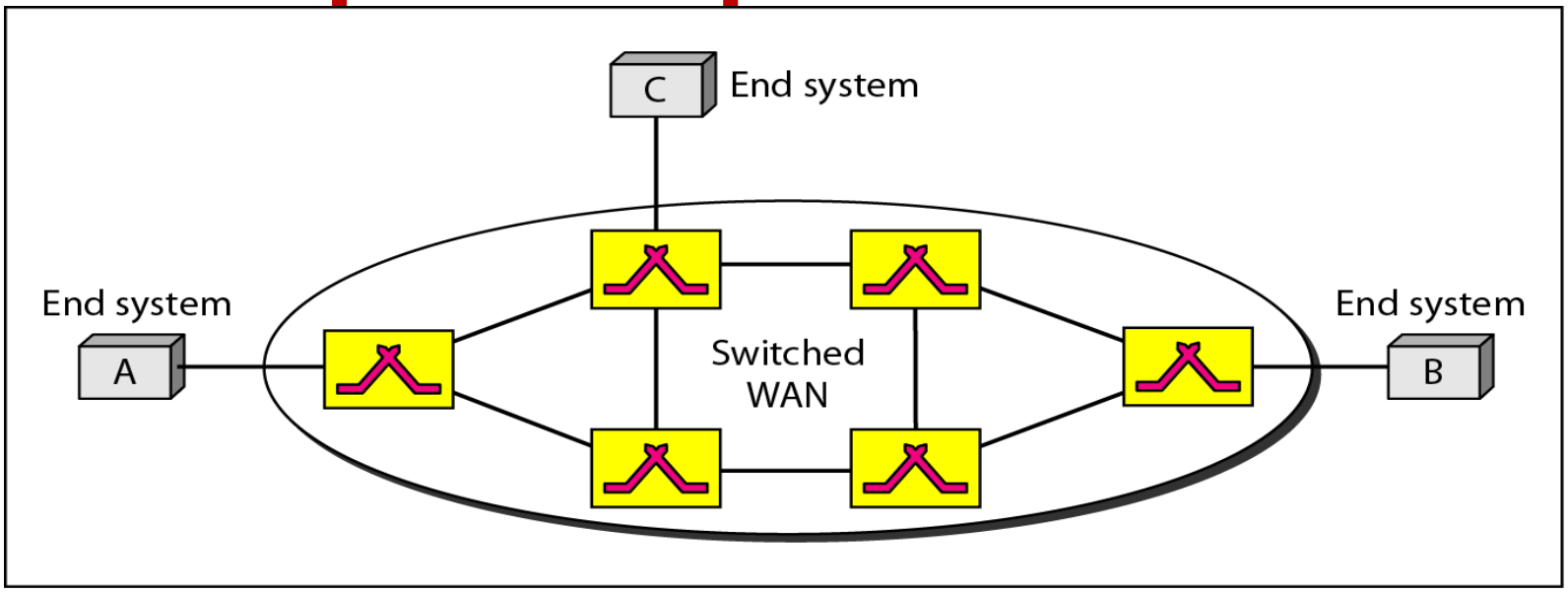


Wide Area Networks (WANs)

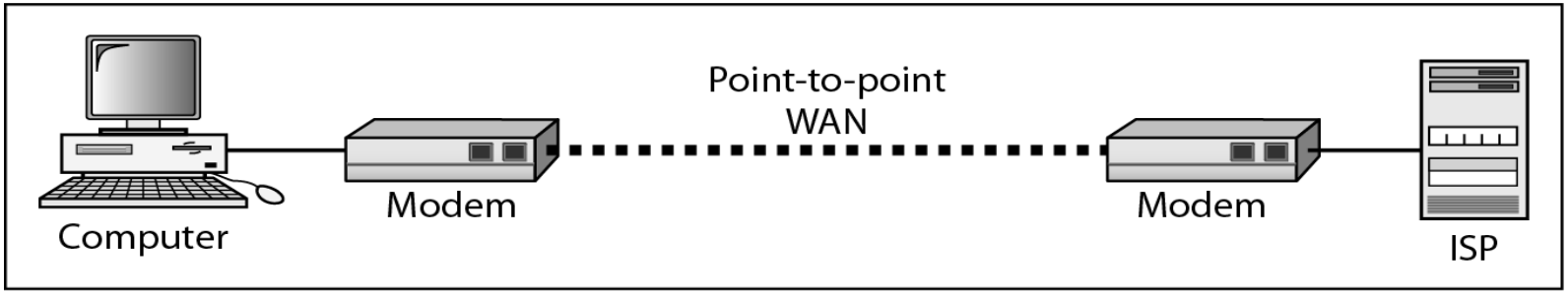
– Long distances

– Provide connectivity over large areas

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

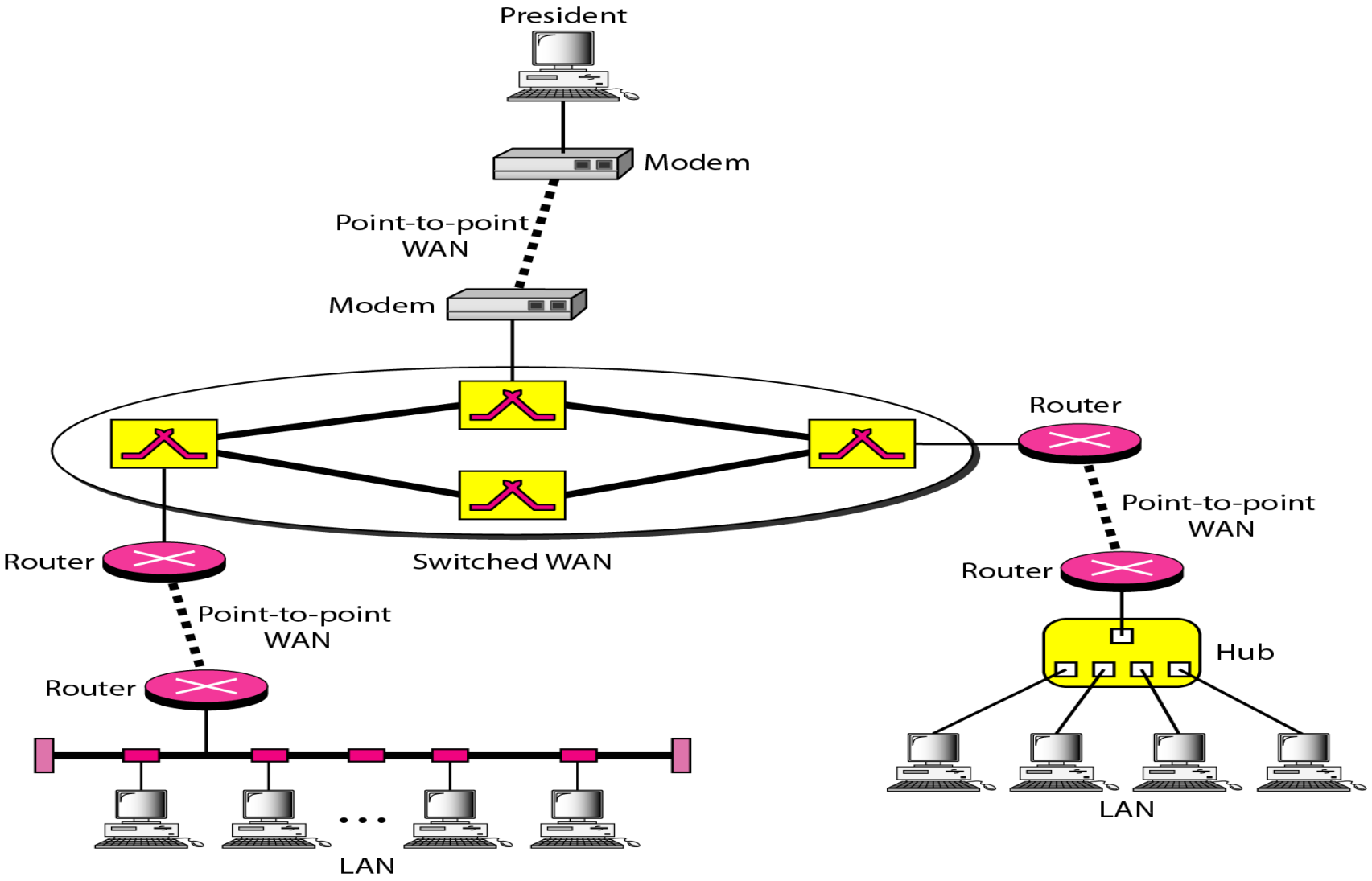


a. Switched WAN



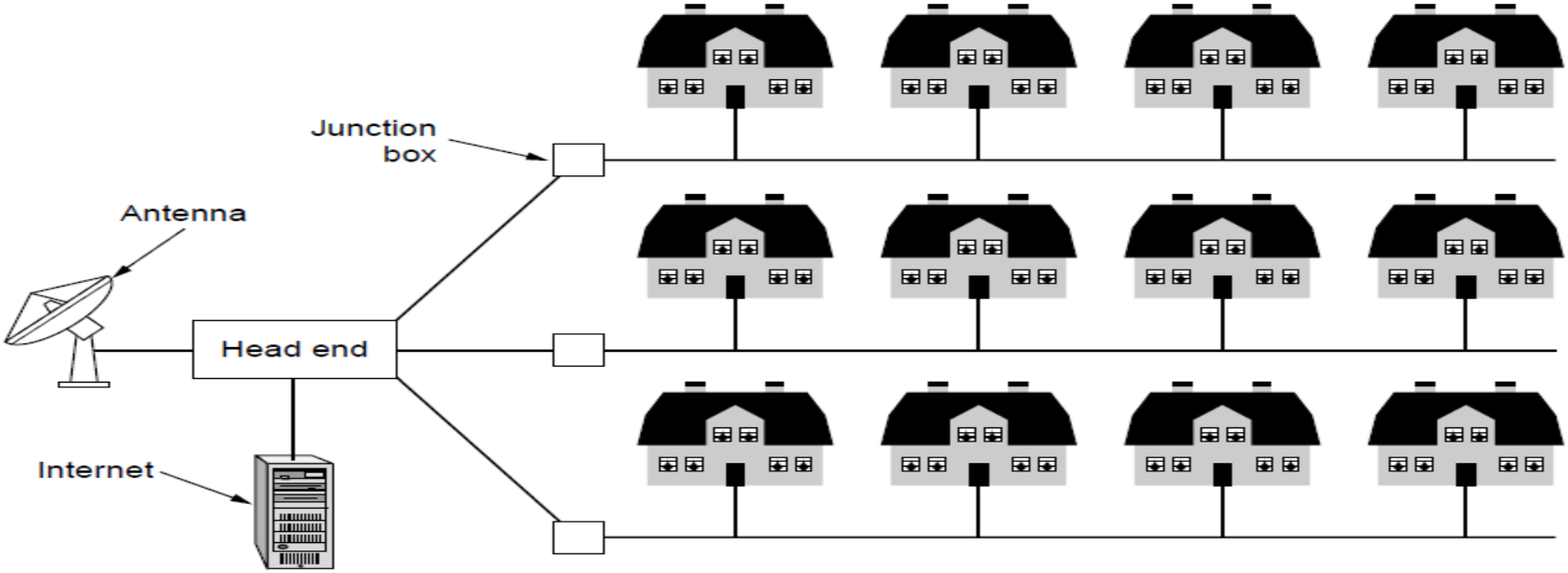
b. Point-to-point WAN

A heterogeneous network made of four WANs and two LAN

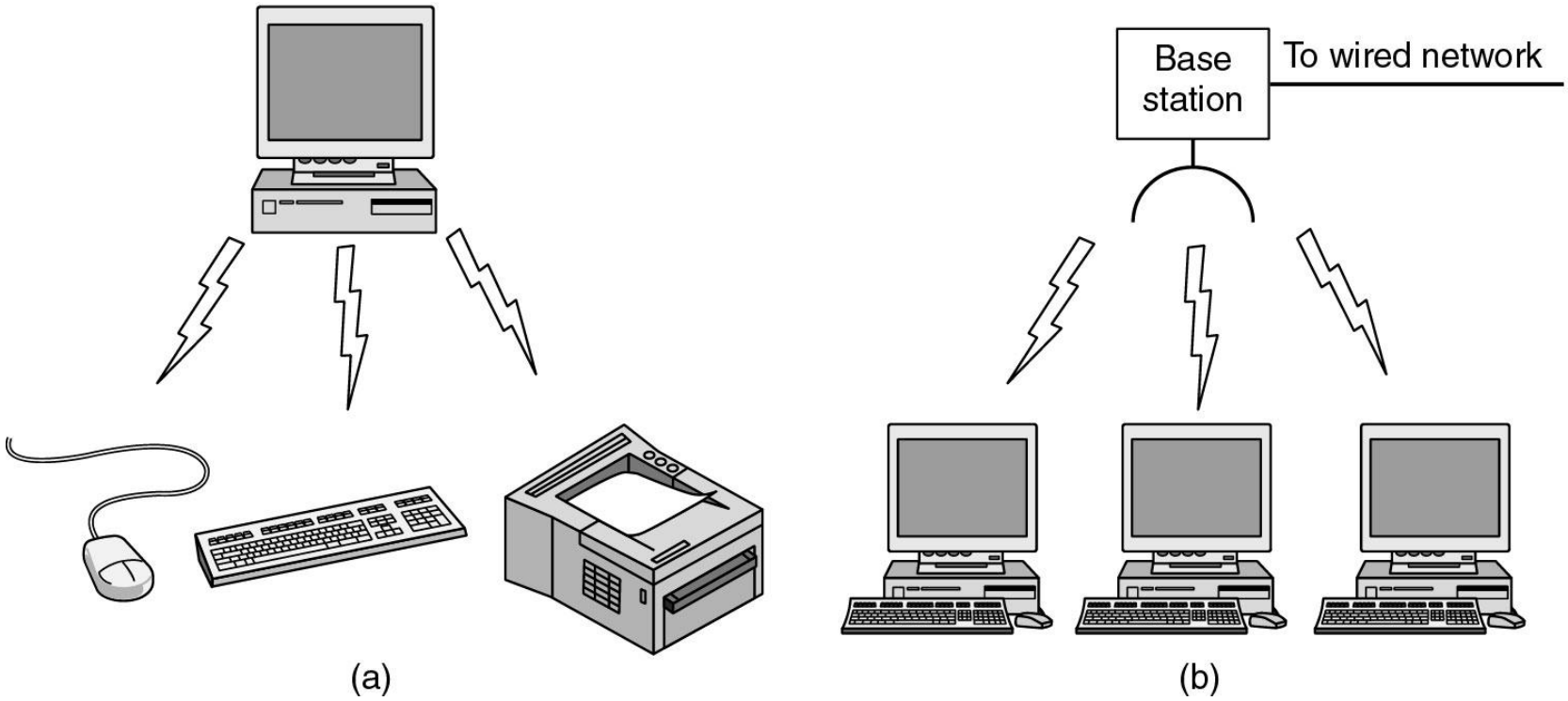


Metropolitan Area Networks (MANs)

- Provide connectivity over areas such as a city, a campus
- A metropolitan area network based on cable TV or telephone cable using DSL

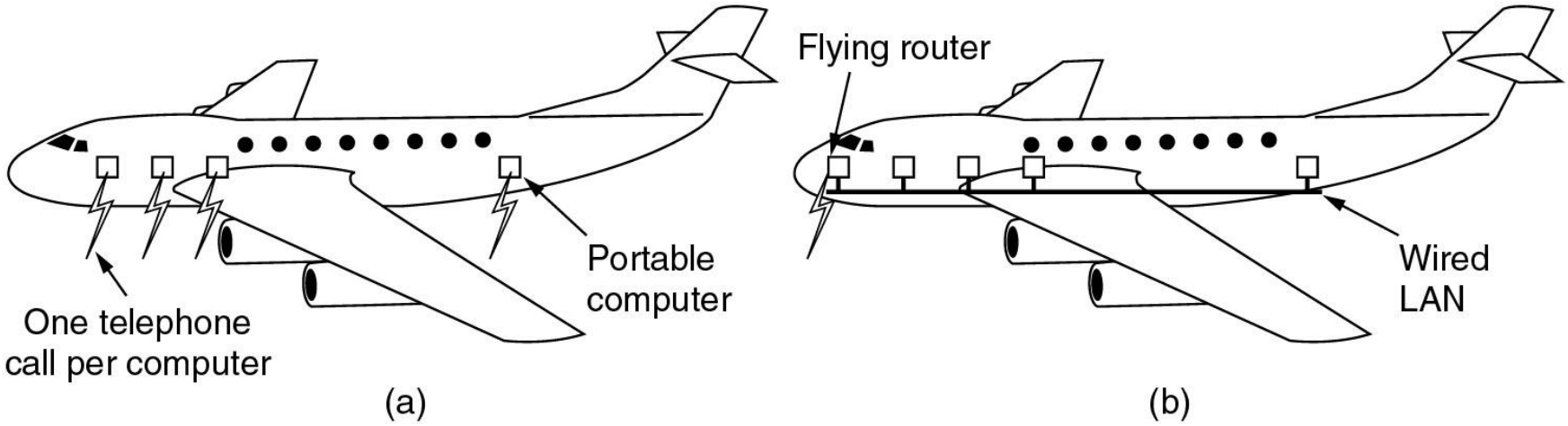


Wireless Networks



- (a) Bluetooth configuration
- (b) Wireless LAN

Wireless Networks



- (a) Individual mobile computers
- (b) A flying LAN

Home Network Categories

- Computers (desktop PC, PDA, shared peripherals
- Entertainment (TV, DVD, VCR, camera, stereo, MP3)
- Telecomm (telephone, cell phone, intercom, fax)
- Appliances (microwave, fridge, clock, furnace, airco)
- Telemetry (utility meter, burglar alarm, babycam).

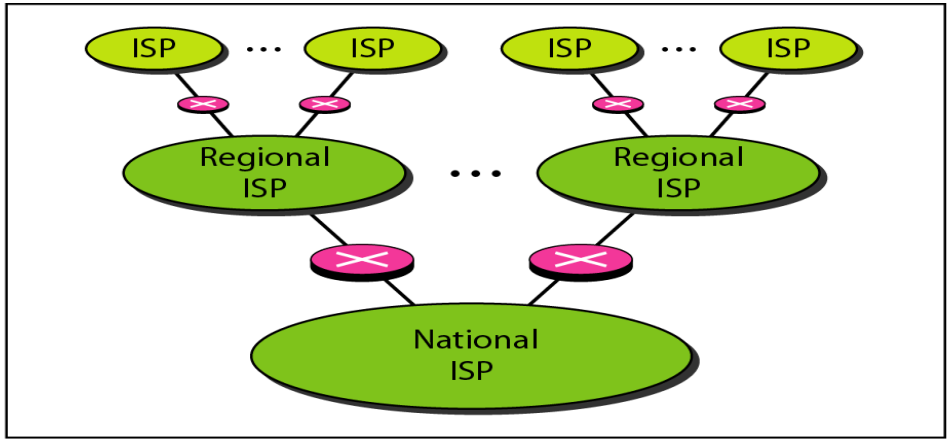
THE INTERNET

- Inter connection of two or more networks become an internet.

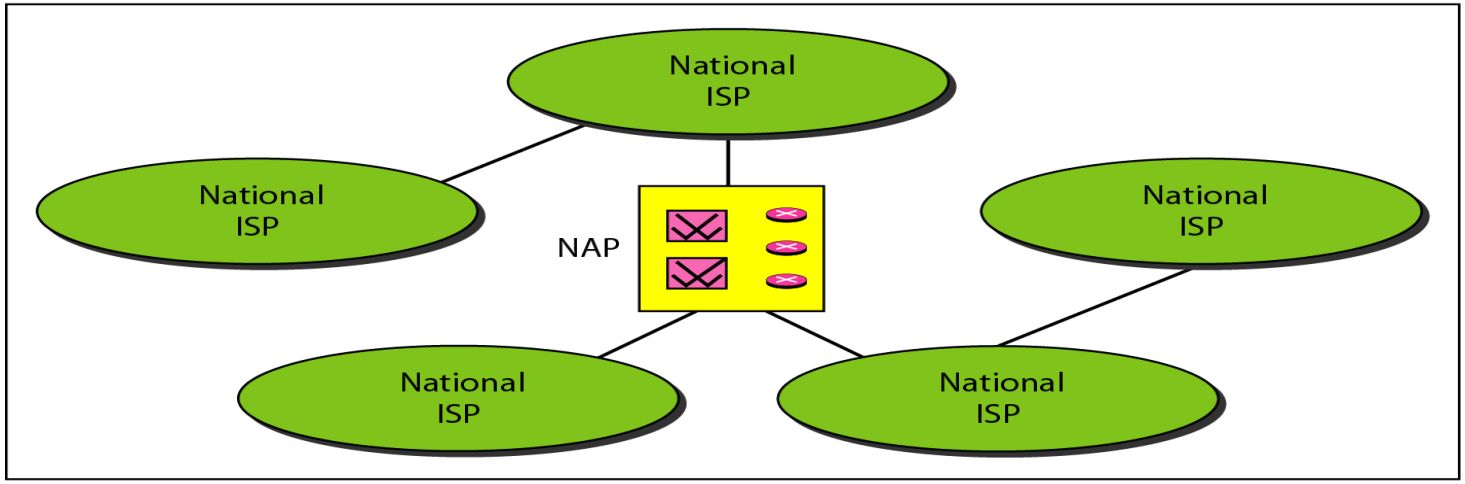
- The Internet has revolutionized many aspects of our daily lives. It has affected the way we do business as well as the way we spend our leisure time.

- The Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use.

Hierarchical organization of the Internet



a. Structure of a national ISP



b. Interconnection of national ISPs

Broadcast Networks

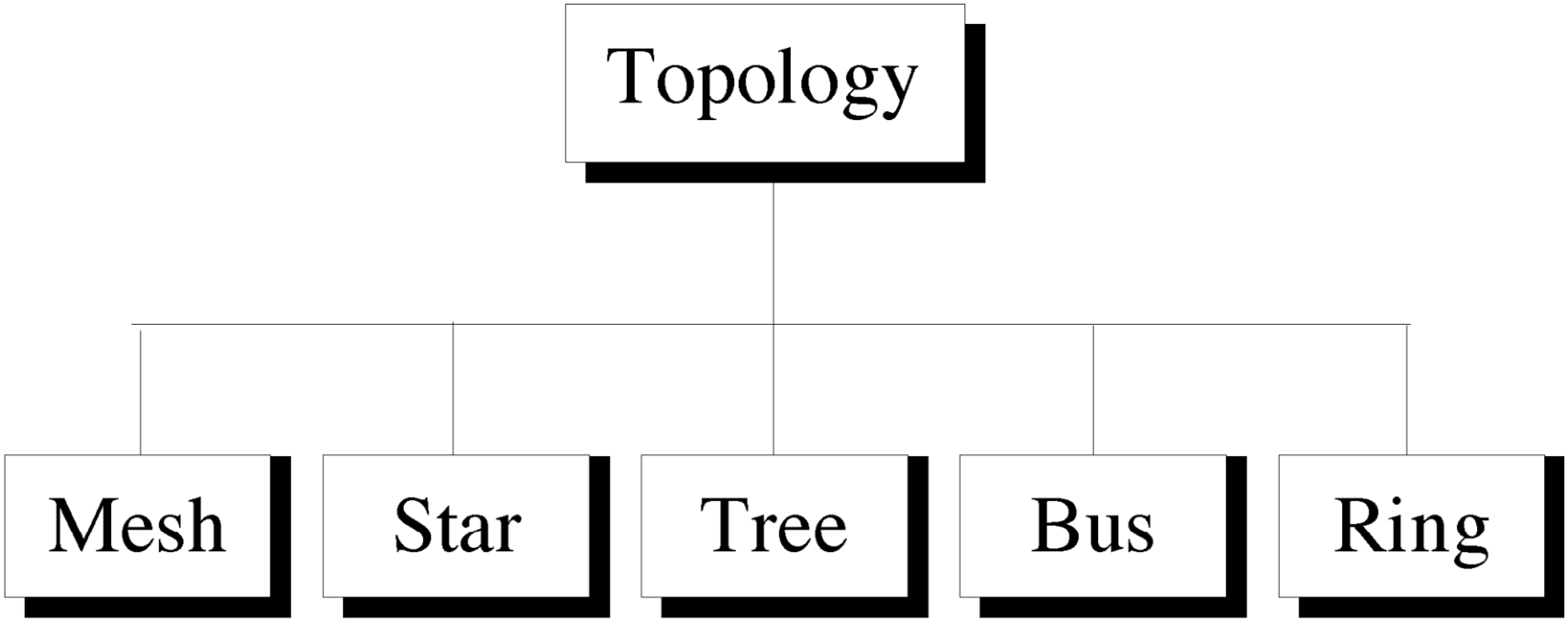
- Classification of interconnected processors by scale.

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Network Topology

- The topology of a network defines how the nodes of a network are connected.
- The shape of the cabling layout used to link devices is called the **physical topology** of the network.
- The **logical topology**, in contrast, is the way that the signals act on the network media, or the way that the data passes through the network from one device to the next without regard to the physical interconnection of the devices.

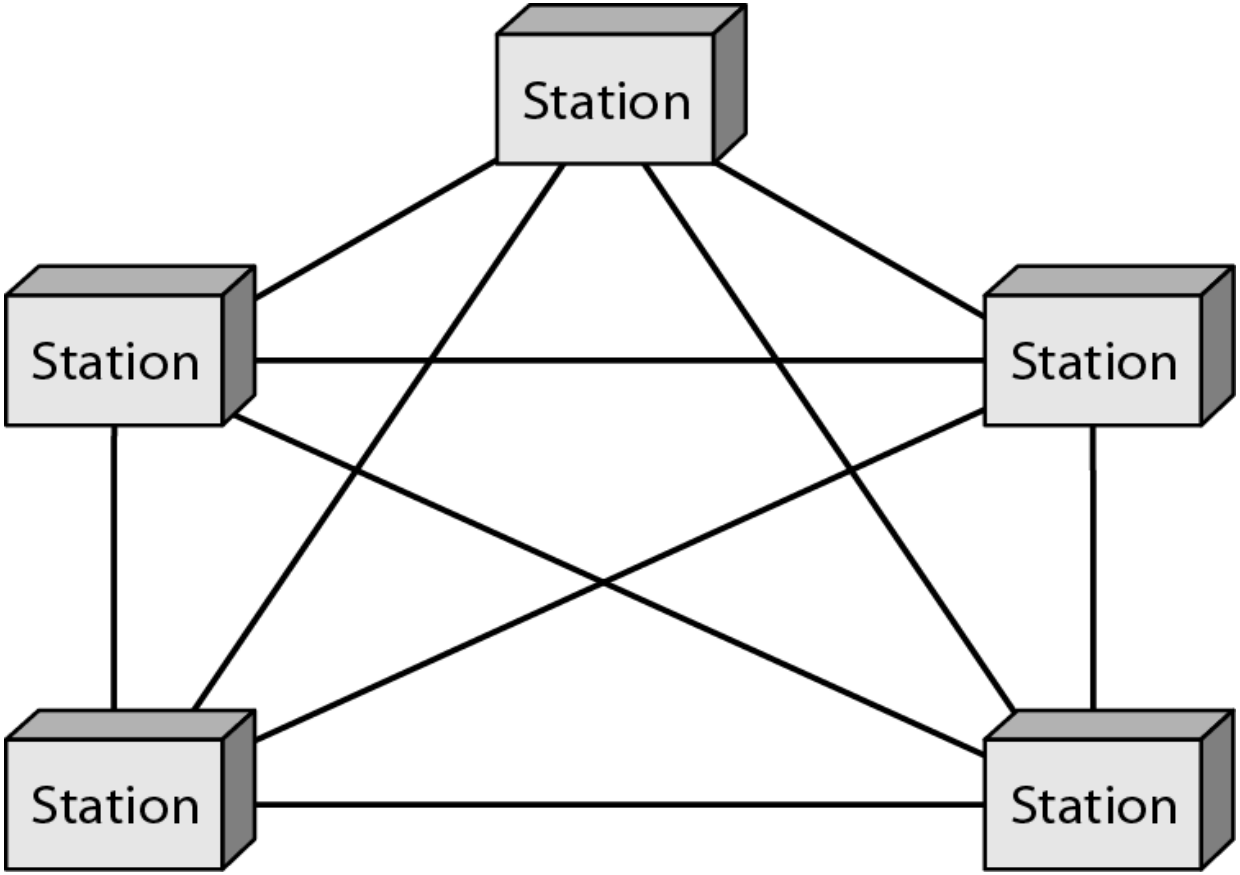
Categories of Physical Topology



Mesh Topology

- Here every device has a point to point link to every other device.
- Node 1 node must be connected with n-1 nodes.
- A fully connected mesh can have n(n-1)/2 physical channels to link n devices.
- It must have n-1 I/O ports.

A fully connected mesh topology (five devices)



Advantages of Mesh

1. They use dedicated links so each link can only carry its own data load. So traffic problem can be avoided.
2. It is robust. If any one link get damaged it cannot affect others.
3. It gives privacy and security.(Message travels along a dedicated link)
4. Fault identification and fault isolation are easy.

Disadvantages of Mesh

1. The amount of cabling and the number of I/O ports required are very large. Since every device is connected to each devices through dedicated links.
2. The sheer bulk of wiring is larger then the available space.
3. Hardware required to connected each device is highly expensive.

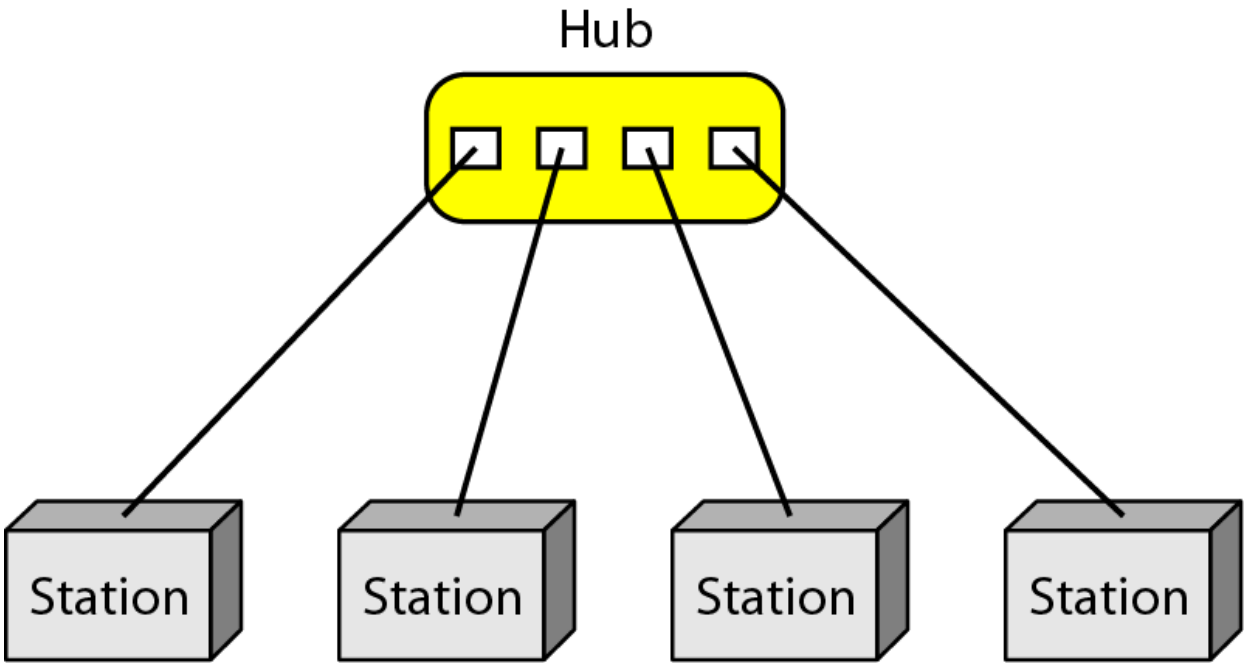
Applications of Mesh

1. Telephone Regional office.
2. WAN.(Wide Area Network).

Star Topology

- Here each device has a dedicated point-to-point link to the central controller called "Hub"(Act as a Exchange).
- There is no direct traffic between devices.
- The transmission are occurred only through the central "hub".
- When device 1 wants to send data to device 2; First sends the data to hub. Which then relays the data to the other connected device.

Star Topology



Advantages of Star Topology

1. Less expensive then mesh since each device is connected only to the hub.
2. Installation and configuration are easy.
3. Less cabling is need then mesh.
4. Robustness.(if one link fails, only that links is affected. All other links remain active)
5. Easy to fault identification & to remove parts.
6. No distruptions to the network then connecting(or) removing devices.

Disadvantages of Star Topology

1. Even it requires less cabling then mesh when compared with other topologies it still large.(Ring or bus).

2. Dependency(whole n/w dependent on one single point(hub). When it goes down. The whole system is dead.

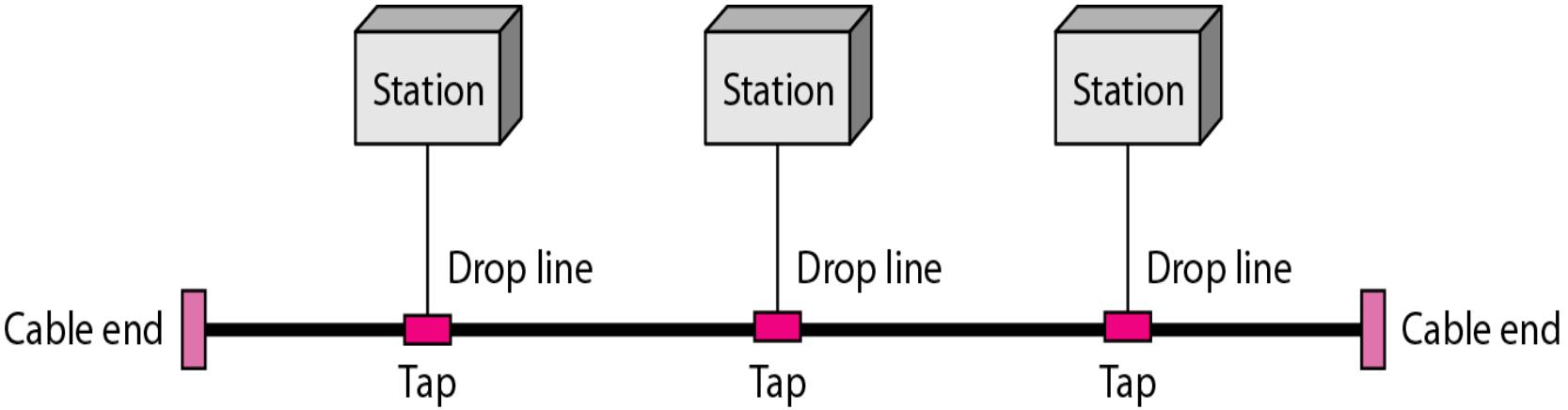
Applications of Star Topology

- Star topology used in Local Area Networks(LANs).
- High speed LAN often used STAR.

Bus Topology

- A bus topology is multipoint.
- Here one long cable act as a backbone to link all the devices are connected to the backbone by drop lines and taps.
- Drop line- is the connection b/w the devices and the cable.
- Tap- is the splitter that cut the main link.
- This allows only one device to transmit at a time.

Bus Topology



- When a device sends a message, it is broadcast down on the cable in both directions. Terminators at the end of the cable prevent the signal from reflecting back to the sender.

- All devices on the cable constantly monitor for messages meant to them. When a device detects a message meant for it, it reads the message from the cable and the other devices will ignore it.

- Since all devices are sharing the same cable, some form of control is needed to make sure which device will transmit when, otherwise there will be a collision.

Advantages of Bus Topology

1. Ease of installation.
2. Less cabling.
3. less expensive.

Disadvantages of Bus Topology

1. Difficult reconfiguration and fault isolation.
2. Difficult to add new devices.
3. Signal reflection at top can degradation in quality.
4. If any fault in backbone can stops all transmission.

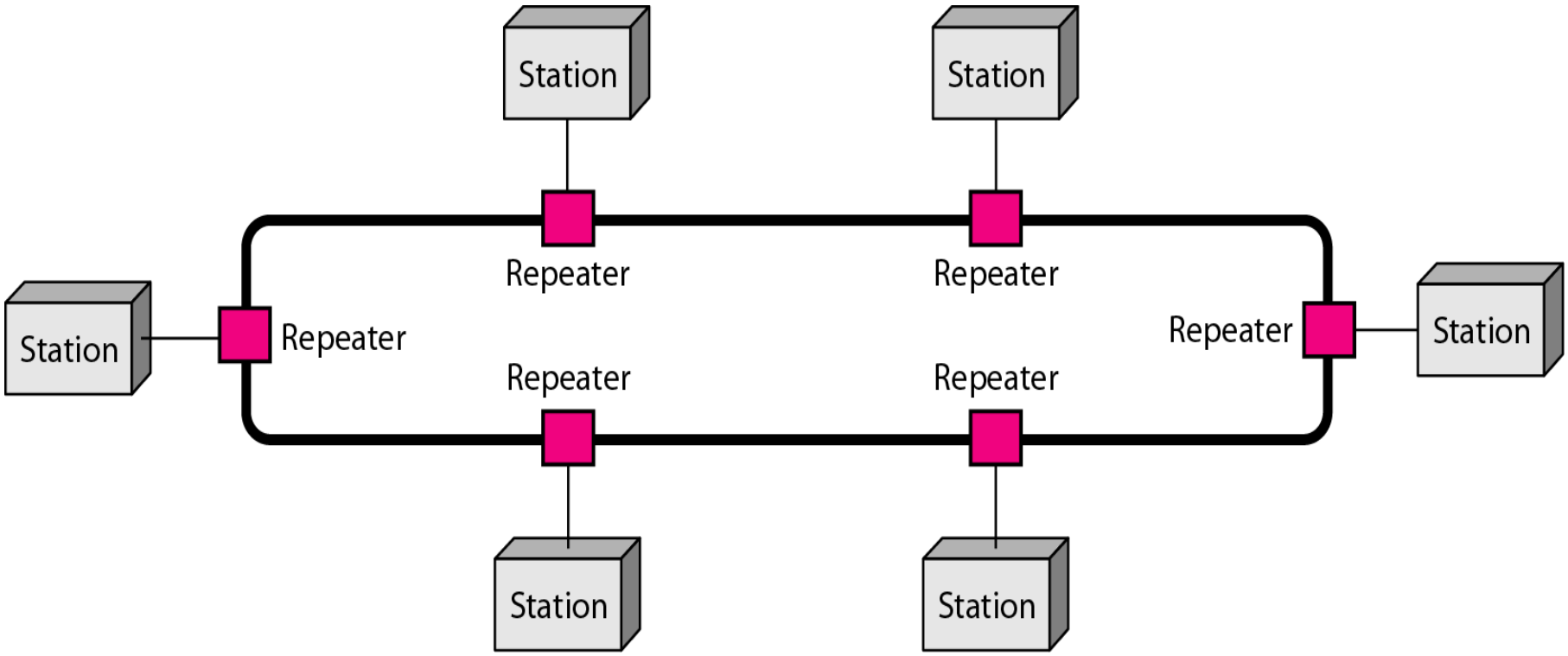
Applications of Bus Topology

- Most computer motherboard.

Ring Topology

- Here each device has a dedicated connection with two devices on either side.
- The signal is passed in one direction from device to device until it reaches the destination and each device have repeater.
- When one device received signals instead of intended another device, its repeater then regenerates the data and passes them along.
- To add or delete a device requires changing only two connections.

Ring Topology



Ring Topology

Advantages:

1. Easy to install.
2. Easy to reconfigure.
3. Fault identification is easy.

Disadvantages:

1. Unidirectional traffic.
2. Break in a single ring can break entire network.

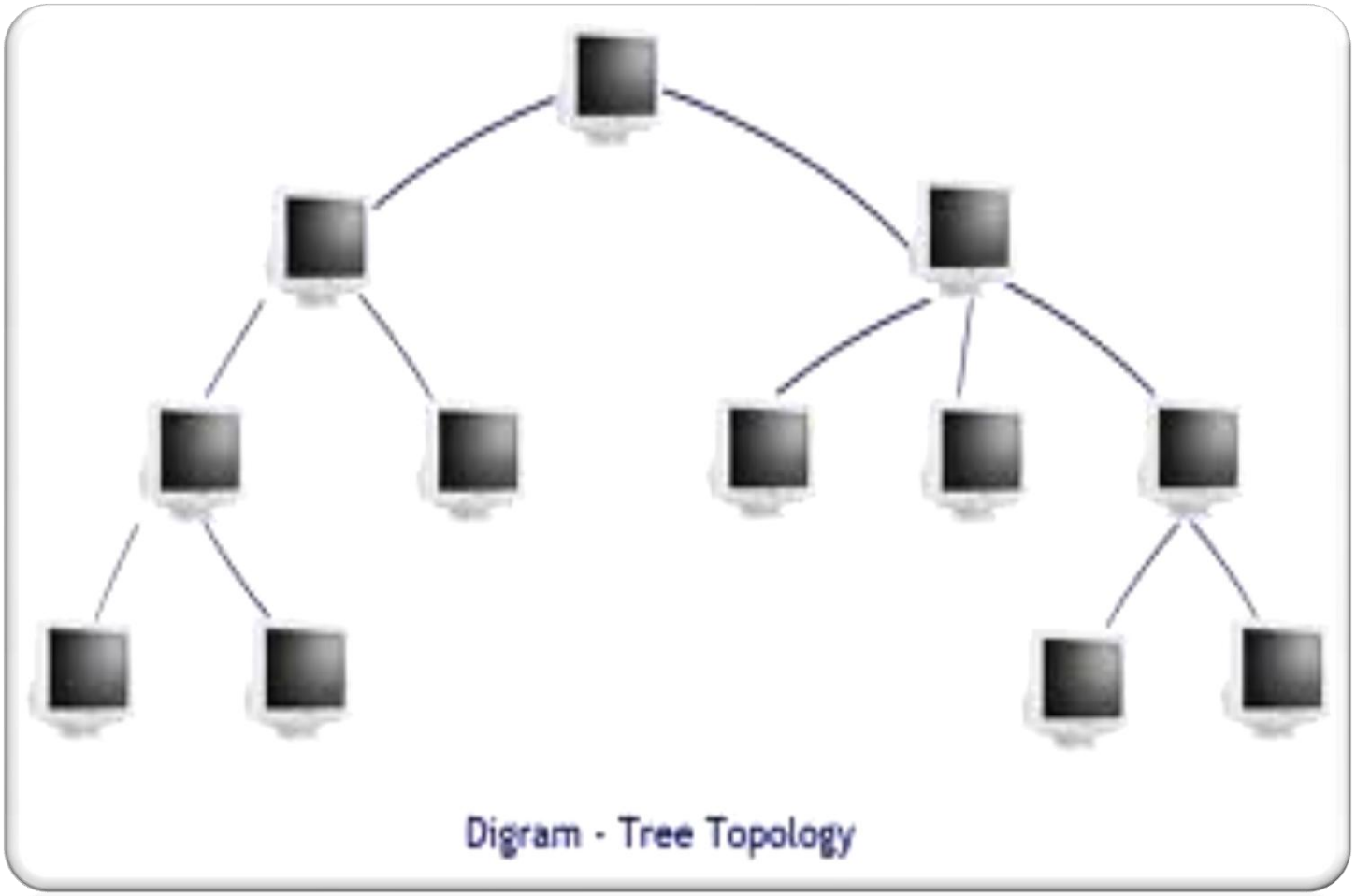
Ring Topology

Applications:

- Ring topologies are found in some office buildings or school campuses.
- Today high speed LANs made this topology less popular.

Tree Topology

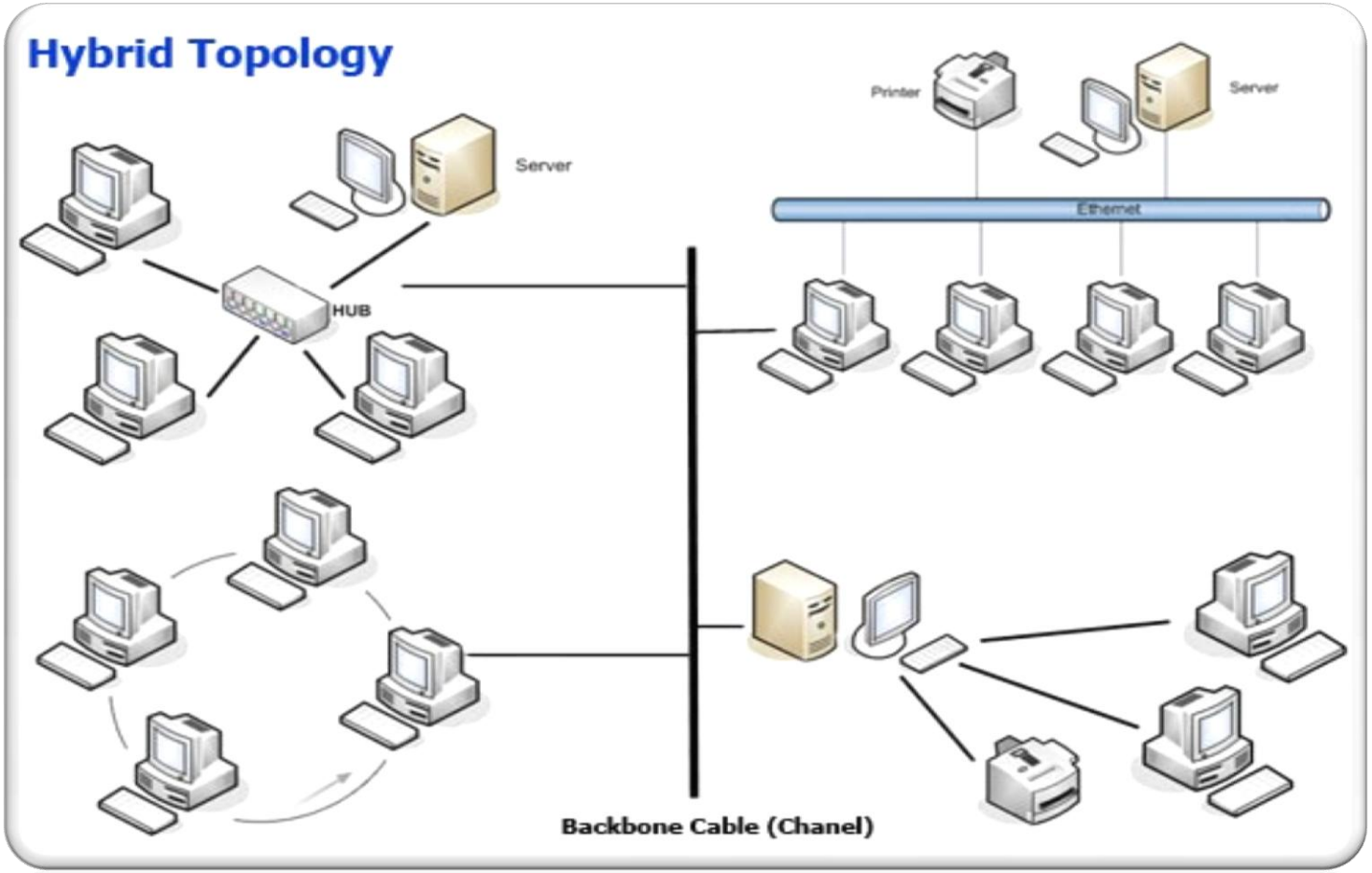
- Alternatively referred to as a star bus topology.
- Tree topology is one of the most common network setups that is similar to a bus topology and a star topology.
- A tree topology connects multiple star networks to other star networks. Below is a visual example of a simple computer setup on a network using the star topology.



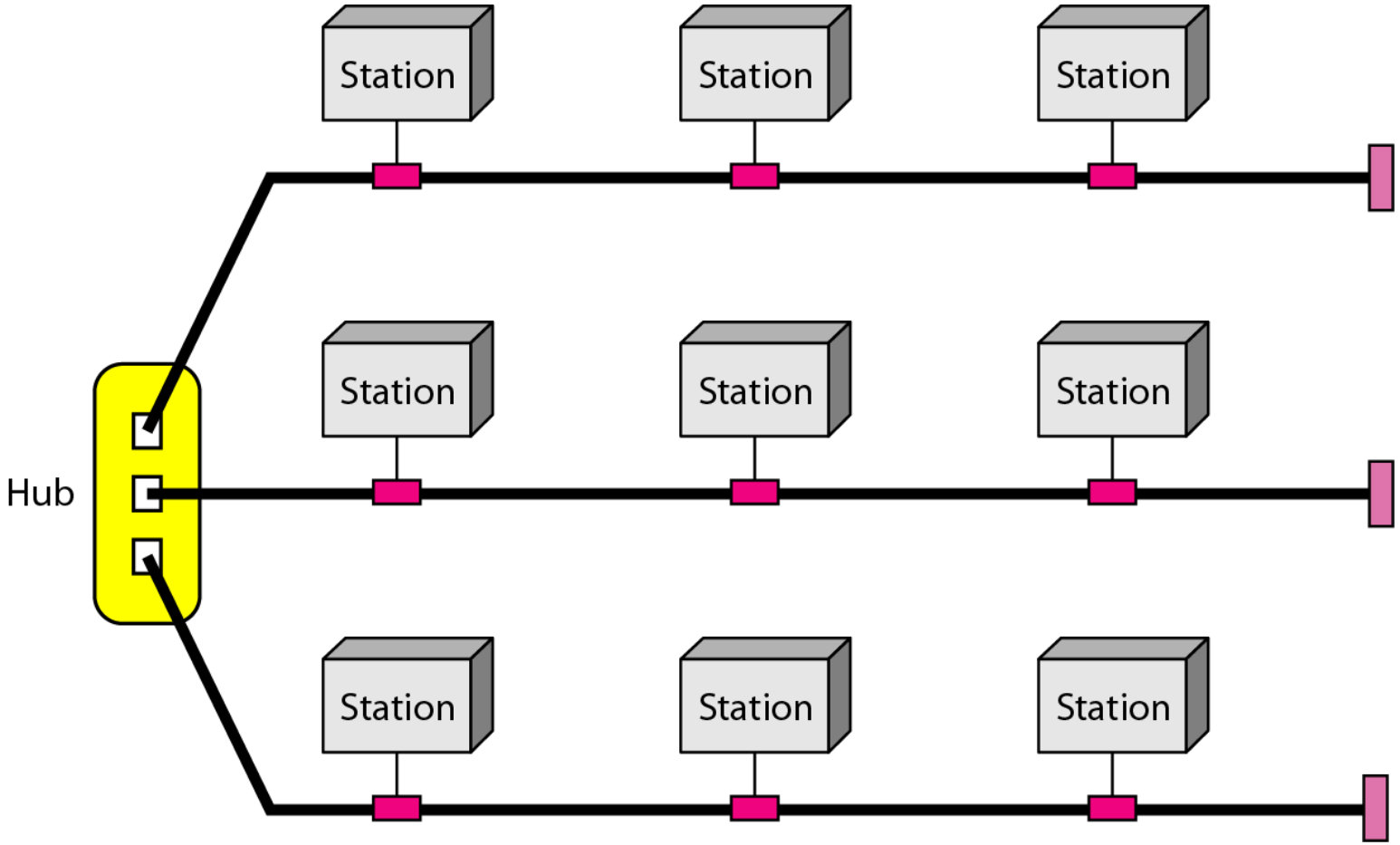
Digram - Tree Topology

Hybrid Topology

- A network which contain all type of physical structure and connected under a single backbone channel.


Hybrid Topology
Server
HUB
Printer
Server
Ethernet
Backbone Cable (Chanel)

Hybrid Topology



Considerations for Choosing Network Topology

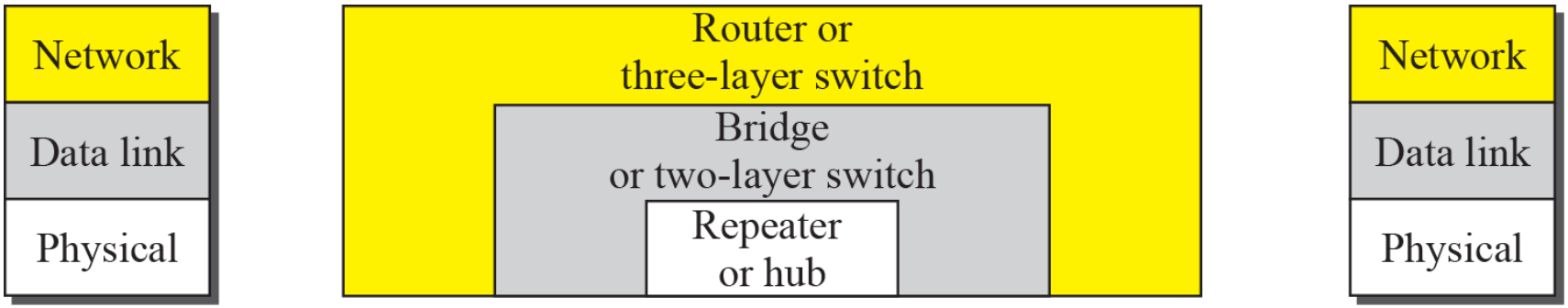
- Money-Bus n/w may be the least expensive way to install a n/w.
- Length-of cable needed- the linear bus n/w uses shorter lengths of cable.
- Future growth-with star topology, expending a n/w is easily done by adding another devices.
- Cable type-most common used cable in commercial organization is twisted pair. Which is often used with star topologies.

- Full **mesh topology** is theoretically the best since every device is connected to every other device.(thus maximizing speed and security. however, it quite expensive to install)
- Next best would be **tree topology** , which is basically a connection of star.

Backbone Networks: Serial Backbone

- Daisy chain: linked series of devices
  - Hubs and switches often connected in daisy chain to extend a network
- Hubs, gateways, routers, switches, and bridges can form part of backbone
- Extent to which hubs can be connected is limited

Connecting devices



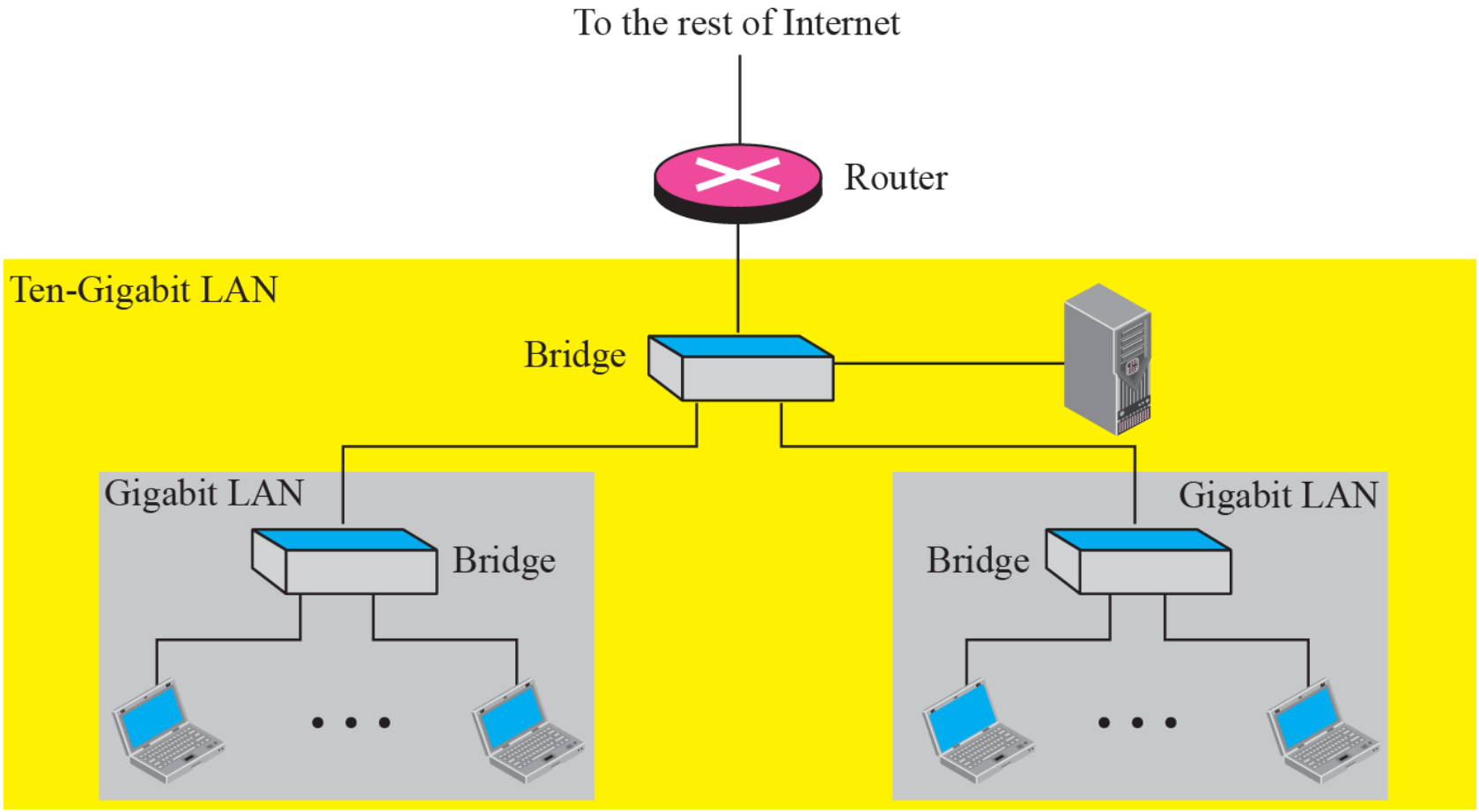
Repeater or hub

A repeater forwards every bit; it has no filtering capability.

A router is a three-layer (physical, data link, and network) device.

A repeater or a bridge connects segments of a LAN. A router connects independent LANs or WANs to create an internetwork (internet).

Routing example



Hub

- Broadcast
- More collision
- Connect same networking device

Switch

- Switch is intelligent device
- Learning the address
- Forwarding
- Work on mac address

Router

- Connect different networks
- Routing

Network Software Architecture and its Layers and Protocols

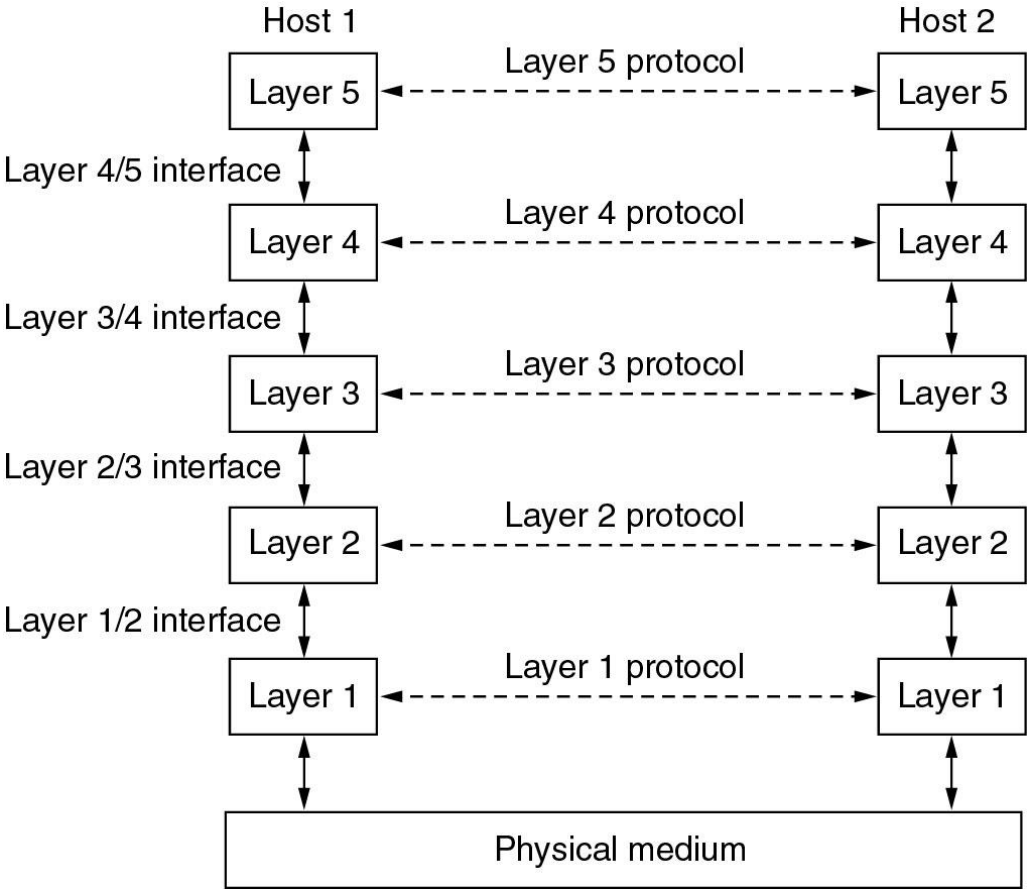
CSE306

Network Software

- Protocol Hierarchies
- Design Issues for the Layers
- Connection-Oriented and Connectionless Services
- Service Primitives
- The Relationship of Services to Protocols

Network Software

Protocol Hierarchies



- Layers, protocols, and interfaces- **Network Architecture**

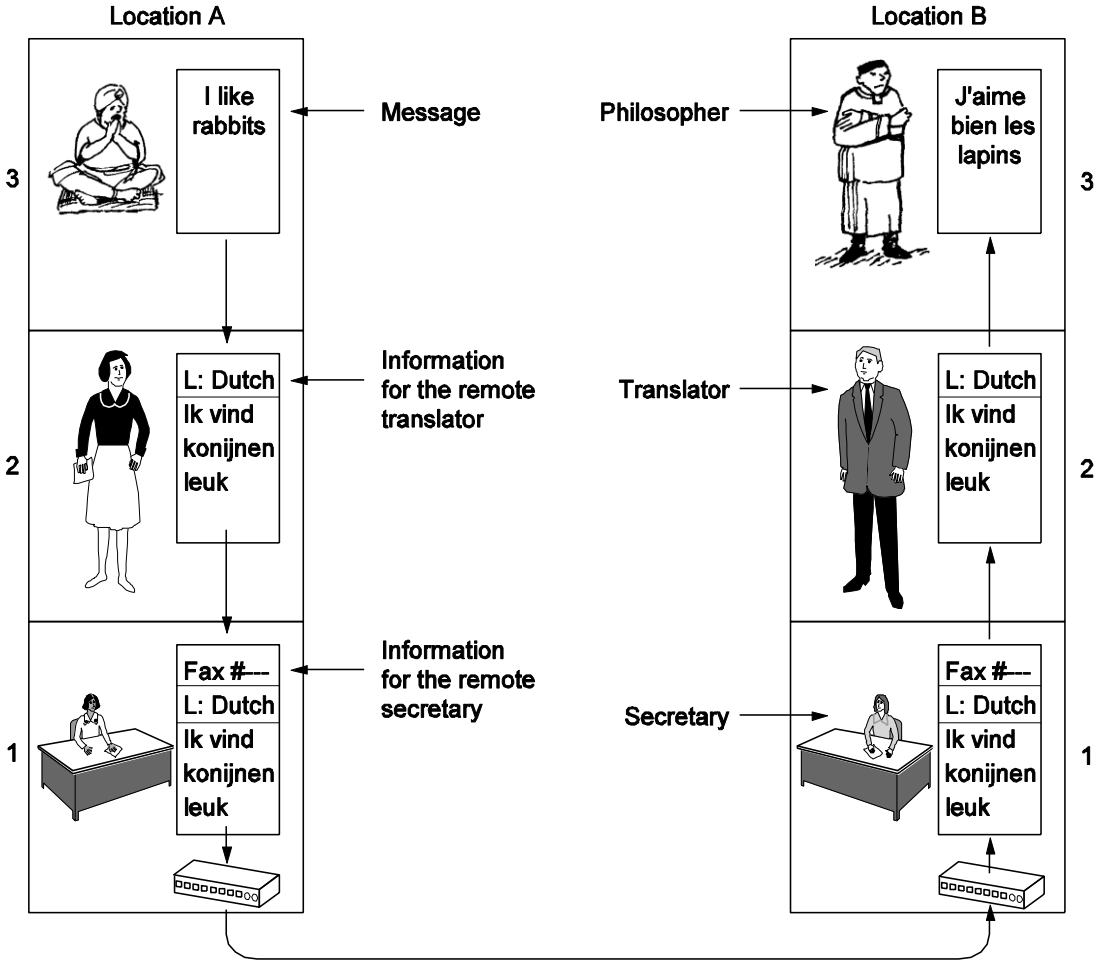
- A **protocol** is an agreement between the communicating parties on how communication is to proceed.

- The entities comprising the corresponding layers on different machines are called **peers.** The peers may be software processes, hardware devices, or even human beings. In other words, it is the peers that communicate by using the protocol to talk to each other.

- A list of the protocols used by a certain system, one protocol per layer, is called a **protocol stack.**

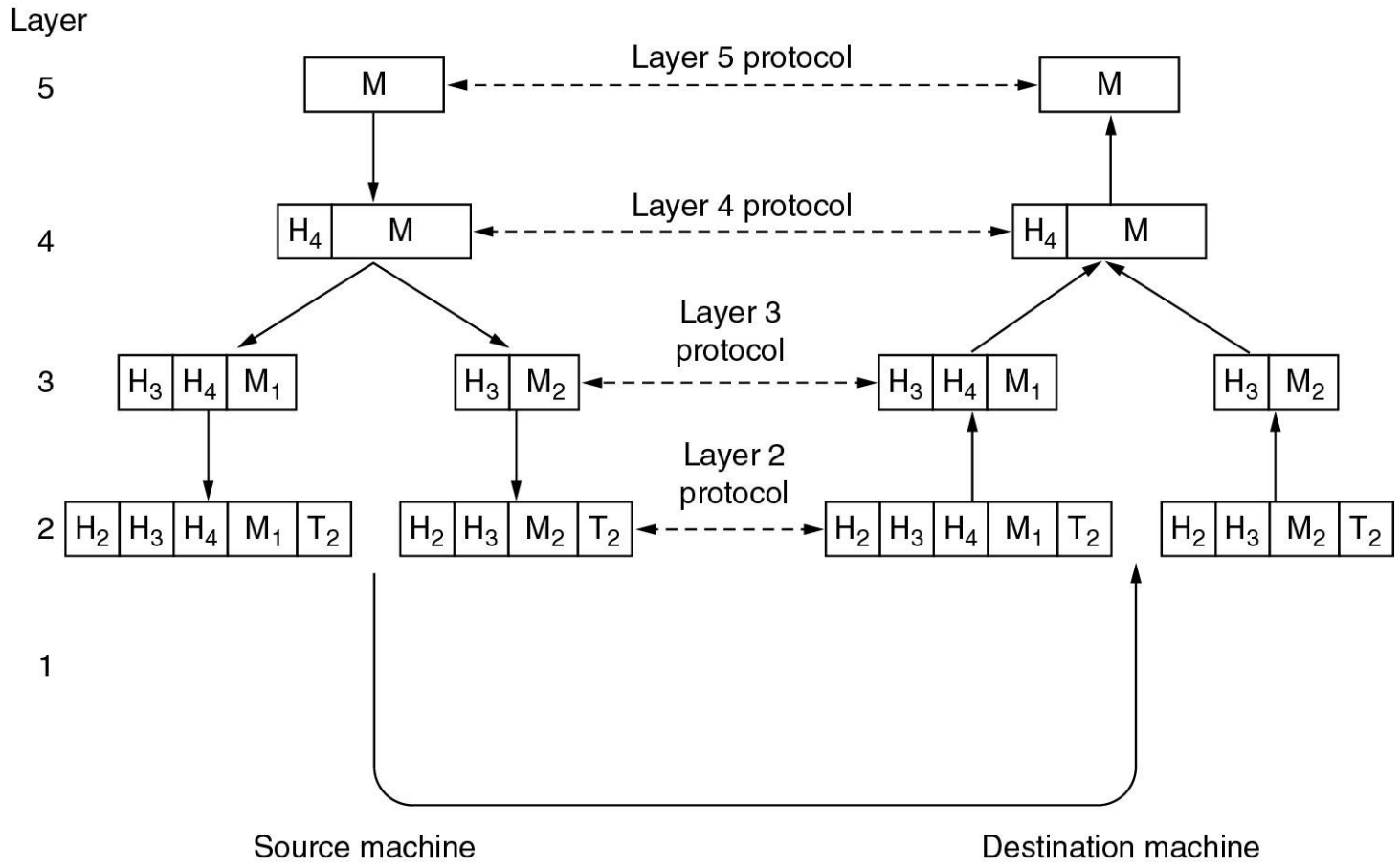
Protocol Hierarchies (2)

- The philosopher-translator-secretary architecture.



Protocol Hierarchies (3)

- Example information flow supporting virtual communication in layer 5.



Design Issues for the Layers

- Addressing or naming
- Error Control
- Flow Control---*Congestion*
- Statistical Multiplexing
- Routing
- Scalable
- QoS---*real time*
- Reliability
- Security

Connection-Oriented and Connectionless Services

- A **circuit is another name for a connection with associated resources,** such as a fixed bandwidth.
- This dates from the telephone network in which a circuit was a path over copper wire that carried a phone conversation.
- In contrast to connection-oriented service, **connectionless service is modeled** after the postal system.
- Each message (letter) carries the full destination address, and each one is routed through the intermediate nodes inside the system independent of all the subsequent messages.
- **Store or forward switching**
- **Cut through switching**

- Each kind of service can further be characterized by its reliability. Some services are reliable in the sense that they never lose data.

- Usually, a reliable service is implemented by having the receiver acknowledge the receipt of each message so the sender is sure that it arrived.

- Reliable connection-oriented service has two minor variations: **message sequences and byte streams.**

- The acknowledgement process introduces overhead and delays, which are often worth it but are sometimes undesirable.

- One such application is digitized voice traffic for voice over IP.

- Unreliable (meaning not acknowledged) connectionless service is often called **datagram service.**

Connection-Oriented and Connectionless Services

- Six different types of service.

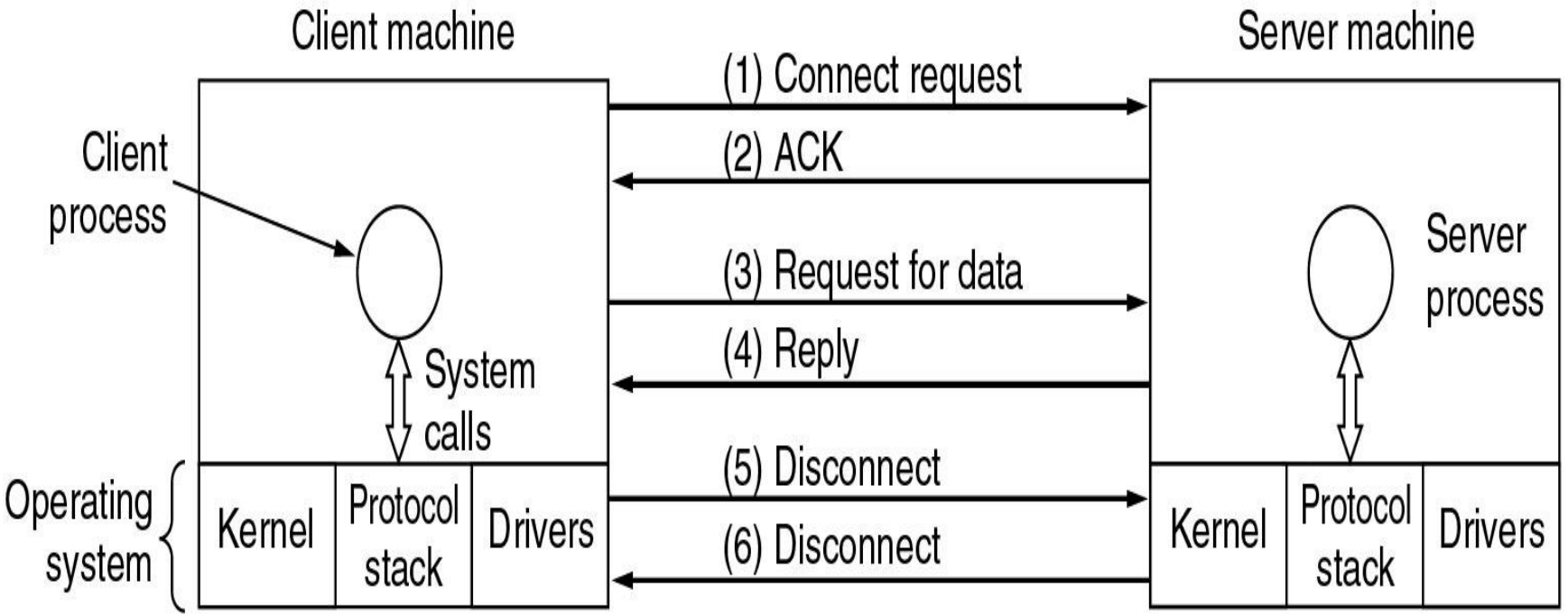
	Service	Example
Connection-oriented	Reliable message stream	Sequence of pages
	Reliable byte stream	Remote login
	Unreliable connection	Digitized voice
Connection-less	Unreliable datagram	Electronic junk mail
	Acknowledged datagram	Registered mail
	Request-reply	Database query

Service Primitives

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

- Five service primitives for implementing a simple connection-oriented service.

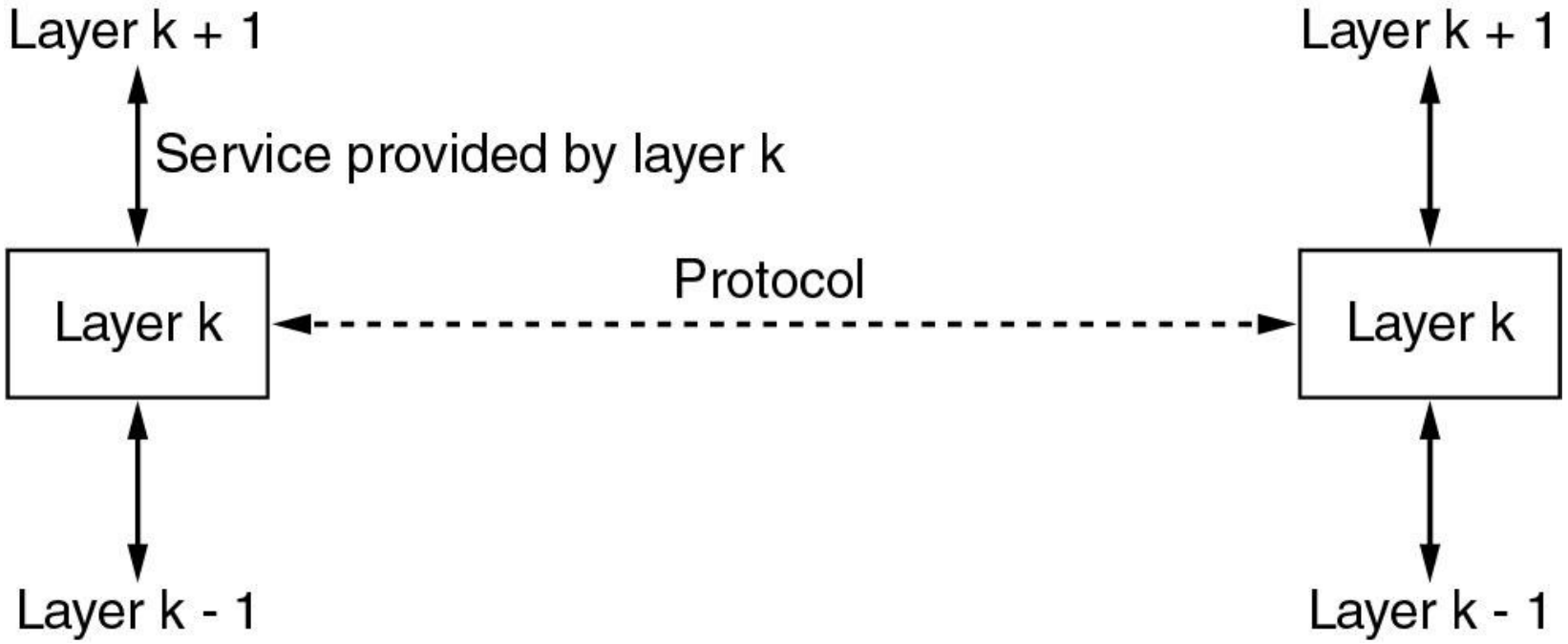
Service Primitives (2)



- Packets sent in a simple client-server interaction on a connection-oriented network.

Services to Protocols Relationship

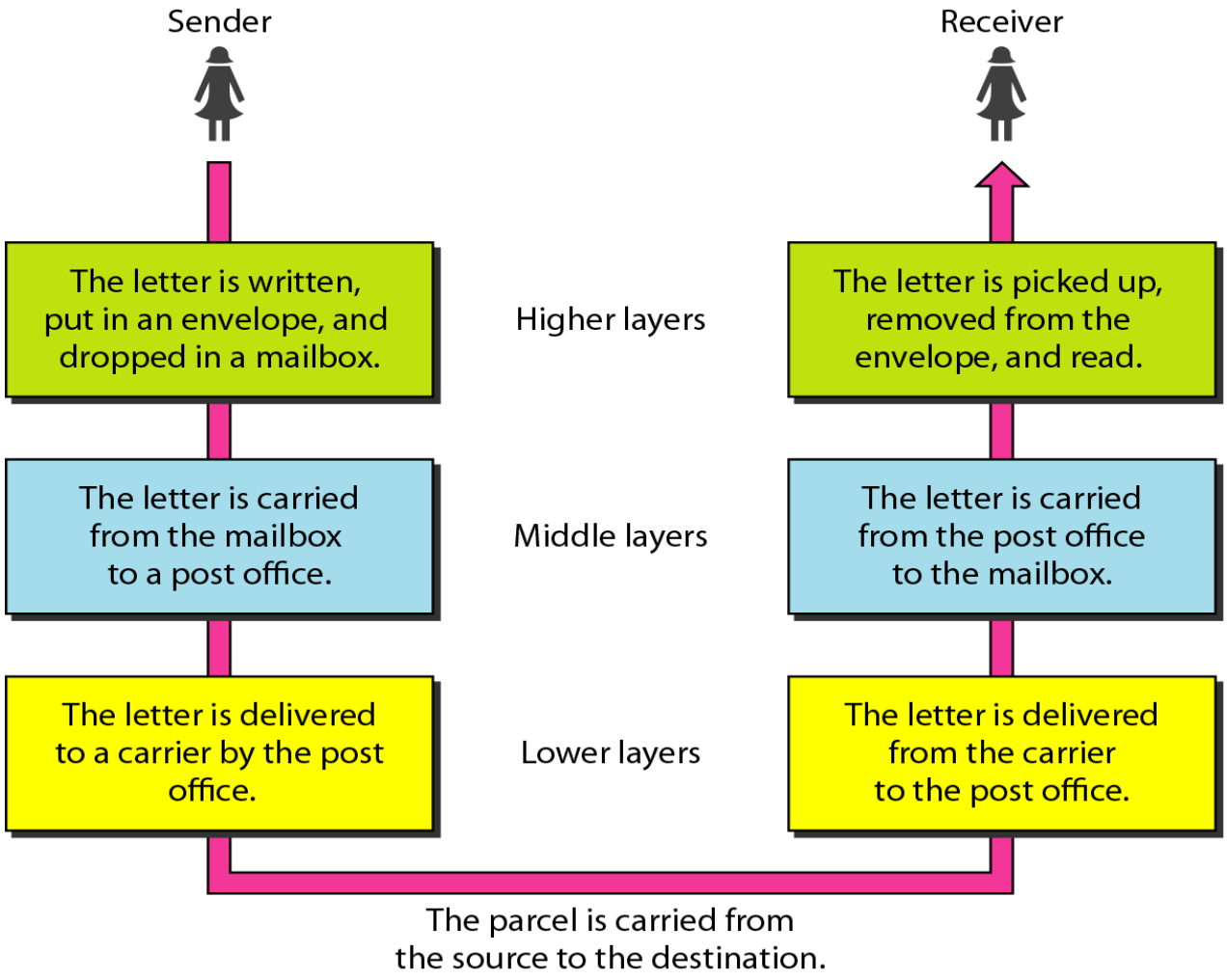
- The relationship between a service and a protocol.



OSI Model and TCP/IP protocol suite)

CSE306

Tasks involved in sending a letter



THE OSI MODEL

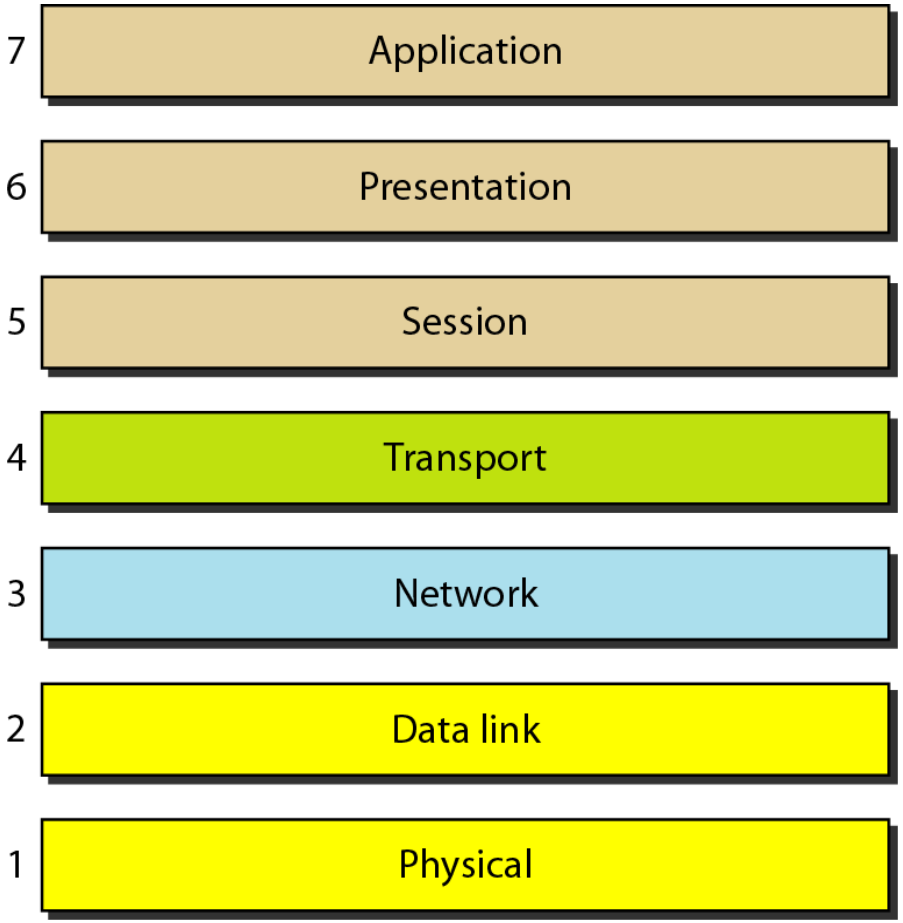
Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards. An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model. It was first introduced in the late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

Topics discussed in this section:

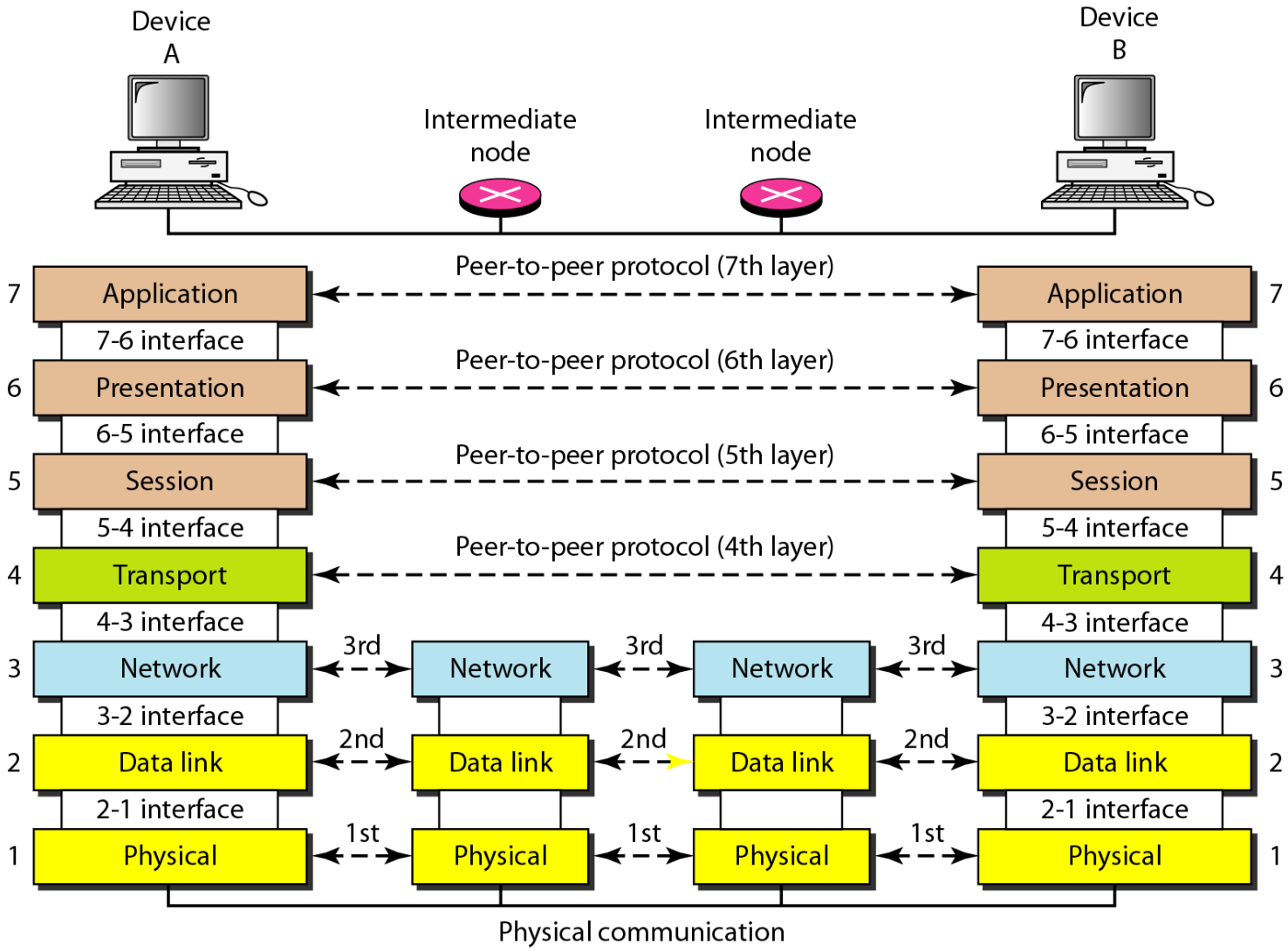
Layered Architecture
Peer-to-Peer Processes
Encapsulation

ISO is the organization.
OSI is the model.

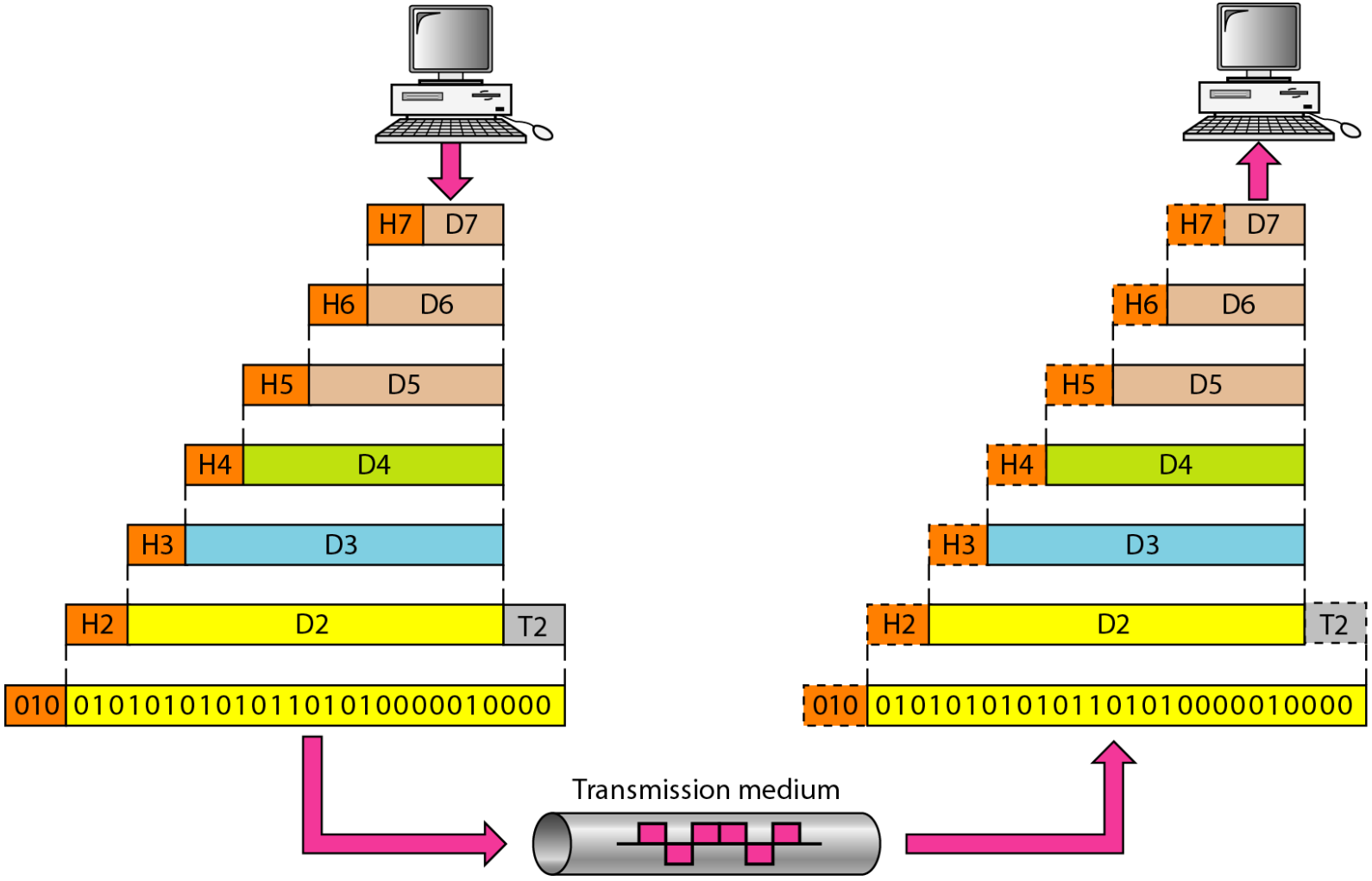
Seven layers of the OSI model



The interaction between layers in the OSI model



An exchange using the OSI model



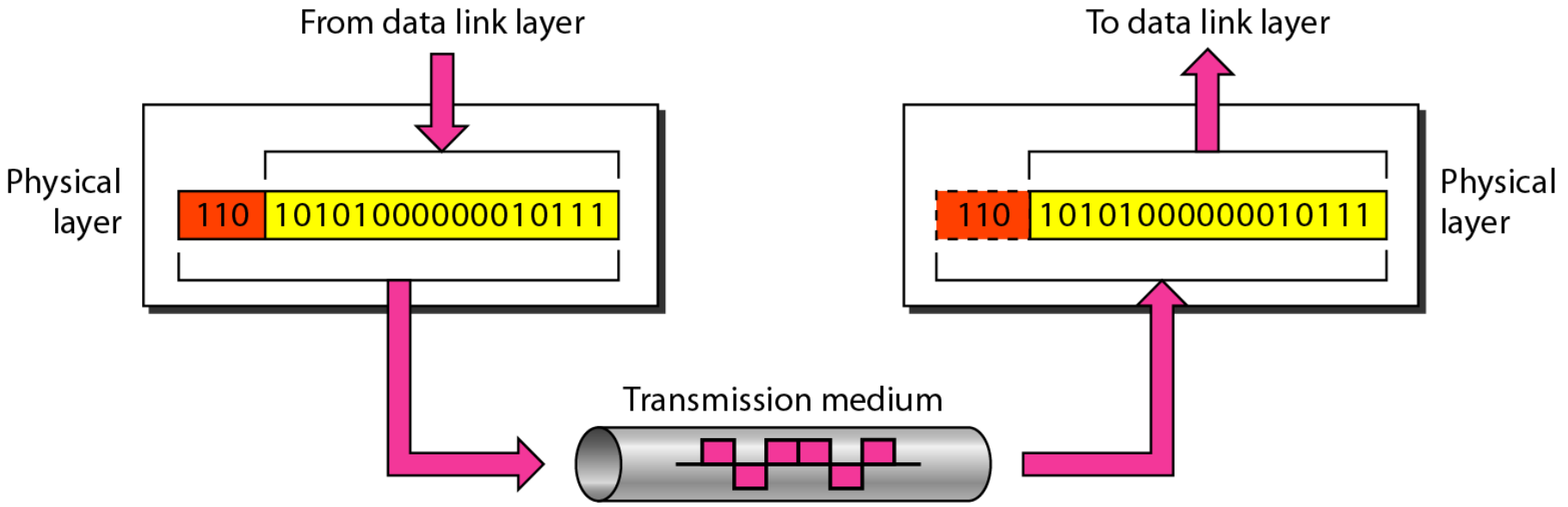
LAYERS IN THE OSI MODEL

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

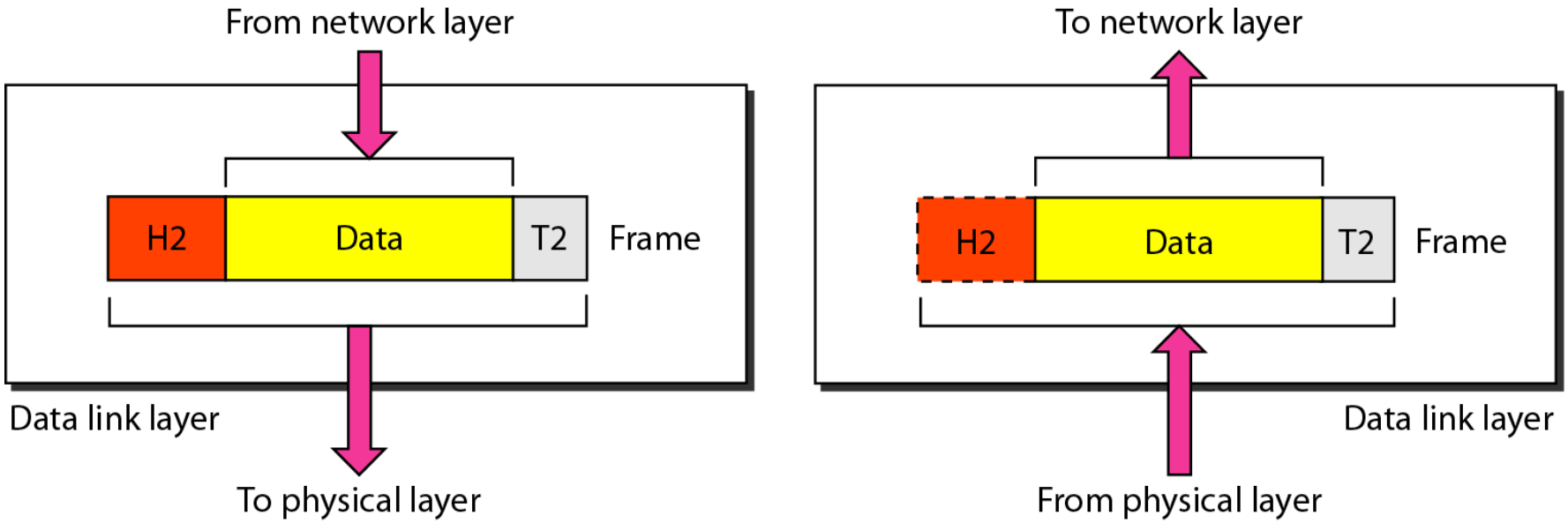


The physical layer is responsible for movements of individual bits from one hop (node) to the next.

Physical layer

- Type of transmission media
- Representation of bits
- Data rate
- Synchronization of bits
- Line Configuration
- Topology
- Transmission mode

Data link layer

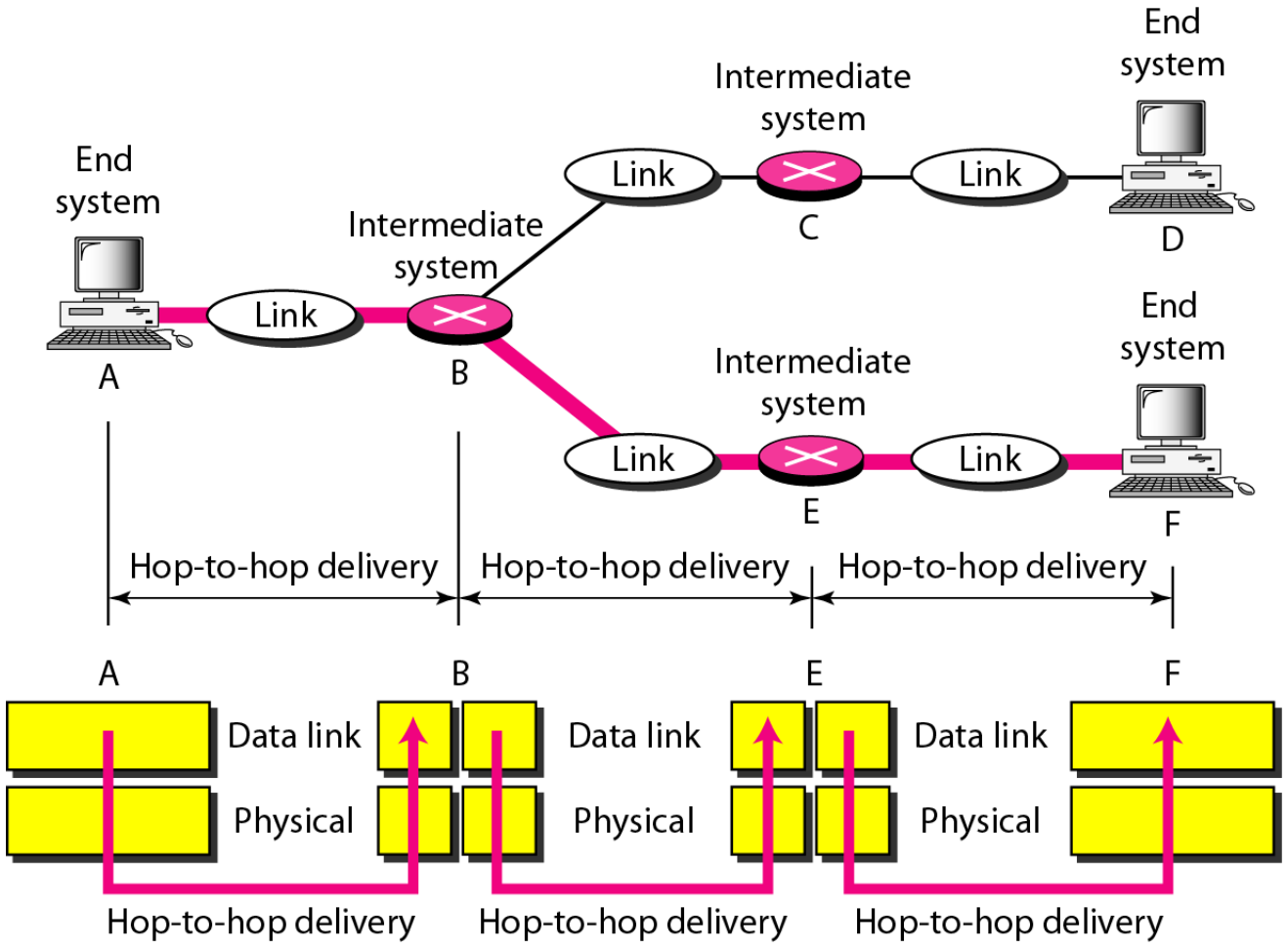


The data link layer is responsible for moving frames from one hop (node) to the next.

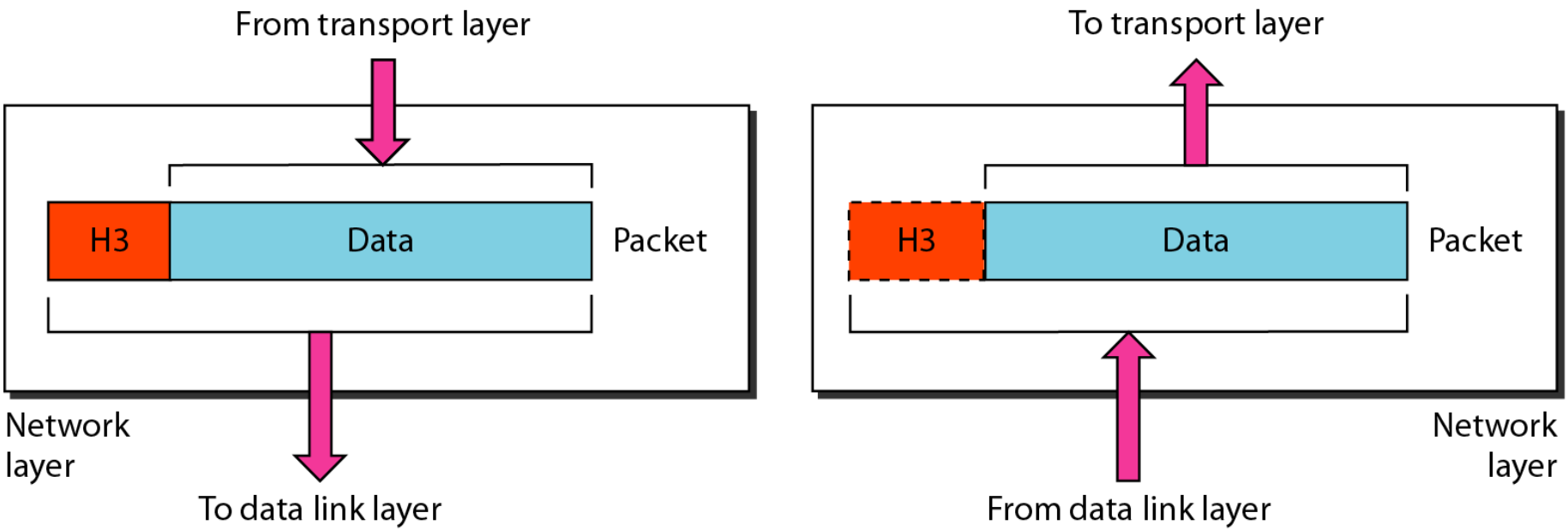
Data link layer

- Framing
- Physical addressing
- Flow control
- Error control
- Access control

Hop-to-hop delivery



Network layer

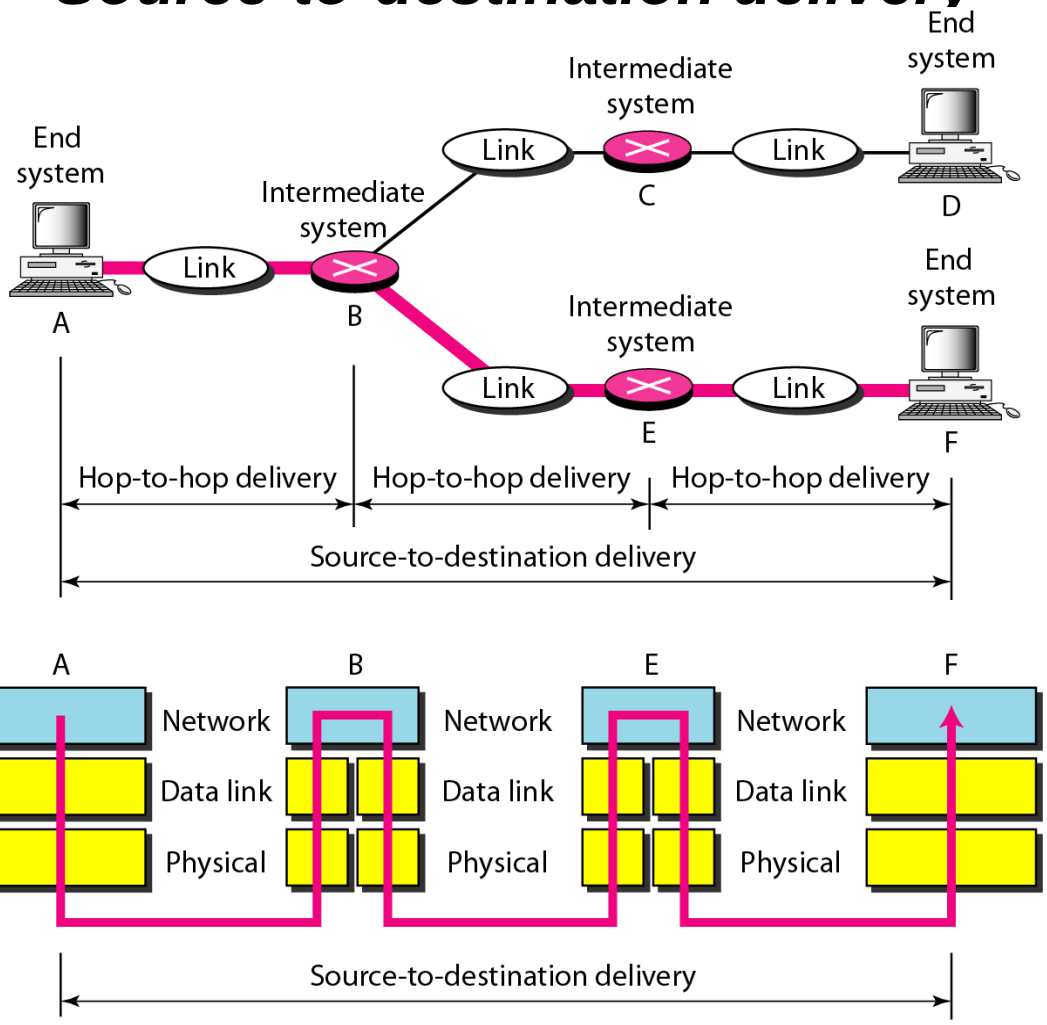


The network layer is responsible for the delivery of individual packets from the source host to the destination host.

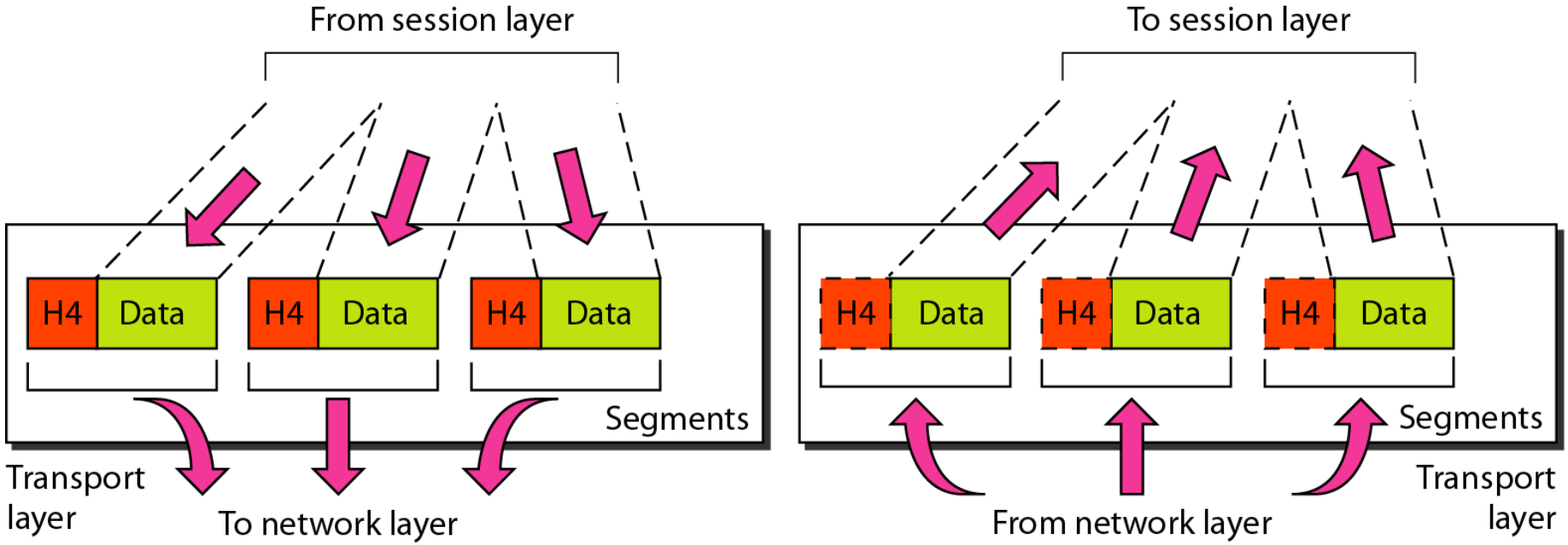
Network layer

- Logical addressing
- Routing

Source-to-destination delivery



Transport layer

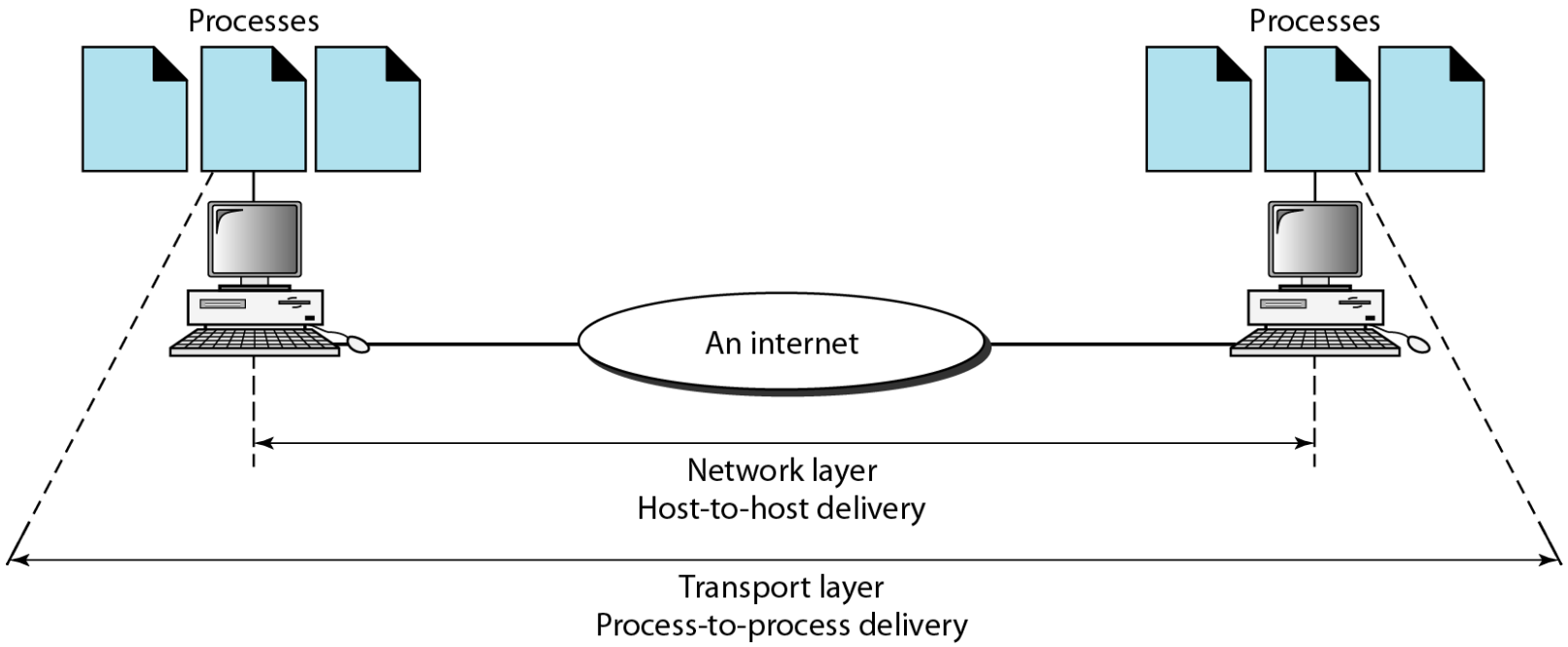


The transport layer is responsible for the delivery of a message from one process to another.

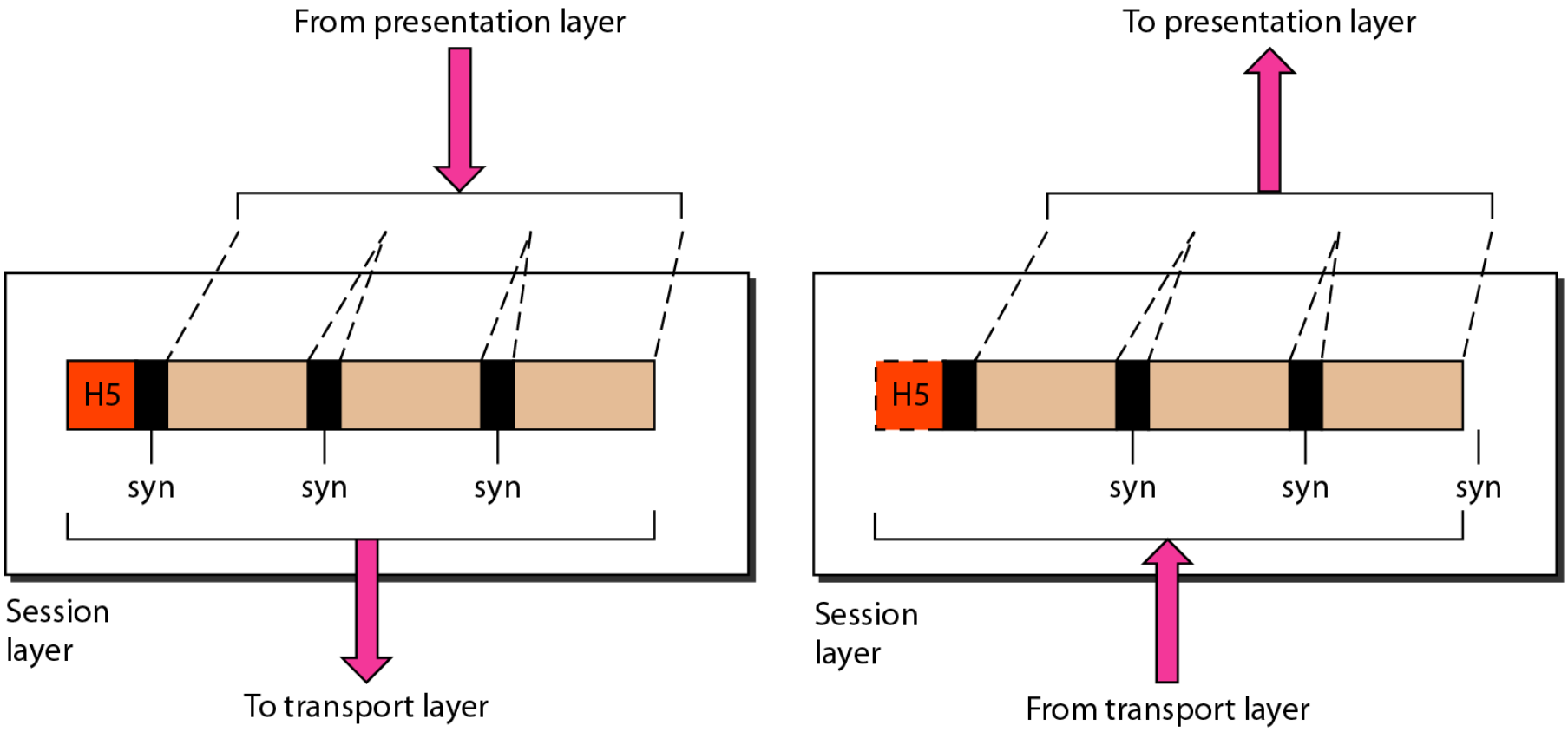
Transport layer

- Service-point addressing
- Segmentation and reassembly
- Connection control
- Flow control
- Error control

Reliable process-to-process delivery of a message



Session layer

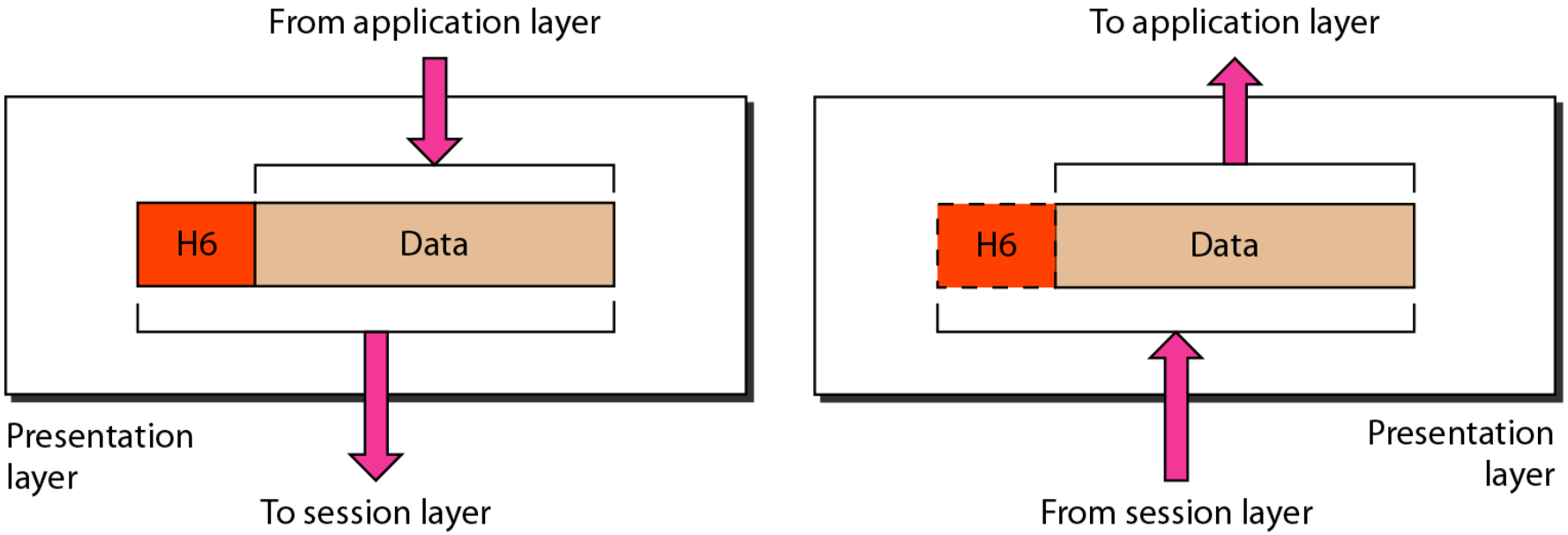


The session layer is responsible for dialog control and synchronization.

Session layer

- Dialog control (turn to transmit)
- Synchronization (introducing check point)

Presentation layer

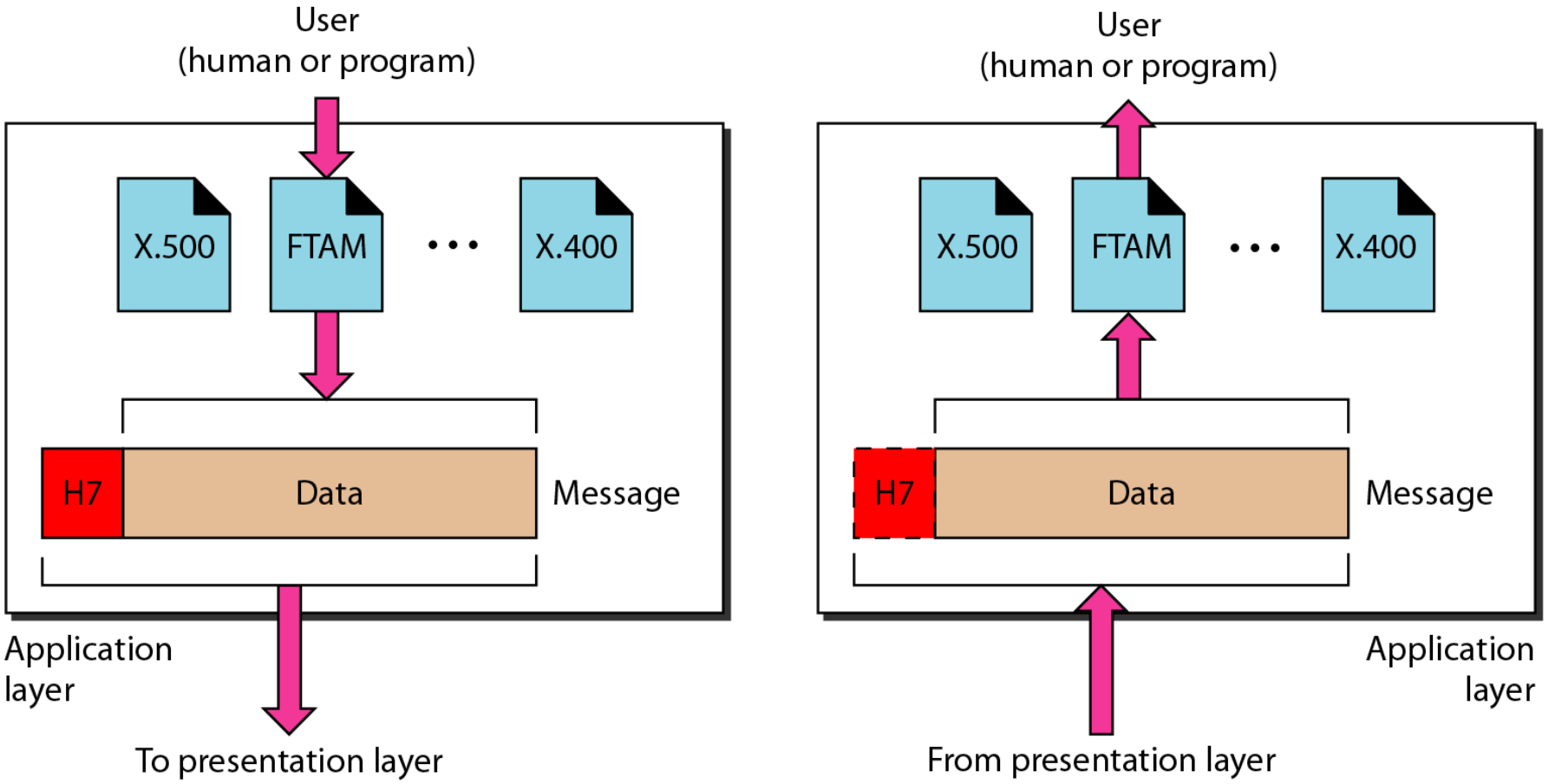


The presentation layer is responsible for translation, compression, and encryption.

Presentation layer

- Translation
- Encryption
- Compression

Application layer

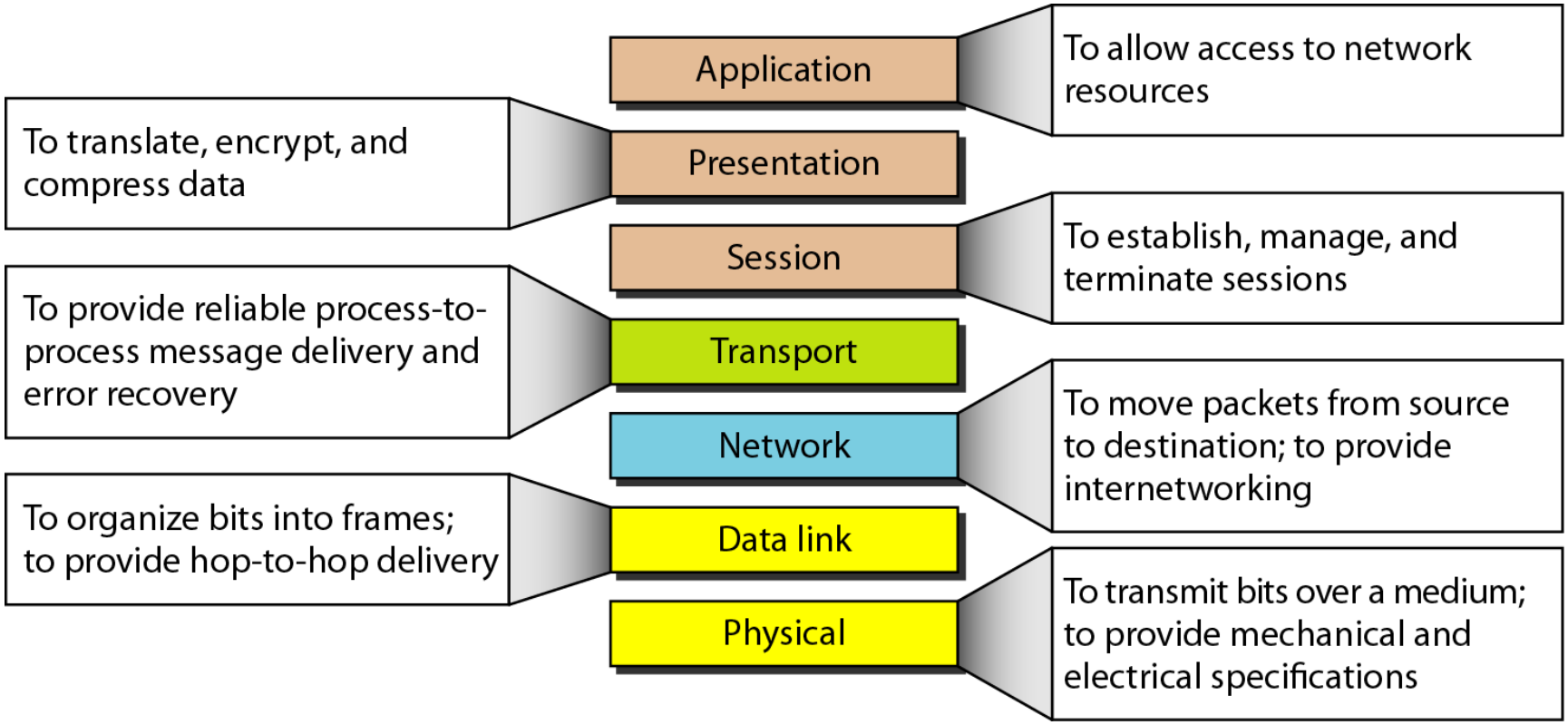


The application layer is responsible for providing services to the user.

Application layer

- Network Virtual Terminal
- File transfer, access, and management.
- Mail services
- Directory Services

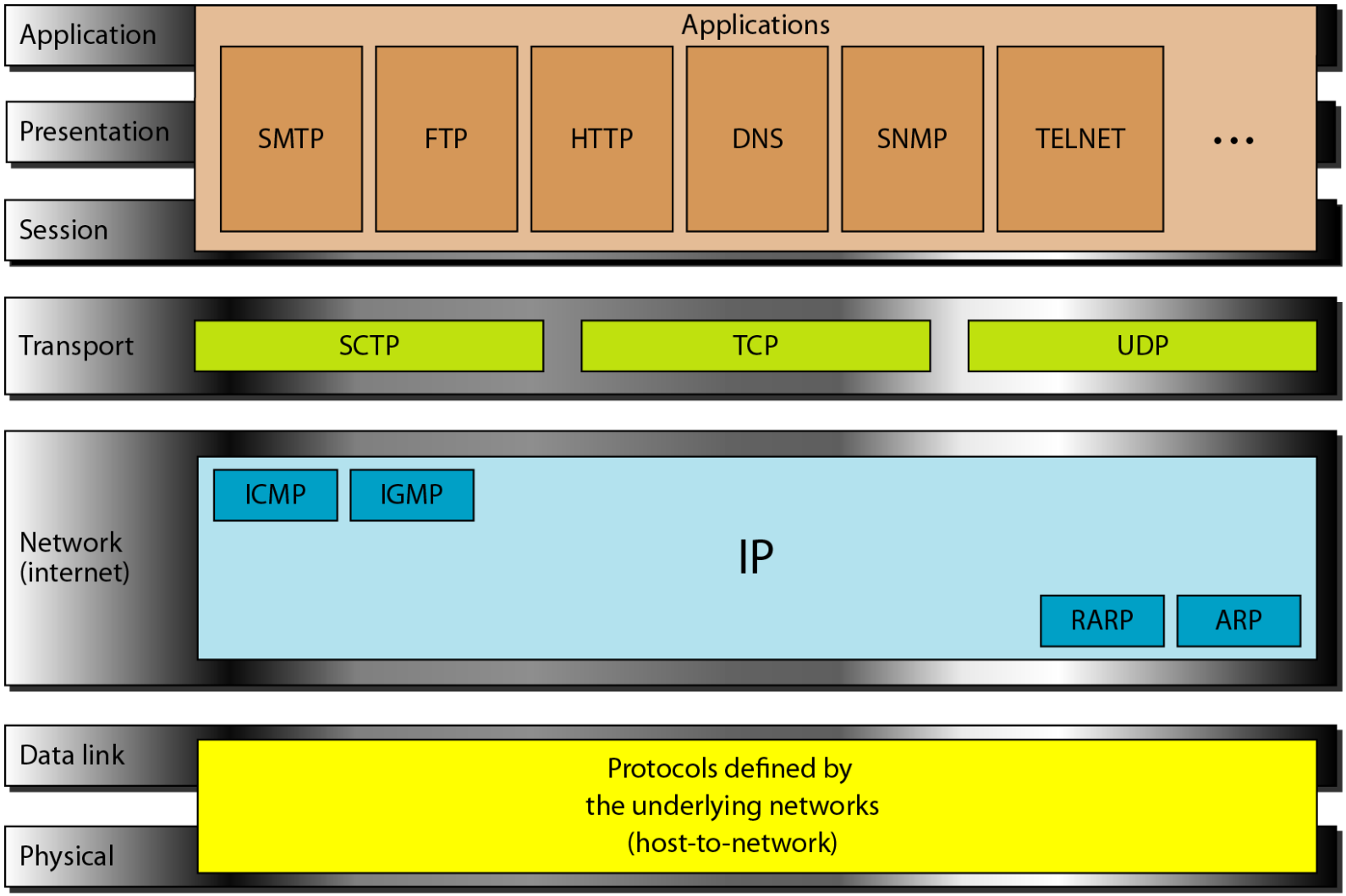
Summary of layers



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.

TCP/IP and OSI model

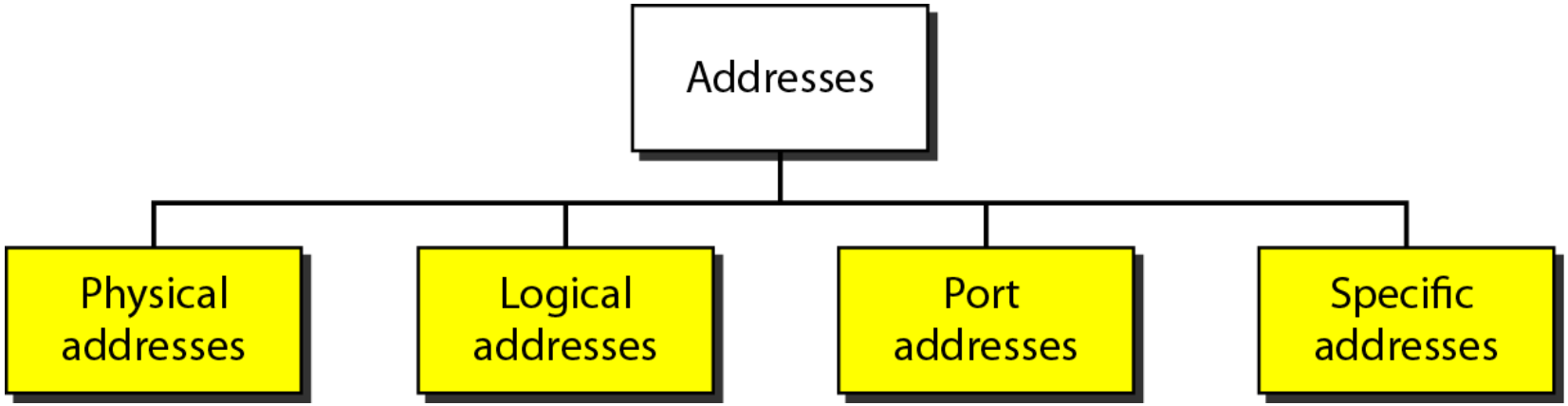


ADDRESSING

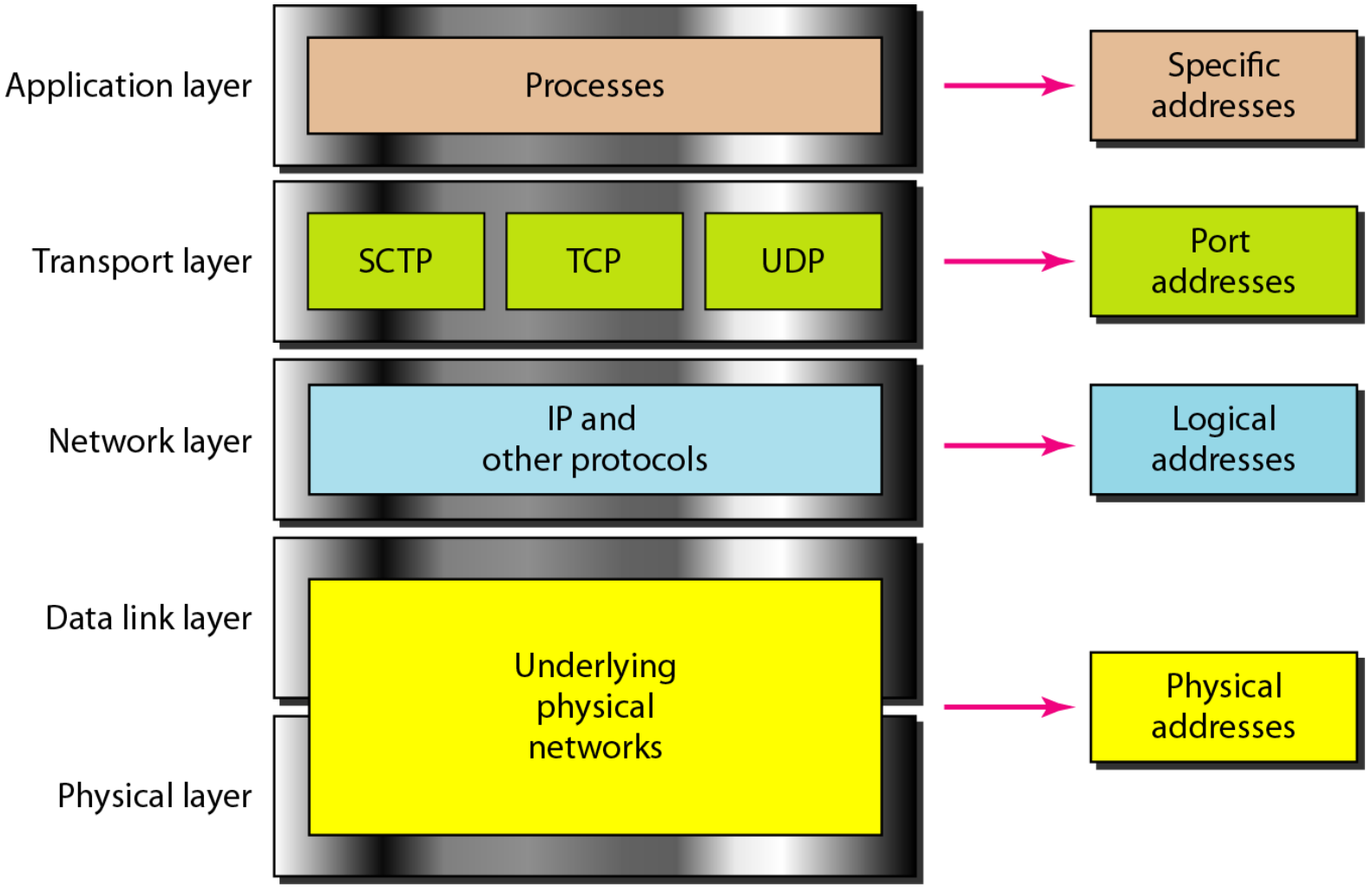
Four levels of addresses are used in an internet employing the TCP/IP protocols: physical, logical, port, and specific.

Physical Addresses
Logical Addresses
Port Addresses
Specific Addresses

Addresses in TCP/IP



Relationship of layers and addresses in TCP/IP



Comparison of the OSI and TCP/IP Reference Models

- Functionality of the layers is roughly similar

Concepts central to OSI model

- Services : The service definition tells what the layer does, not how entities above it access it . It defines the layer's semantics.
- Interfaces : tells the processes above it how to access it. It specifies what the parameters are and what results to expect
- Protocols: the layer's own business.

Comparison of the OSI and TCP/IP Reference Models

- OSI reference model was devised before the corresponding protocols were invented. This ordering means that the model was not biased toward one particular set of protocols
- In TCP/IP, the protocols came first, and the model was really just a description of the existing protocols
- Number of layers: the OSI model has seven layers and the TCP/IP has four layers.
- The TCP/IP model has only one mode in the network layer (connectionless) but supports both modes in the transport layer.