

Chapter 1

Fundamental concepts of computer networks.

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computer networks.**

Lecture 1

1-1 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 wireless.*

1. ***Delivery*** → ***Correct destination***
2. ***Accuracy*** → ***Accurate data***
3. ***Timelines*** → ***Real-time transmission***
4. ***Jitter*** → ***Uneven delay***

Topics discussed in this section:

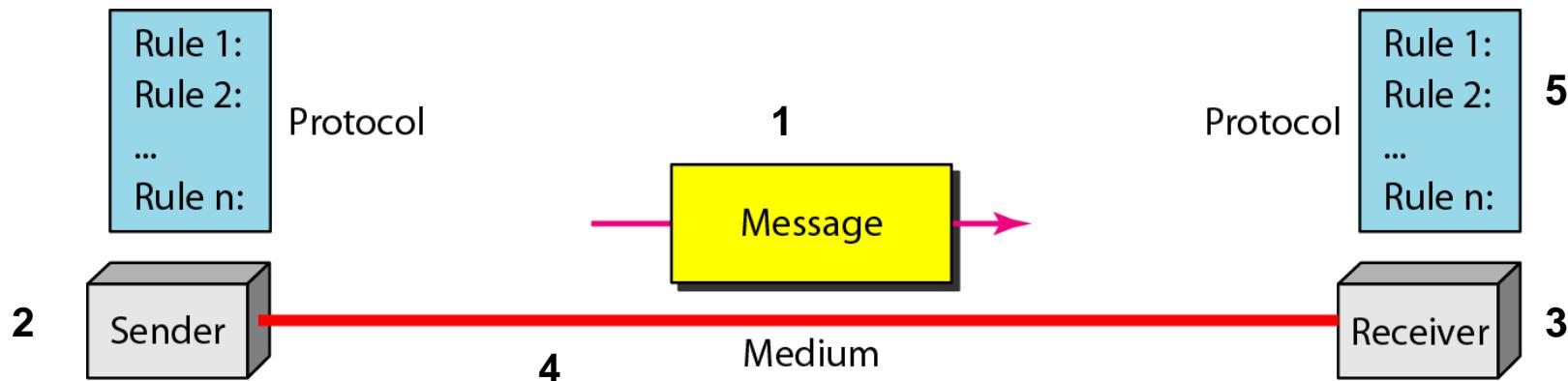
Components

Data Representation

Data Flow

Components

Figure 1.1 *Five components of data communication*

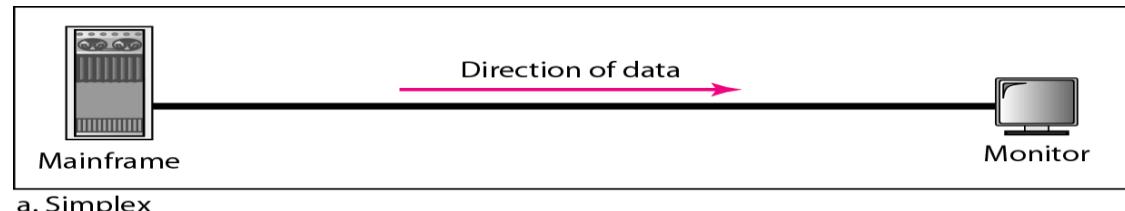


Data Representation

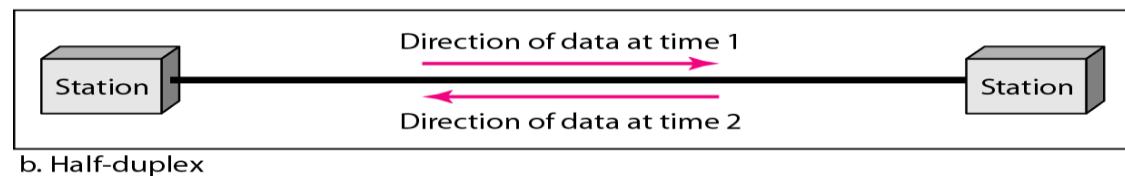
1. *Text*
2. *Numbers*
3. *Images*
4. *Audio*
5. *Video*

Data flow

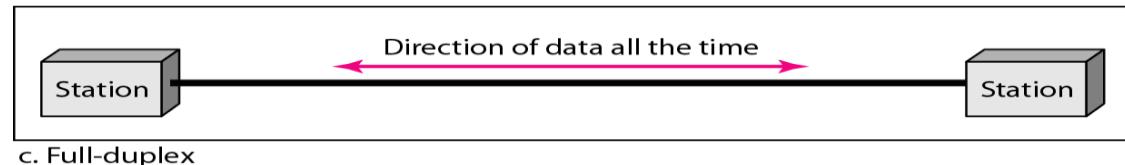
- ***Simplex***



- ***Half-duplex***



- ***Full-duplex***



1-2 NETWORKS

A **network** is a set of devices (**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.

Topics discussed in this section:

Distributed Processing

Network Criteria (performance, reliability, and security)

Physical Structures (type of connections and topologies)

Network Models

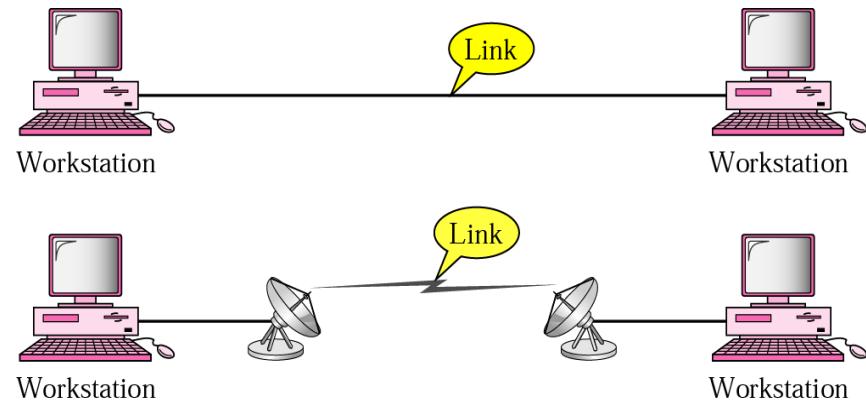
Categories of Networks (LAN, MAN and WAN)

Interconnection of Networks: Internet

Types of connections

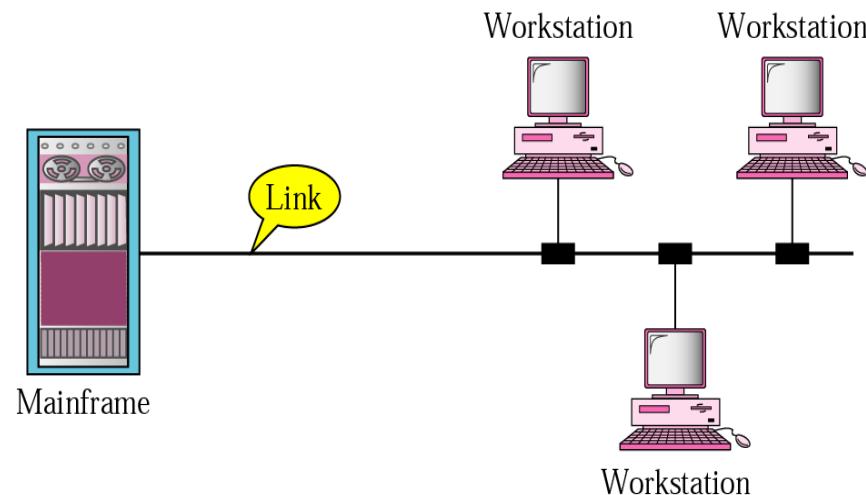
- **Point to point**

- A dedicated link is provided between two devices

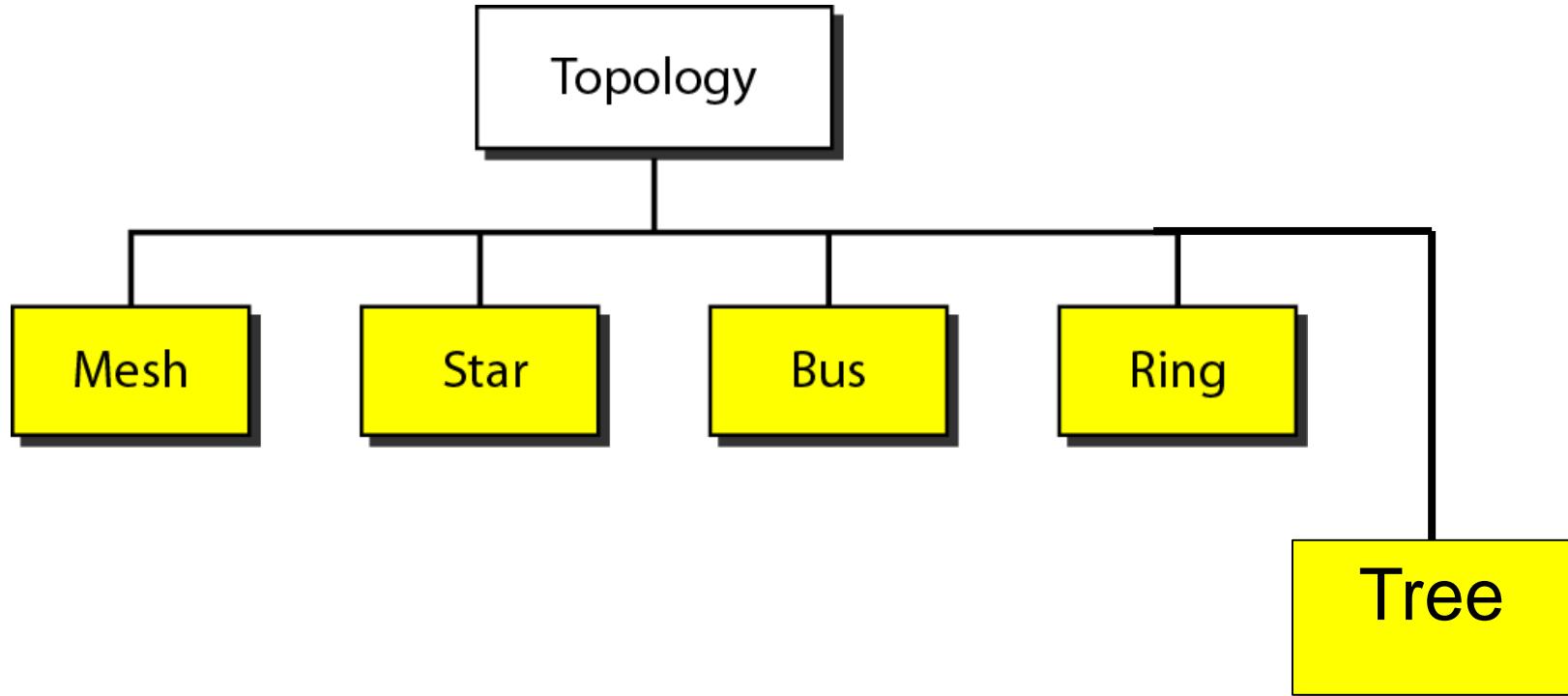


- **Multipoint**

- More than two specific devices share a single link

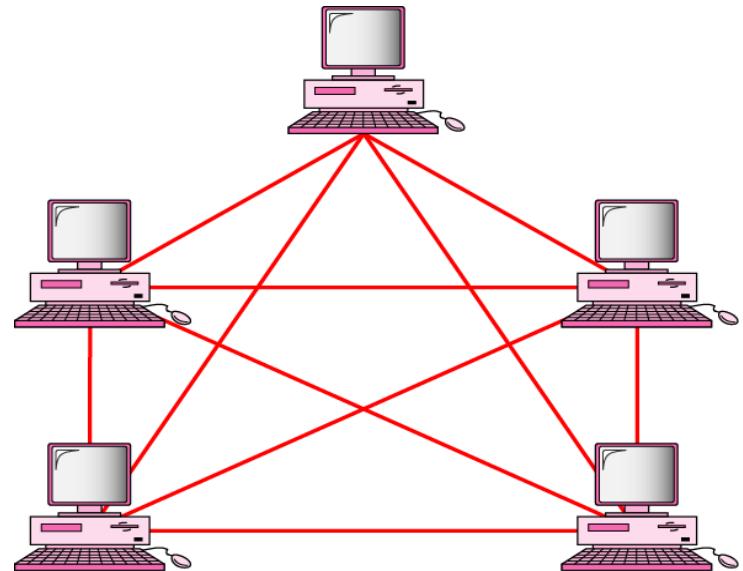


Physical Topology



MESH Topology

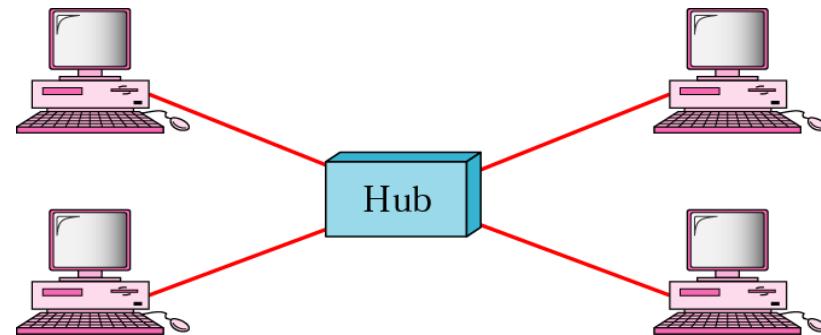
- Every device has a dedicated point-to-point link to every other devices
- Dedicated
 - Link carries traffic only between the two devices it connects
 - A fully connected mesh network has $n(n-1)/2$ physical channels to link n devices
 - Every device on the network must have $n-1$ input/output (I/O) ports
- Advantage
 - Less traffic, robust, secure, easy to maintain
- Disadvantage
 - Need more resource (cable and ports), expensive



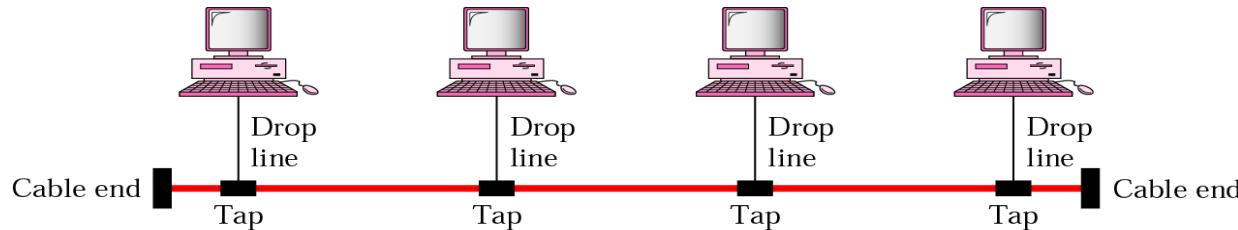
$n(n-1)/2$ physical duplex links

STAR Topology

- Each device has a dedicated point-to-point link only to a central controller, usually called a hub.
- No direct traffic and link between devices
- Advantages
 - Less expensive
 - Easy to install and reconfigure
 - Robustness
- Disadvantage
 - Single point of failure

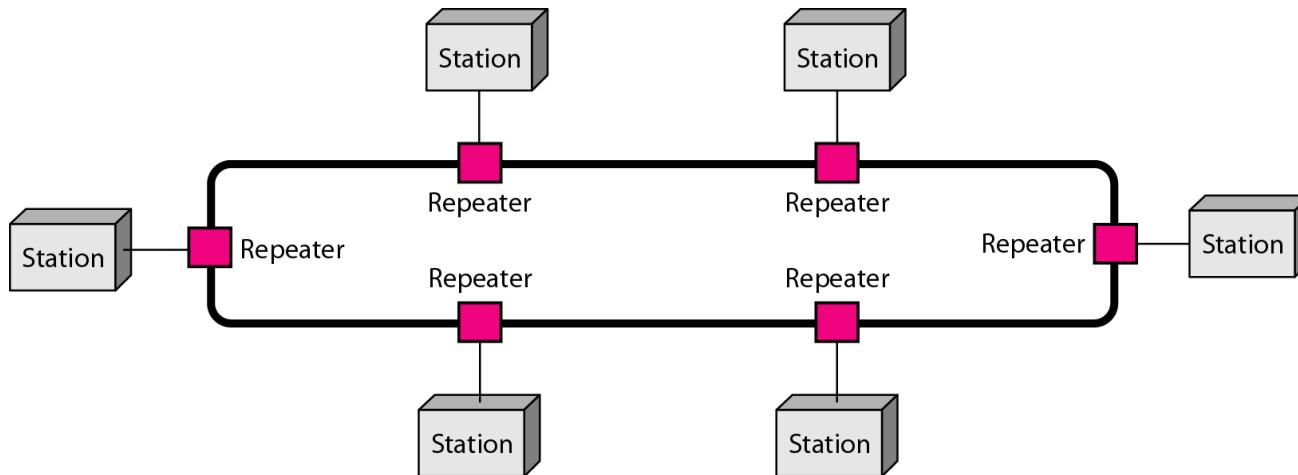


BUS Topology



- A multipoint topology
- All devices are linked through a backbone cable
- Nodes are connected to the bus cable by drop lines and taps.
 - Drop line
 - A connection running between the device and the main cable
 - Tap
 - A connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core
- Advantage:
 - Ease of installation
- Disadvantages:
 - Difficult reconnection and fault isolation
 - Broken or fault of the bus cable stops all transmission

RING Topology



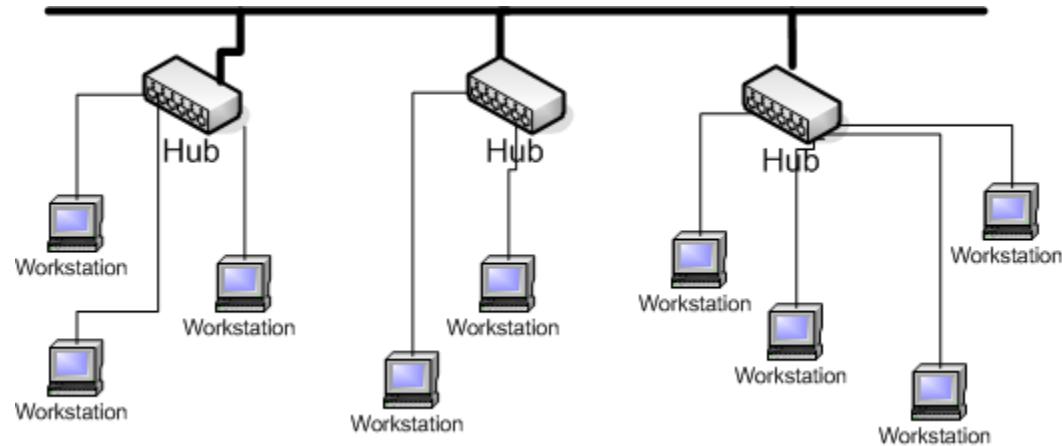
- Each device is dedicated point-to-point connection only with the two devices on either side of it
- A signal is passed along the ring in the direction, from device to device, until it reaches its destination
- Each device in the ring incorporates a repeater

- Advantages
 - Relatively easy to install and reconfigure
 - Fault isolation is simplified
- Disadvantage
 - Unidirectional traffic

Tree Topology

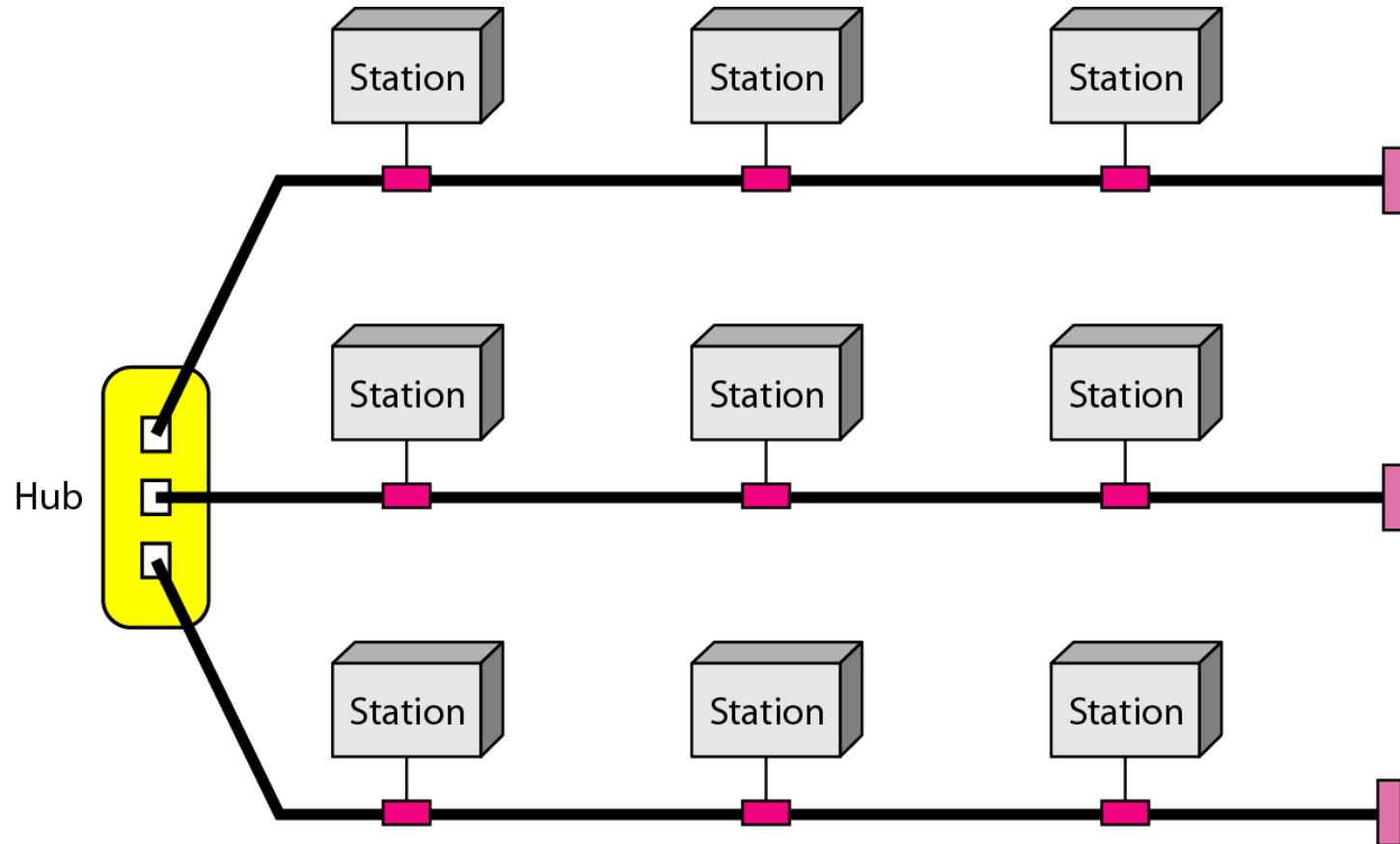
Tree topologies integrate multiple topologies together

Example: Tree topology integrates multiple star topologies together onto a bus



- Advantages:
 - Point-to-point wiring for individual segments.
 - Supported by several hardware and software vendors.
- Disadvantages:
 - Overall length of each segment is limited by the type of cabling used.
 - If the backbone line breaks, the entire segment goes down.
 - More difficult to configure and wire than other topologies.

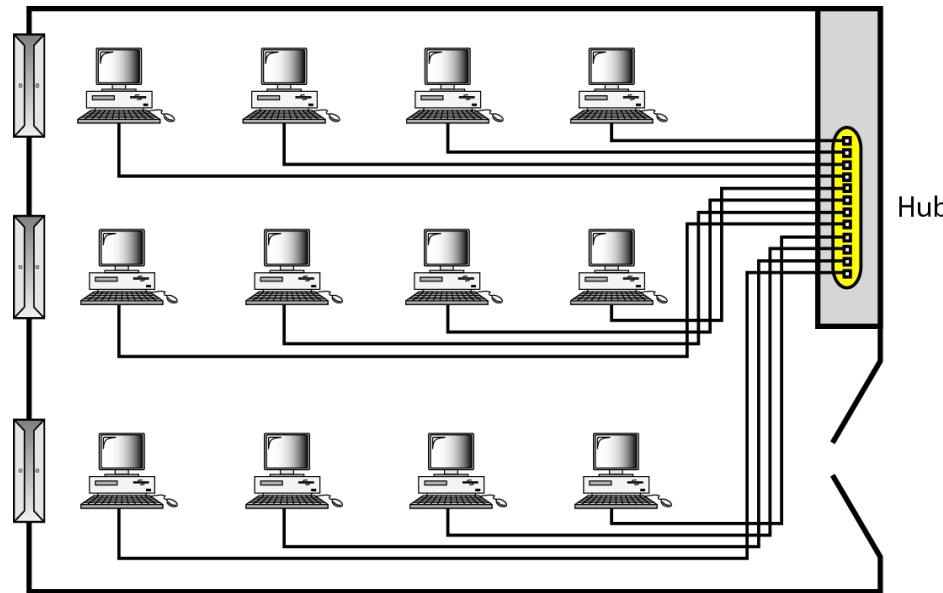
A hybrid topology: a star backbone with three bus networks



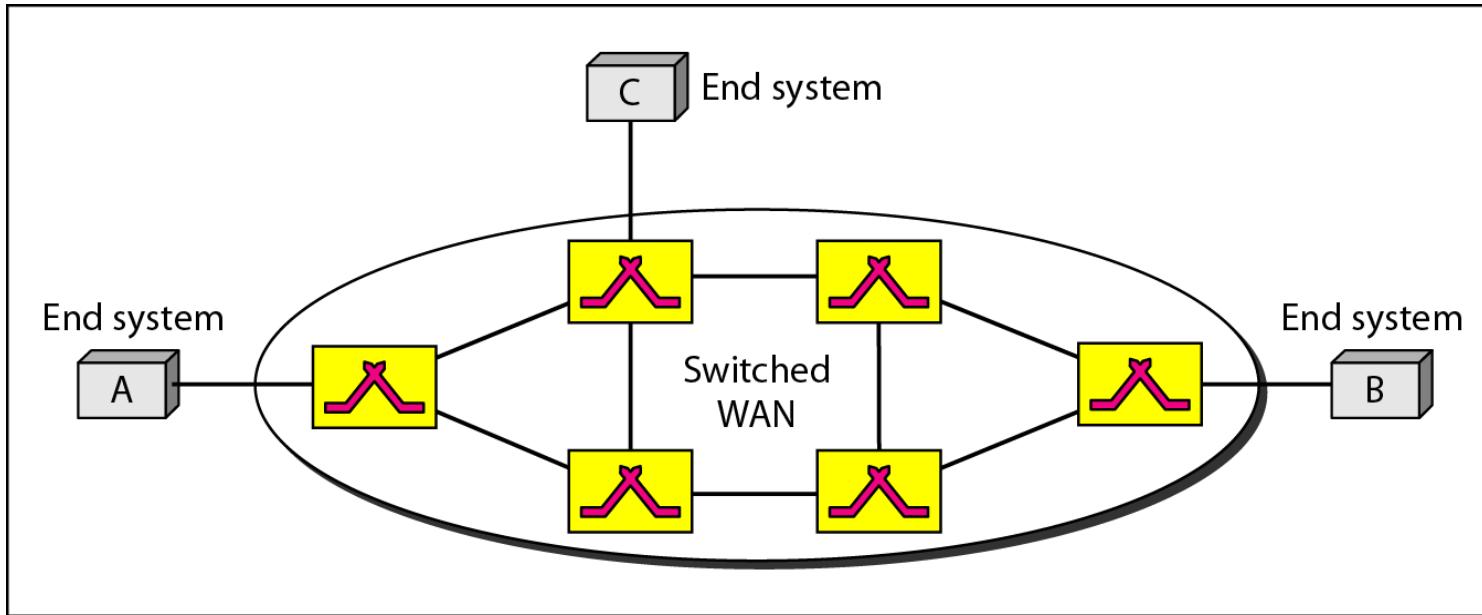
Categories of Networks

1. Local Area Network (LAN)
2. Wireless Local Area Network (WLAN)
3. Metropolitan Area Network (MAN)
4. Wide Area Network (WAN)

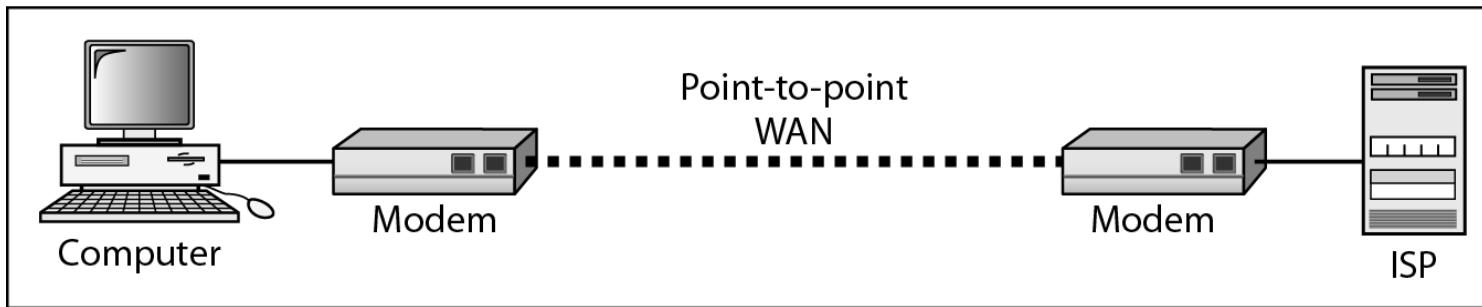
An isolated LAN connecting 12 computers to a hub in a closet



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



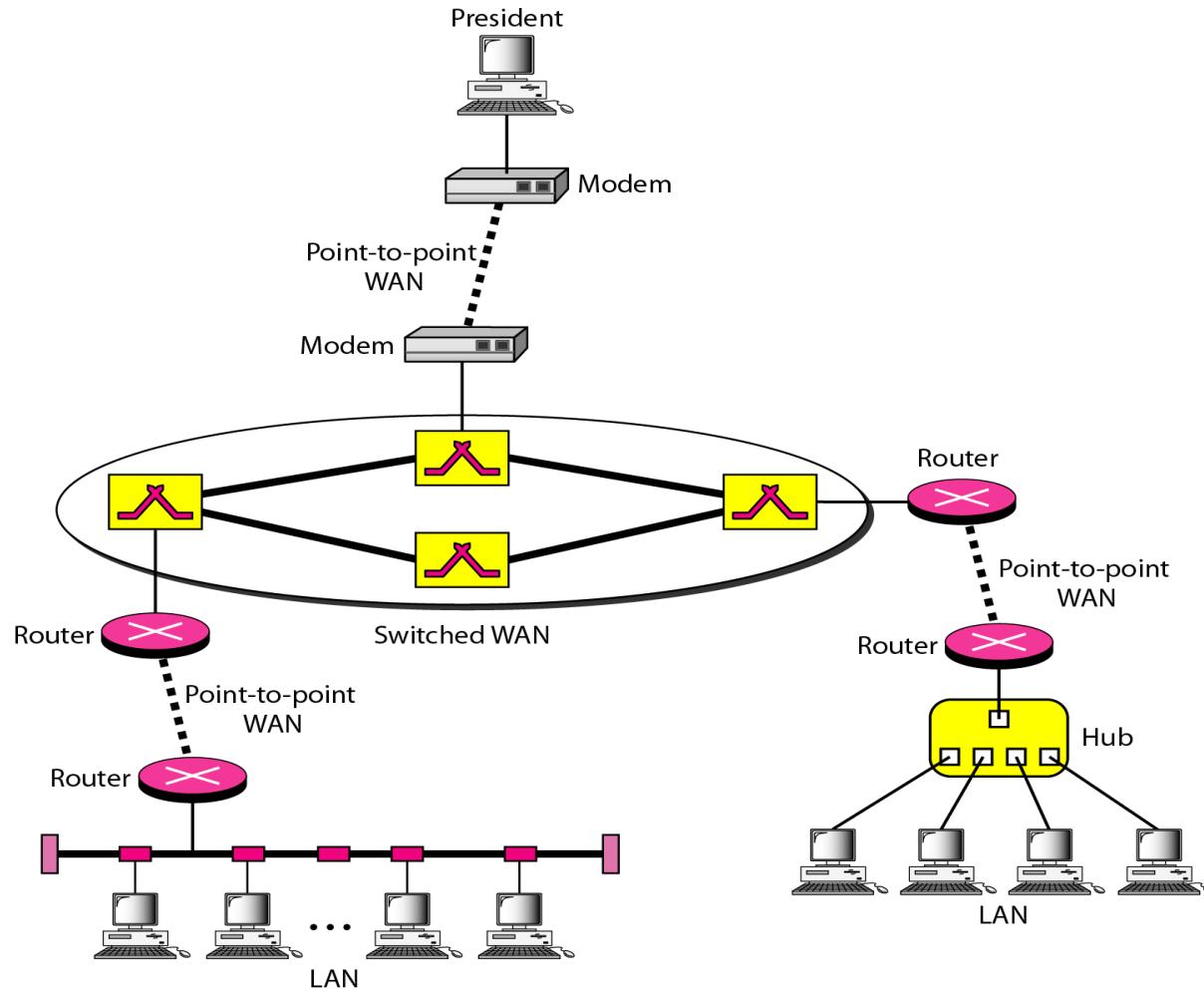
a. Switched WAN



b. Point-to-point WAN

Interconnection of Networks: internet

A heterogeneous network made of four WANs and two LANs



1-3 THE INTERNET

The Internet has changed 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.

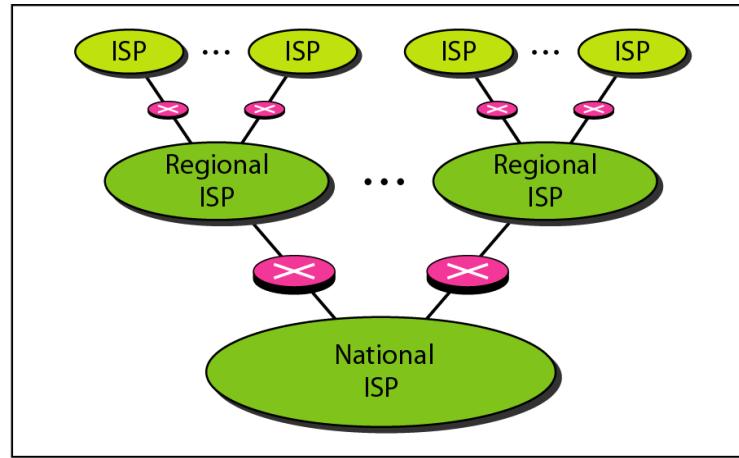
Topics discussed in this section:

A Brief History → ARPANET

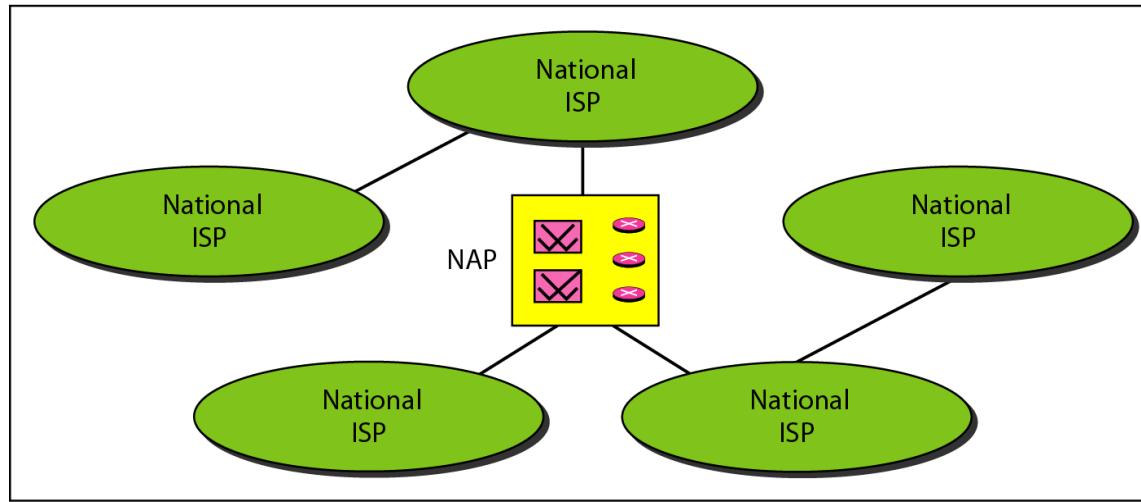
- 1967 ACM
- 1969 UCLA, UCSB, SRI, UoU
- 1972 TCP

The Internet Today (ISPs)

Hierarchical organization of the Internet



a. Structure of a national ISP



b. Interconnection of national ISPs

1-4 PROTOCOLS AND STANDARDS

protocols and standards.

Protocol is synonymous with rule.

Standards are agreed-upon rules.

Topics discussed in this section:

Protocols

Standards

Standards Organizations

Internet Standards

PROTOCOLS AND STANDARDS

Protocols

- Syntax → format of the data
- Semantics → meaning of each section
- Timing → when data should be sent and how fast.

Standards

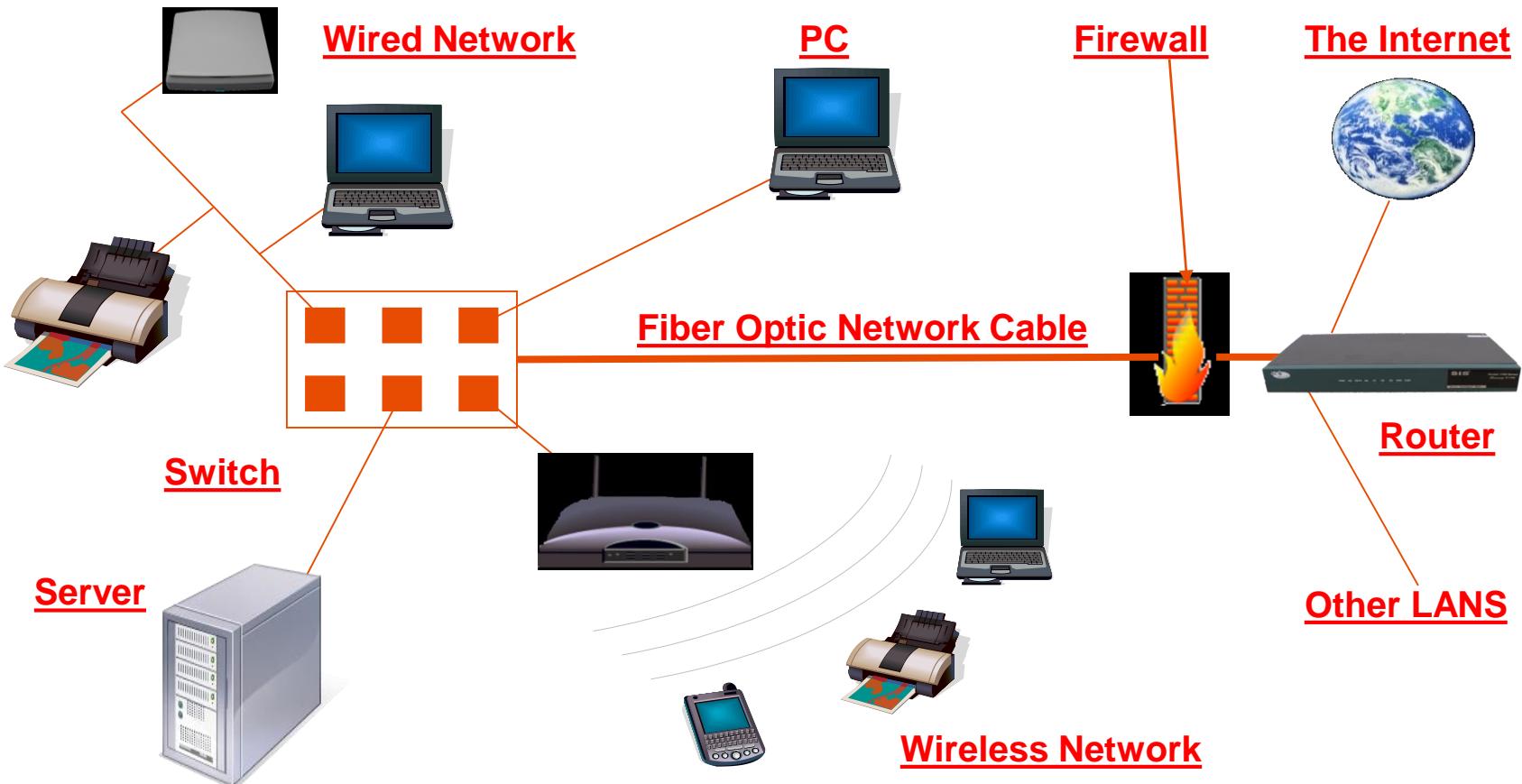
- De facto → by fact (not approved as a standard)
- De jure → by Law (approved)

PROTOCOLS AND STANDARDS

Standards Organizations

- International Organization for Standardization (**ISO**)
- International Telecommunication Union - Telecommunication Standards (**ITU-T**)
- American National Standards Institute (**ANSI**)
- Institute of Electrical and Electronics Engineers (**IEEE**)
- Electronic Industries Association (**EIA**)

The Network Diagram



The Networking Devices(Nodes)

- 1. NIC Card**
- 2. Repeater**
- 3. Hub**
- 4. Switch**
- 5. Bridge**
- 6. Router**
- 7. Gateway**
- 8. Firewall**

Network Media

The function of the media is to carry a flow of information through a LAN.

A. Wired Media:- A widely adopted *family* that uses copper and fiber media in local area network (LAN) technology are collectively known as Ethernet

1. Copper Cable
 - a. Coaxial Cables
 - b. Shielded Twisted Pair(STP)
 - c. Unshielded Twisted Pair
2. Fibre Optic Cable

B. Wireless Media:- use the atmosphere, or space, as the medium.

Physical Media Comparison

| | Twisted Pair | Coaxial | Fiber Optic | Wireless LAN |
|-----------|-----------------|-------------|-------------------------|---------------|
| Bandwidth | Up to 1 Gbps | 10–100 Mbps | Up to 10 Gbps or higher | Up to 54 Mbps |
| Distance | Up to 100 m | Up to 500 m | Up to 60 km | Up to 100 m |
| Price | Least expensive | Inexpensive | Most expensive | Moderate |

Network Models

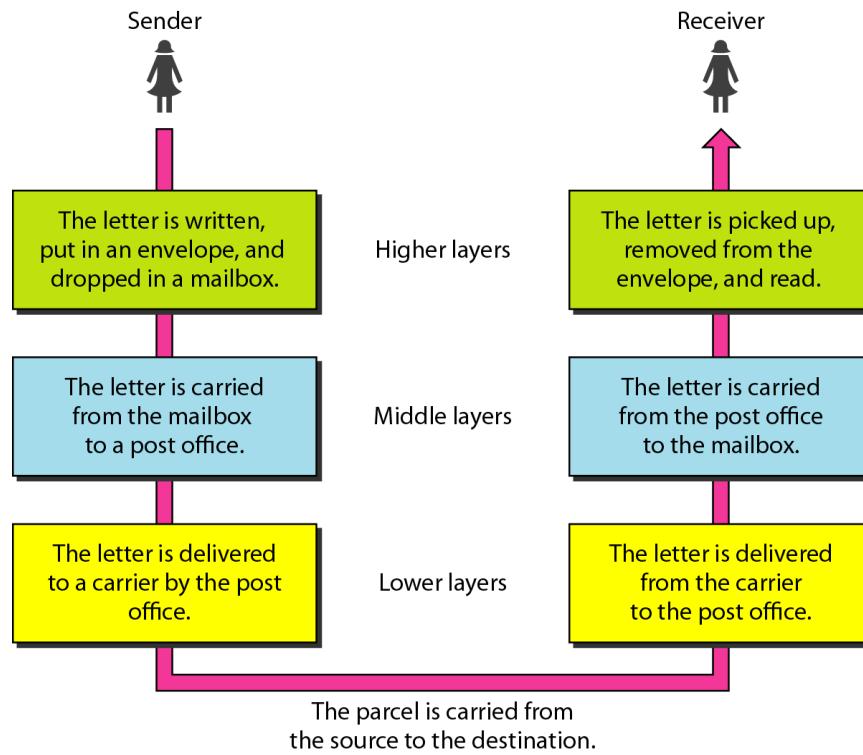
Lecture 2

OSI Model

1-5 LAYERED TASKS

- A network model is a layered architecture
 - Task broken into subtasks
 - Implemented separately in layers in stack
 - Functions need in both systems
 - Peer layers communicate
- Protocol:
 - A set of rules that governs data communication
 - It represents an agreement between the communicating devices

Tasks involved in sending a letter



Topics discussed in this section:
Sender, Receiver, and Carrier

1-5.1 THE OSI MODEL

Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards.

An ISO is the Open Systems Interconnection (OSI) model is the standard that covers all aspects of network communications from ISO. It was first introduced in the late 1970s.

**ISO is the organization.
OSI is the model.**

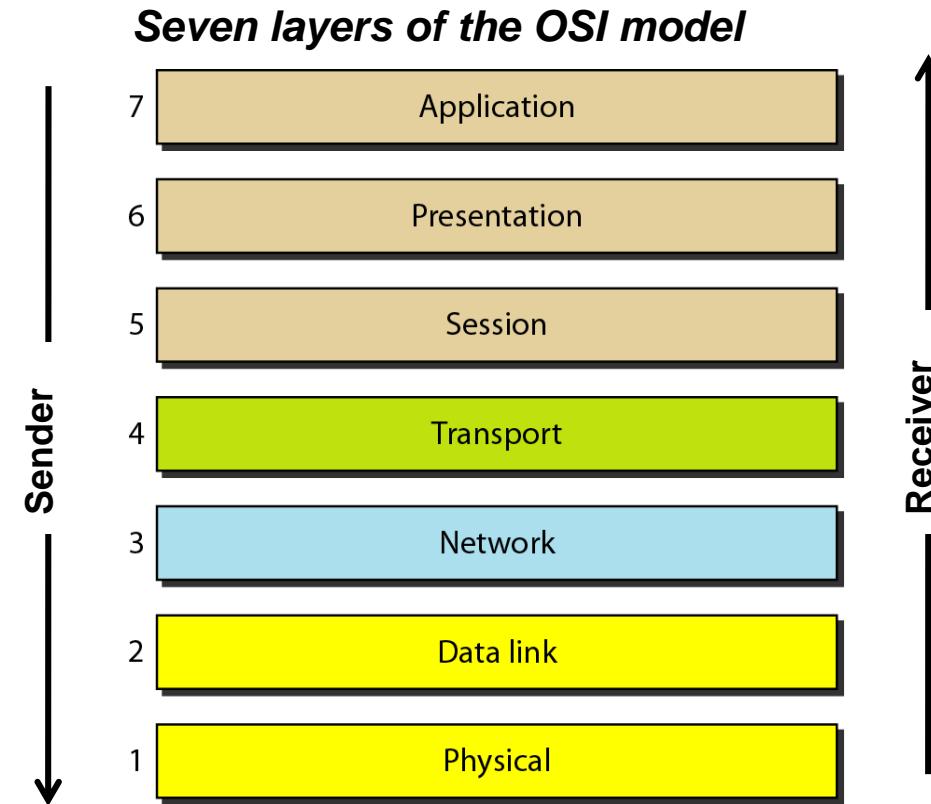
Topics discussed in this section:

**Layered Architecture
Peer-to-Peer Processes
Encapsulation**

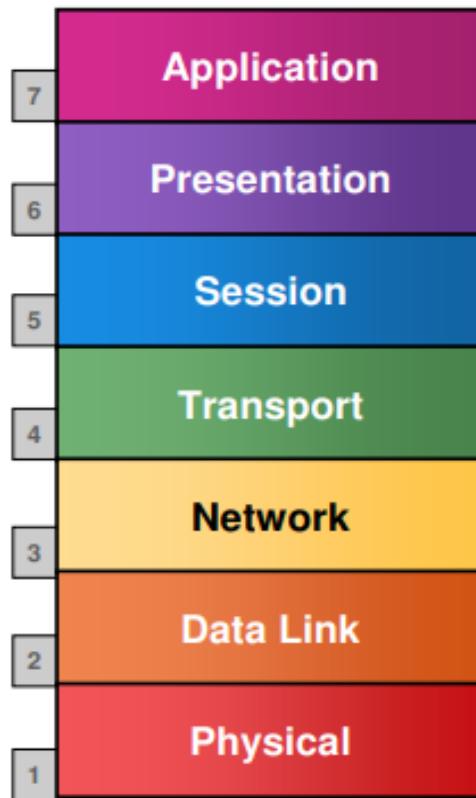
Layered Architecture

Layers

- Layer 7. Application
- Layer 6. Presentation
- Layer 5. Session
- Layer 4. Transport
- Layer 3. Network
- Layer 2. Data Link
- Layer 1. Physical



The OSI Model— Why a Layered Network Model?

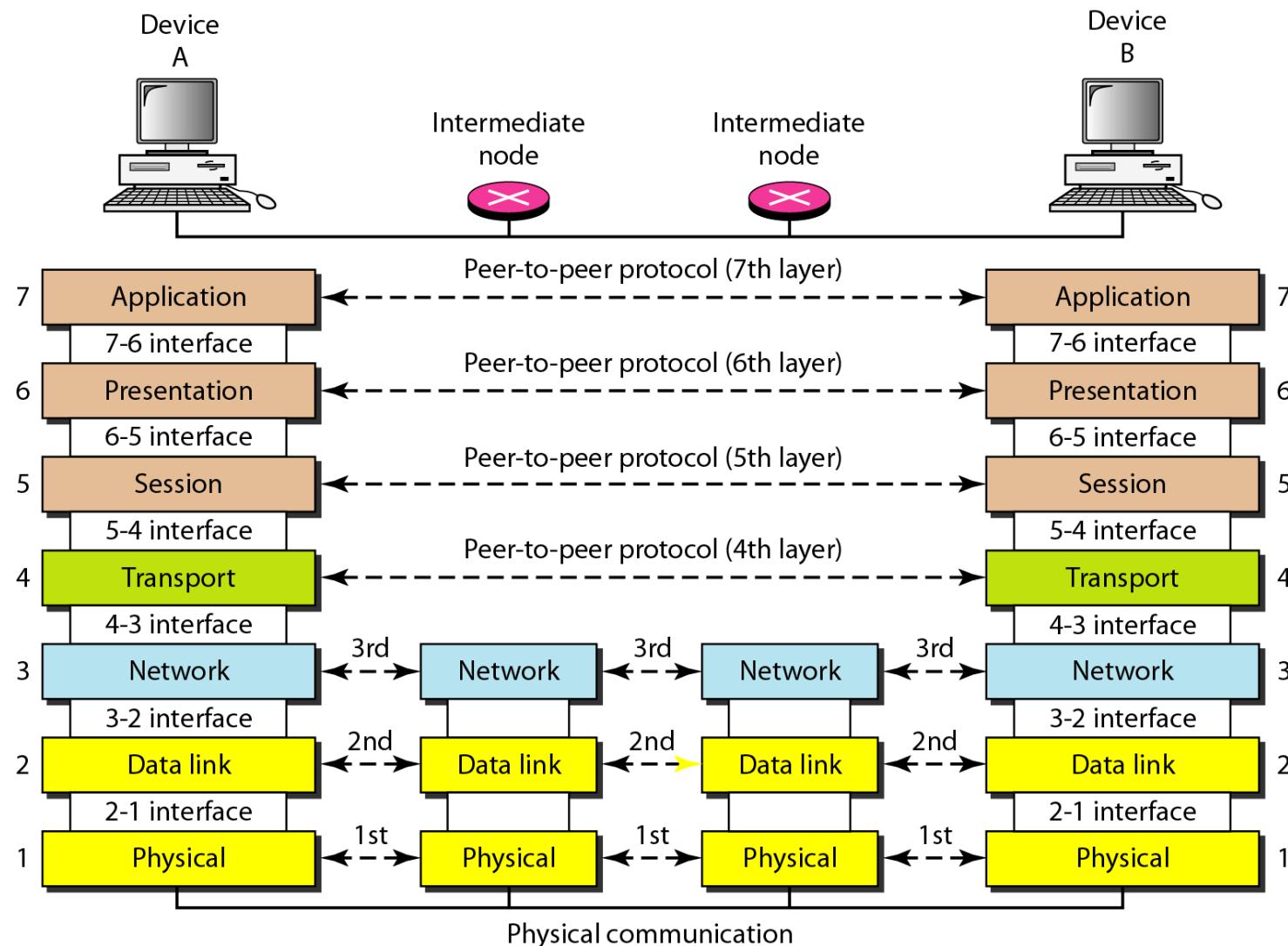


- Reduces complexity
- Standardizes interfaces
- Facilitates modular engineering
- Ensures interoperable technology
- Accelerates evolution
- Simplifies teaching and learning

PEER – TO – PEER PROCESS

- Communication must move downward through the layers on the sending device, over the communication channel, and upward to the receiving device
- 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
- At the receiving device, the message is unwrapped layer by layer, with each process receiving and removing the data meant for it

The interaction between layers in the OSI model



PEER – TO – PEER PROCESS

- The passing of the data and network information down through the layers of the sending device and backup through the layers of the receiving device is made possible by interface between each pair of adjacent layers
- Interface defines what information and services a layer must provide for the layer above it.

LAYERS IN THE OSI MODEL

Topics discussed in this section:

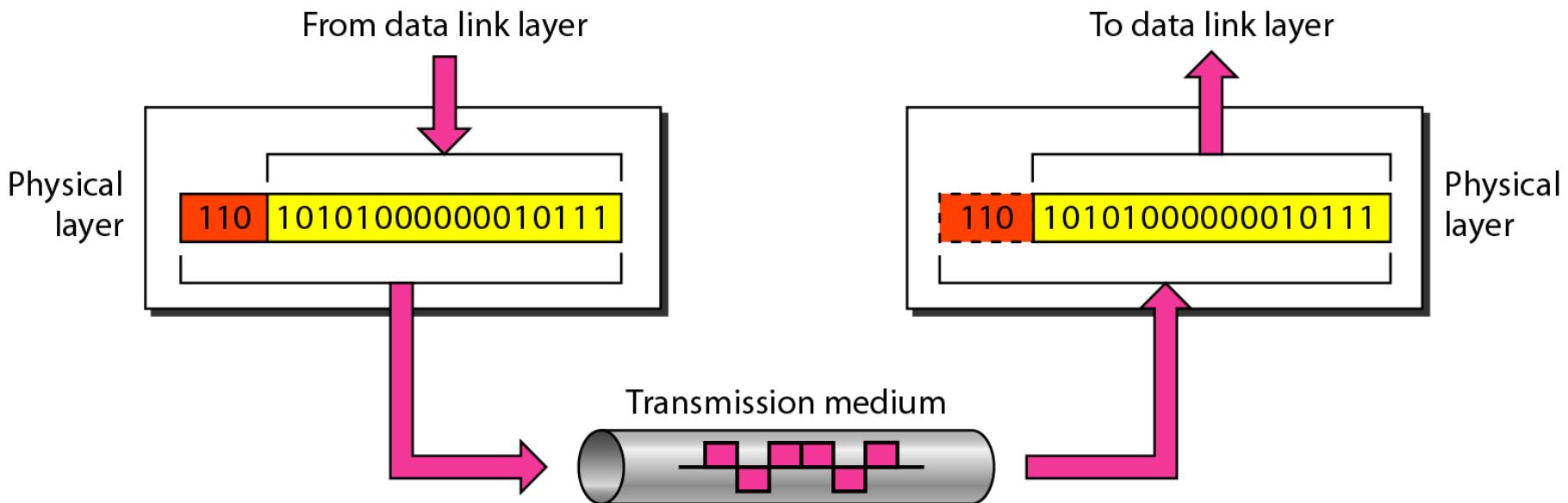
- 1. Physical Layer**
- 2. Data Link Layer**
- 3. Network Layer**
- 4. Transport Layer**
- 5. Session Layer**
- 6. Presentation Layer**
- 7. Application Layer**

Physical Layer

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

- Function
 - Physical characteristics of interfaces and media
 - Representation of bits
 - Data rate
 - Synchronization of bits
 - Line configuration (point-to-point or multipoint)
 - Physical topology (mesh, star, ring or bus)
 - Transmission mode (simplex, half-duplex or duplex)

Physical layer

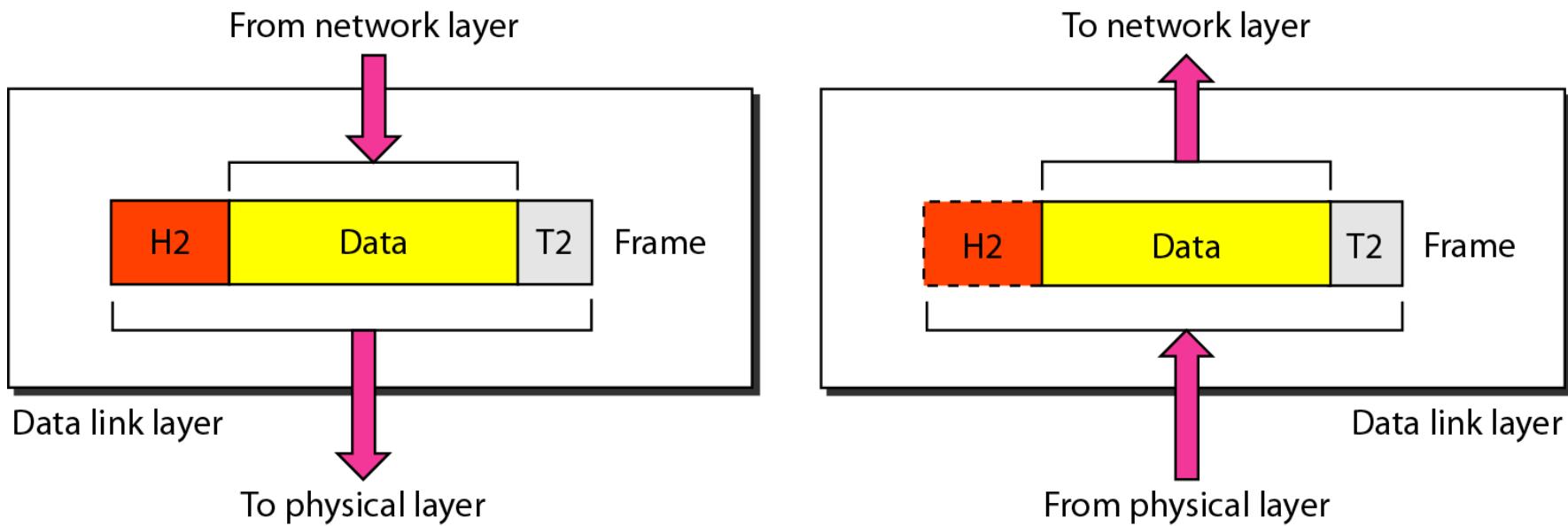


Data Link Layer

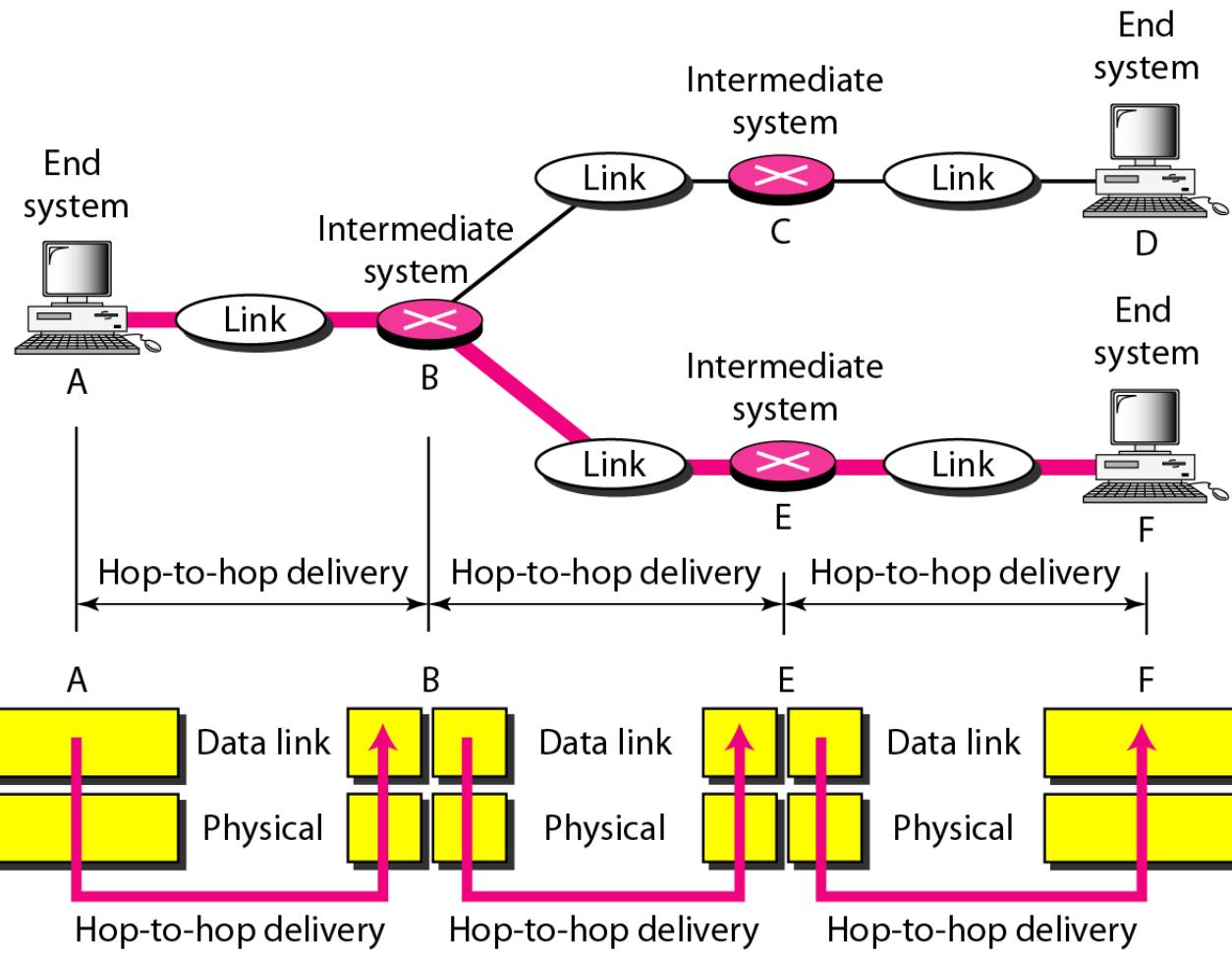
The data link layer is responsible for moving frames from one hop (node) to the next.

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

Data link layer

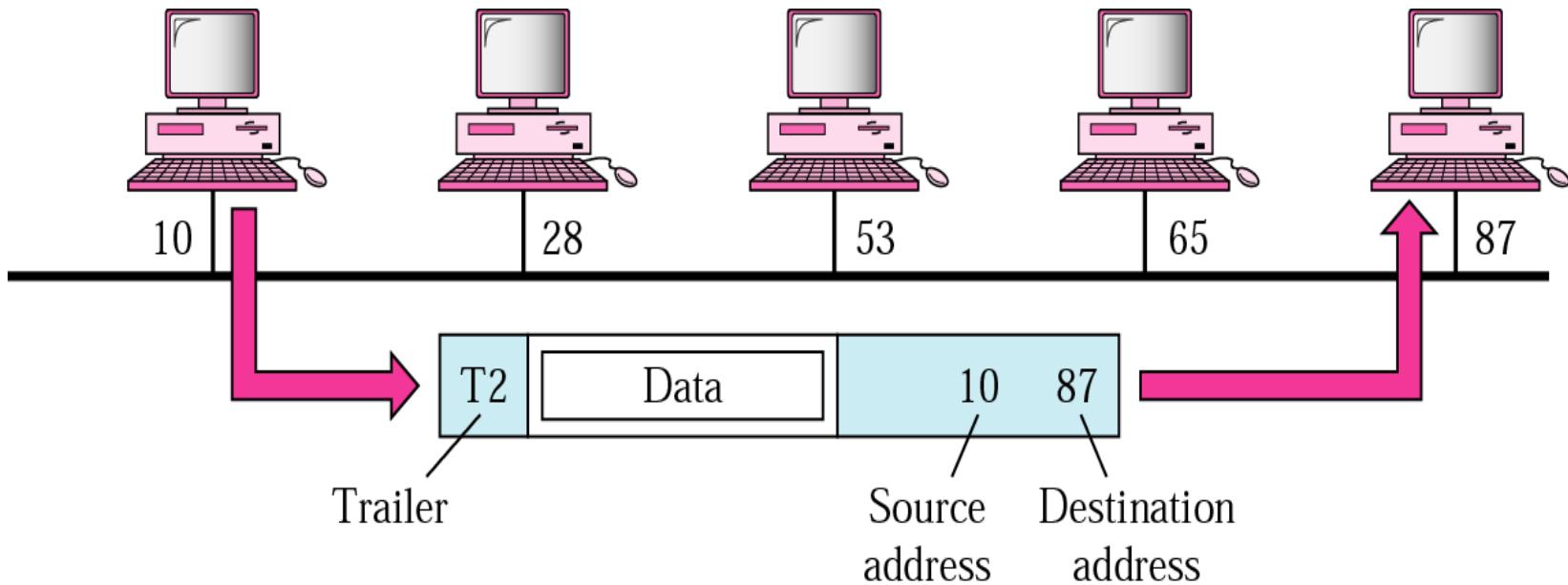


Hop-to-hop delivery



Example 1

In following 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. At the data link level this frame contains physical addresses in the header. These are the only addresses needed. The rest of the header contains other information needed at this level. The trailer usually contains extra bits needed for error detection

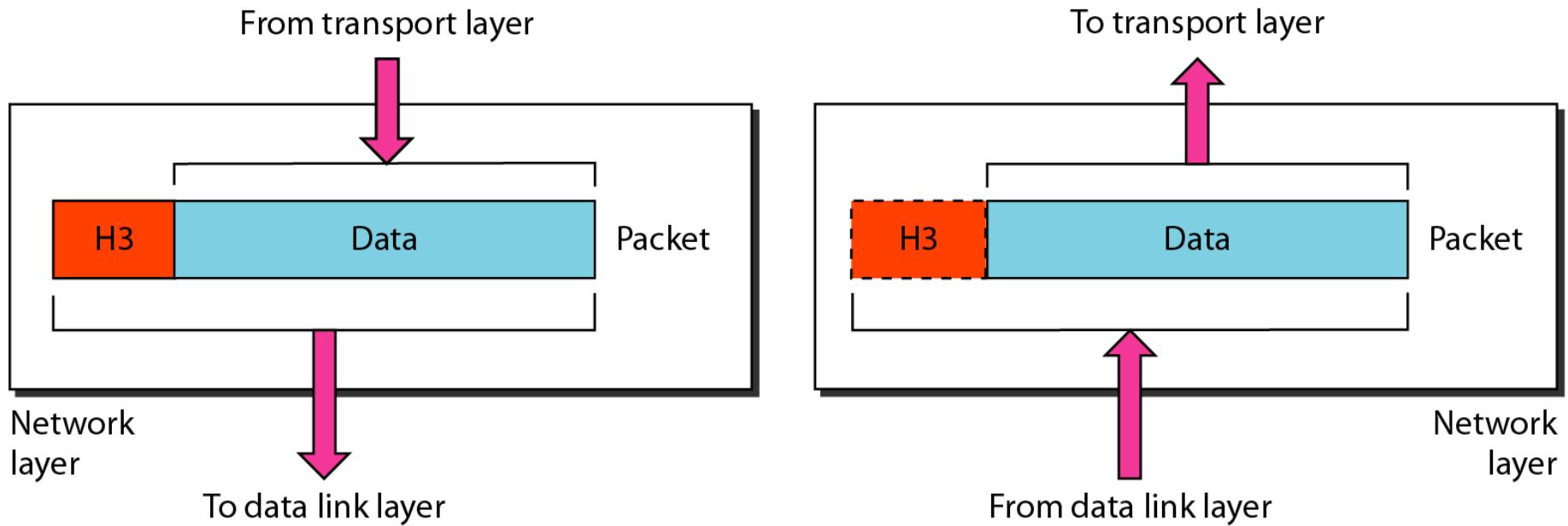


Network Layer

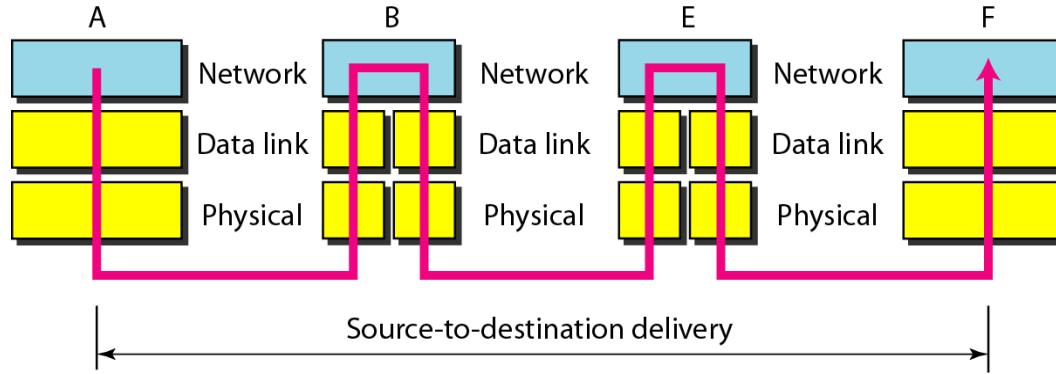
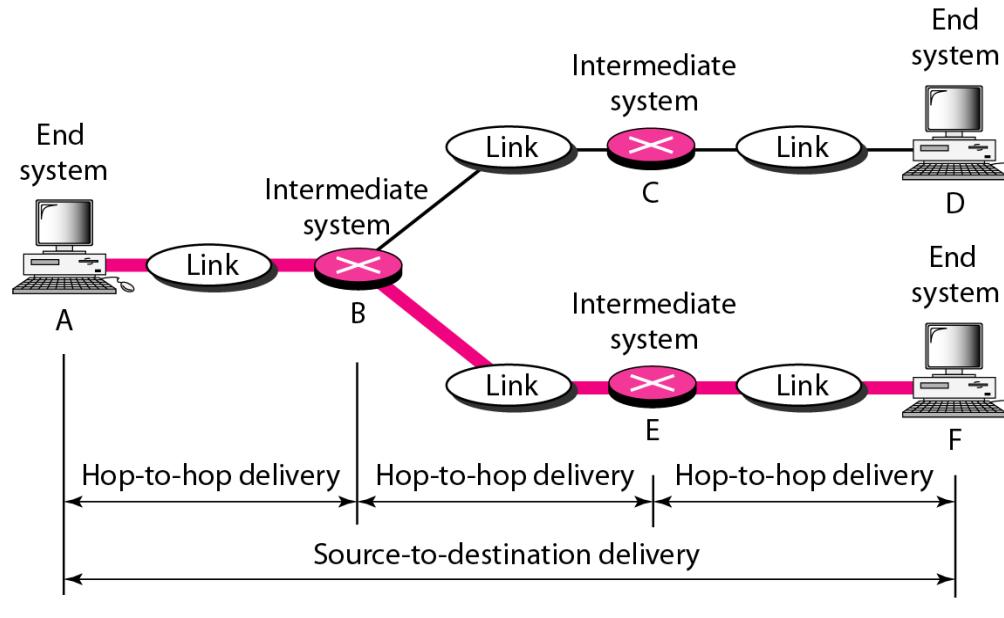
The network layer is responsible for the delivery of individual packets from the source host to the destination host.

- Source-to-destination delivery
- Responsible for the delivery of packets from the original source to the final destination
- Functions
 - Logical addressing
 - routing

Network layer

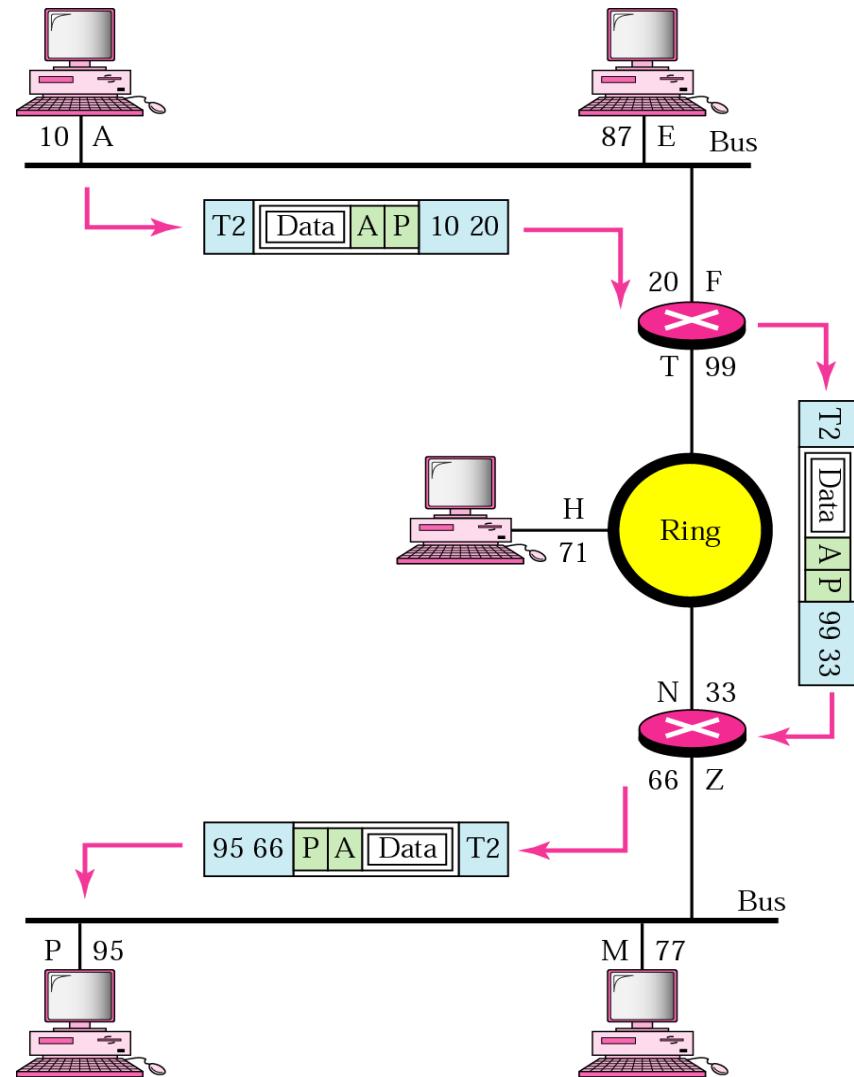


Source-to-destination delivery



Example 2

We want to send data from a node with network address A and physical address 10, located on one LAN, to a node with a network address P and physical address 95, located on another LAN. Because the two devices are located on different networks, we cannot use physical addresses only; the physical addresses only have local influence. What we need here are **universal addresses** that can pass through the LAN boundaries. The network (logical) addresses have this characteristic.

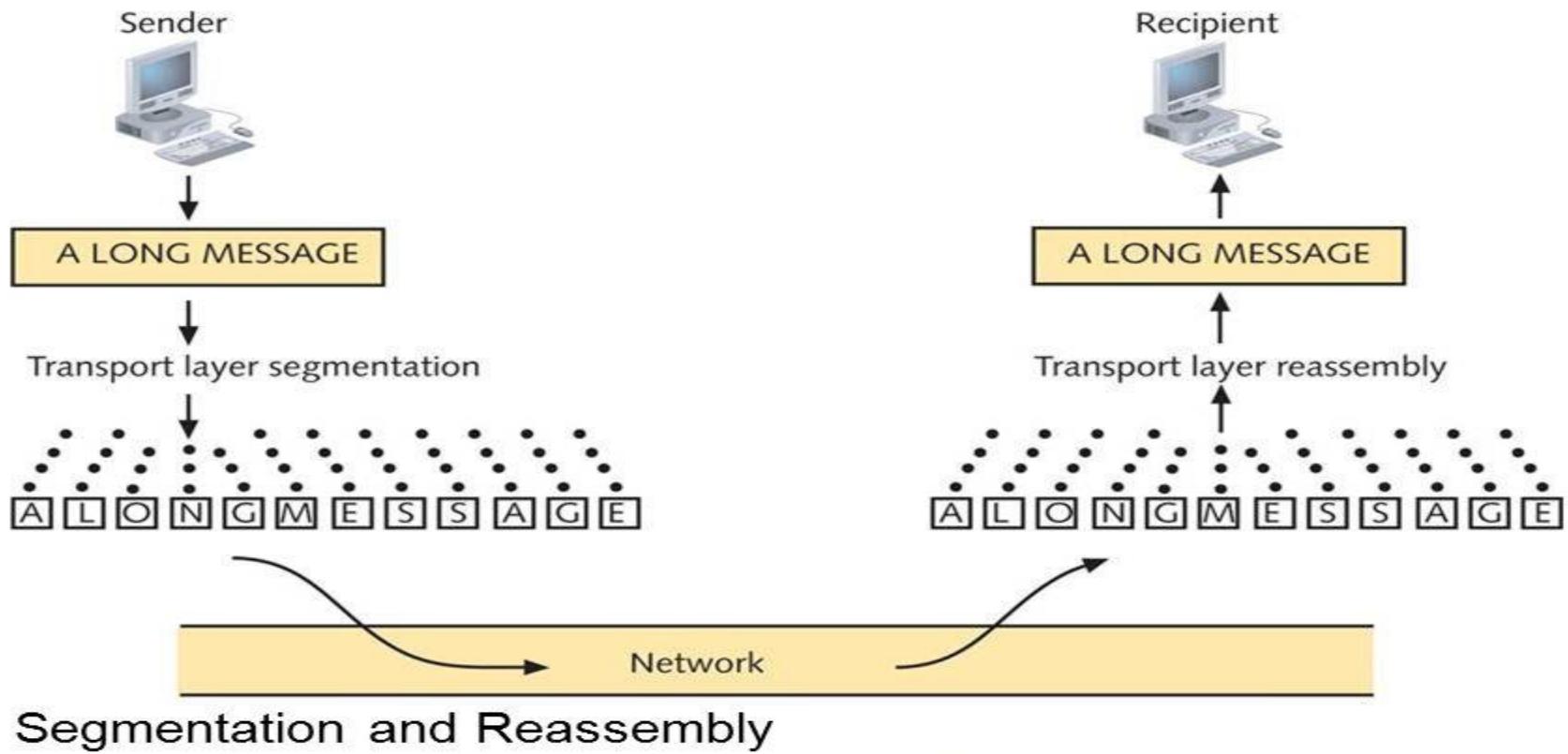


Transport Layer

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

- Process-to- process delivery
- Functions
 - Segmentation and reassemble
 - Connection control (Connection-oriented or connection-less)
 - Flow control
 - Error control

Transport Layer



Session Layer

The session layer is responsible for dialog control and synchronization.

- It establishes, maintains and synchronize the interaction between communicating system
- Function
 - Dialog control
 - Synchronization (checkpoints)

Presentation Layer

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

- Concerned with the syntax and semantics of the information exchanged between two system
- Functions
 - Translation (EBCDIC-coded text file → ASCII-coded file)
 - Encryption and Decryption
 - Compression

Application Layer

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

- **Functions**

- Network virtual terminal (Remote log-in)
- File transfer and access
- Mail services
- Directory services (Distributed Database)
- Accessing the World Wide Web

Summary of layers

| OSI Model | | | |
|------------------------|-----------|-----------------|-------------------------------------------|
| | Data unit | Layer | Function |
| User support layers | Data | 7. Application | Network process to application |
| | | 6. Presentation | Data representation and encryption |
| | | 5. Session | Inter-host communication |
| User↔ Network | Segment | 4. Transport | End-to-end connections and reliability |
| Network support layers | Packet | 3. Network | Path determination and logical addressing |
| | Frame | 2. Data Link | Physical addressing |
| | Bit | 1. Physical | Media, signal and binary transmission |

Network Models

Lecture 3

TCP/IP Model

1-5.2 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

Internet Layer

TCP/IP support the Internet Protocol IP (unreliable).
IP is a host-to-host protocol.

Supporting protocols:

- Address Resolution Protocol (ARP)
- Reverse Address Resolution Protocol (RARP)
- Internet Control Message Protocol (ICMP)
- Internet Group Message Protocol (IGMP)

Transport Layer

Process-to-process protocol.

- User Datagram Protocol (UDP)
- Transmission Control Protocol (TCP)

1-6 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

Physical Address

Physical addresses are imprinted on the NIC. Most local-area networks (Ethernet) use a **48-bit** (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon.

Example:

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

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

Physical Address

- known also as the MAC address
 - Is the address of a node as defined by its LAN or WAN
 - It is included in the frame used by data link layer
-

The physical addresses in the datagram may change from hop to hop.

Logical Address

- IP addresses are necessary for universal communications that are independent of physical network.
- No two host address on the internet can have the same IP address
- IP addresses in the Internet are 32-bit address that uniquely define a host.

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

| Address Classes | RANGE | Bit Pattern of 1 st byte | Decimal Range | Default Subnet Mask | Reserved for |
|-----------------|------------------------------|-------------------------------------|---------------|---------------------|----------------------------|
| A | 1.0.0.0 to 126.255.255.255 | 0xxxxxxx | 1 to 127 | 255.0.0.0 | Governments |
| B | 128.0.0.0 to 191.255.255.255 | 10xxxxxx | 128-191 | 255.255.0.0 | Medium Companies |
| C | 192.0.0.0 to 223.255.255.255 | 110xxxxx | 192-223 | 255.255.255.0 | Small Companies |
| D | 224.0.0.0 to 239.255.255.255 | 1110xxxx | 224-239 | Not Applicable | Reserved for Multicasting |
| E | 240.0.0.0 to 255.255.255.255 | 11110xxx | 240-255 | Not Applicable | Experimental or future use |

Port addresses

Port address is a 16-bit address represented by one decimal number ranged from (0-65535) to choose a process among multiple processes on the destination host.

- Destination port number is needed for delivery.
- Source port number is needed for receiving a reply as an acknowledgments.

In TCP/IP , a 16-bit port address represented as one single number. Example: 753

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

| Port number | Process name | Protocol used | Description |
|-------------|--------------|---------------|----------------------------------|
| 20 | FTP-DATA | TCP | File transfer—data |
| 21 | FTP | TCP | File transfer—control |
| 22 | SSH | TCP | Secure Shell |
| 23 | TELNET | TCP | Telnet |
| 25 | SMTP | TCP | Simple Mail Transfer Protocol |
| 53 | DNS | TCP and UDP | Domain Name System |
| 69 | TFTP | UDP | Trivial File Transfer Protocol |
| 80 | HTTP | TCP and UDP | Hypertext Transfer Protocol |
| 110 | POP3 | TCP | Post Office Protocol 3 |
| 123 | NTP | TCP | Network Time Protocol |
| 143 | IMAP | TCP | Internet Message Access Protocol |
| 443 | HTTPS | TCP | Secure implementation of HTTP |

| TCP/IP | OSI |
|----------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Implementation of OSI model | Reference model |
| Model around which Internet is developed | This is a theoretical model |
| Has only 4 layers | Has 7 layers |
| Considered more reliable | Considered a reference tool |
| Protocols are not strictly defined | Stricter boundaries for the protocols |
| Horizontal approach | Vertical approach |
| Combines the session and presentation layer in the application layer | Has separate session and presentation layer |
| Protocols were developed first and then the model was developed | Model was developed before the development of protocols |
| Supports only connectionless communication in the network layer | Supports connectionless and connection-oriented communication in the network layer |
| Protocol dependent standard | Protocol independent standard |

Here are some cons/ drawbacks of using OSI Model:

- Fitting of protocols is a tedious task.
- You can only use it as a reference model.
- It doesn't define any specific protocol.
- In the OSI network layer model, some services are duplicated in many layers such as the transport and data link layers
- Layers can't work in parallel as each layer need to wait to obtain data from the previous layer.

Here, are few drawbacks of using the TCP/IP model:

- TCP/IP is a complicated model to set up and manage.
- The shallow/overhead of TCP/IP is higher-than IPX (Internetwork Packet Exchange).
- In this, model the transport layer does not guarantee delivery of packets.
- Replacing protocol in TCP/IP is not easy.
- It has no clear separation from its services, interfaces, and protocols.