Chapter 1

Fundamental concepts of computer networks.

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Chapter 1

Fundamental concepts of 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.

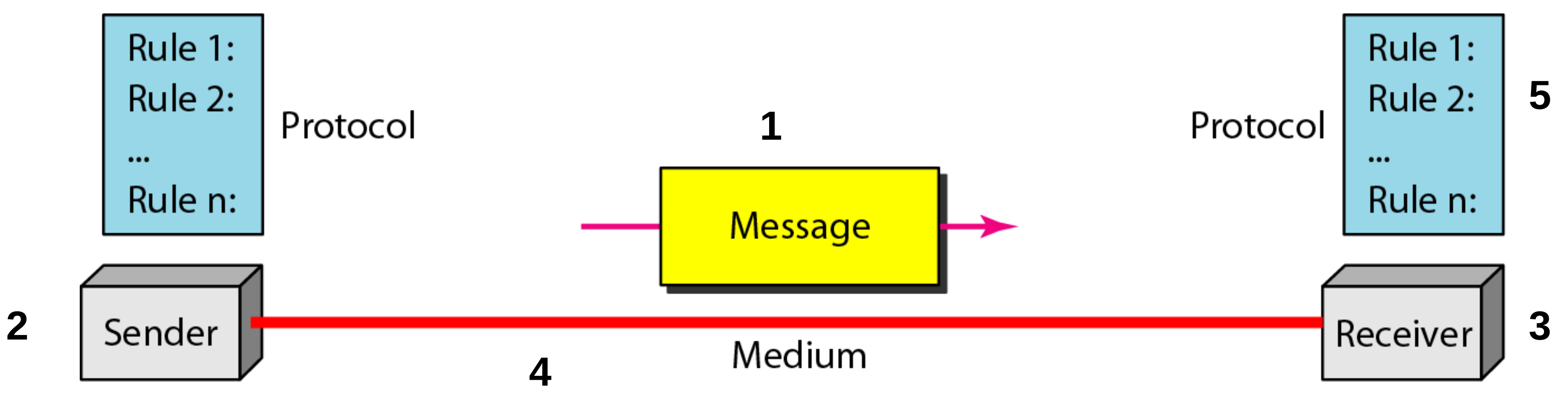
1. ***Delivery → Correct destination***
2. ***Accuracy → Accurate data***
3. ***Timelines → Real-time transmission***
4. ***Jitter → Uneven delay***

Topics discussed in this section:

Components
Data Representation
Data Flow

Components

Figure 1.1 ***Five components of data communication***

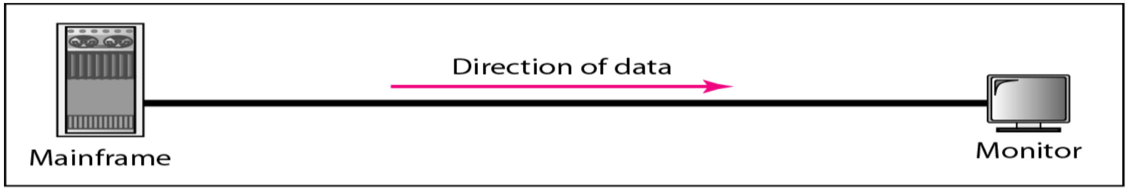


Data Representation

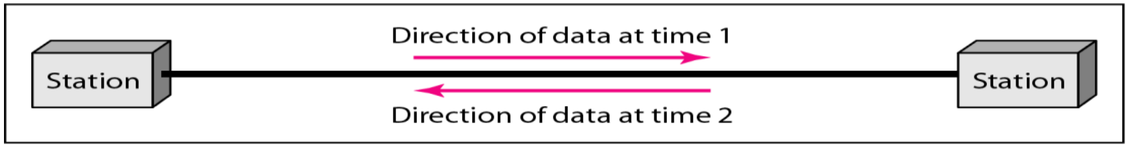
1. *Text*
2. *Numbers*
3. *Images*
4. *Audio*
5. *Video*

Data flow

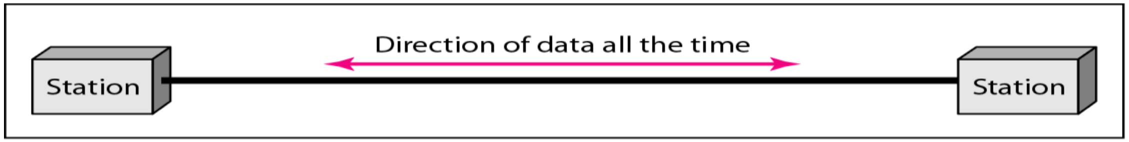
- ***Simplex***
- ***Half-duplex***
- ***Full-duplex***



a. Simplex



b. Half-duplex



c. Full-duplex

1-2 NETWORKS

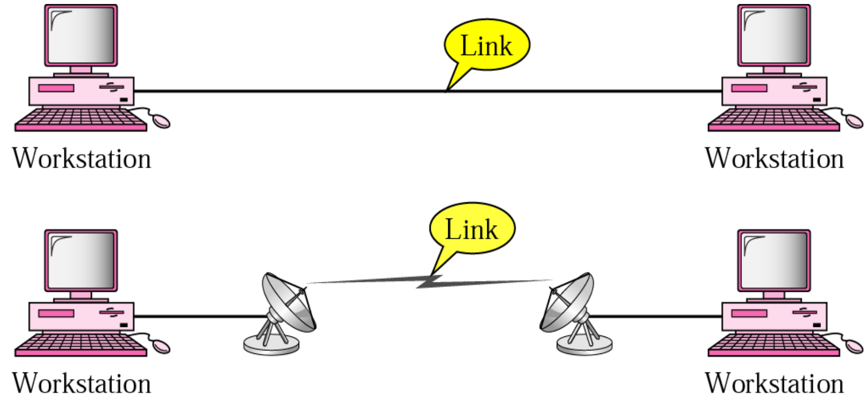
A network is a set of devices (nodes) connected by communication links. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.

Topics discussed in this section:

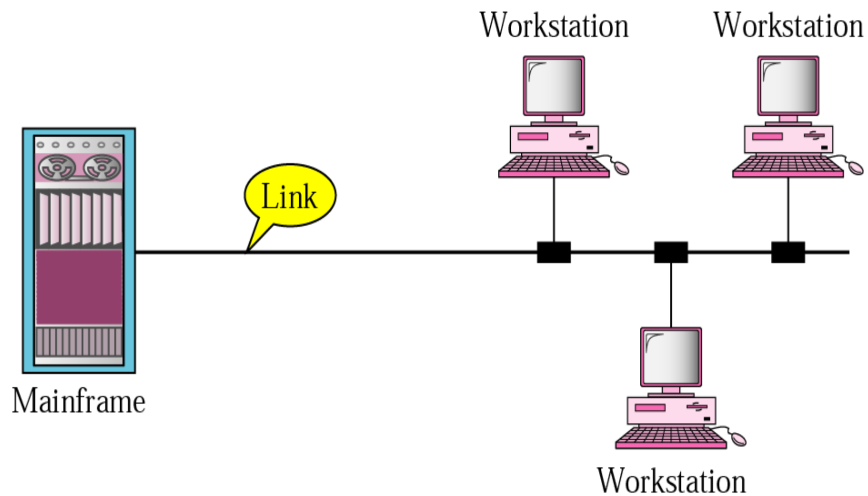
Distributed Processing
Network Criteria (performance, reliability, and security)
Physical Structures (type of connections and topologies)
Network Models
Categories of Networks (LAN, MAN and WAN)
Interconnection of Networks: Internet

Types of connections

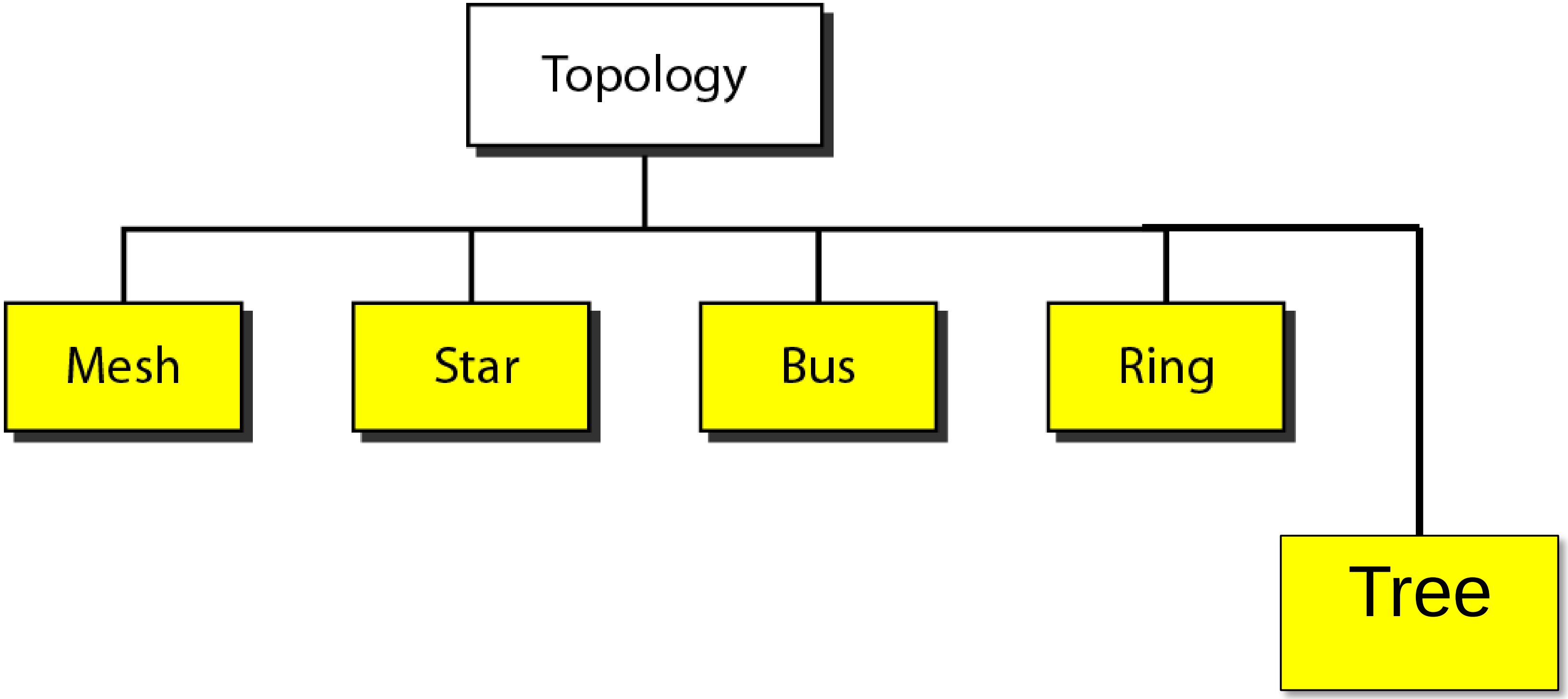
- Point to point
  - A dedicated link is provided between two devices



- Multipoint
  - More than two specific devices share a single link

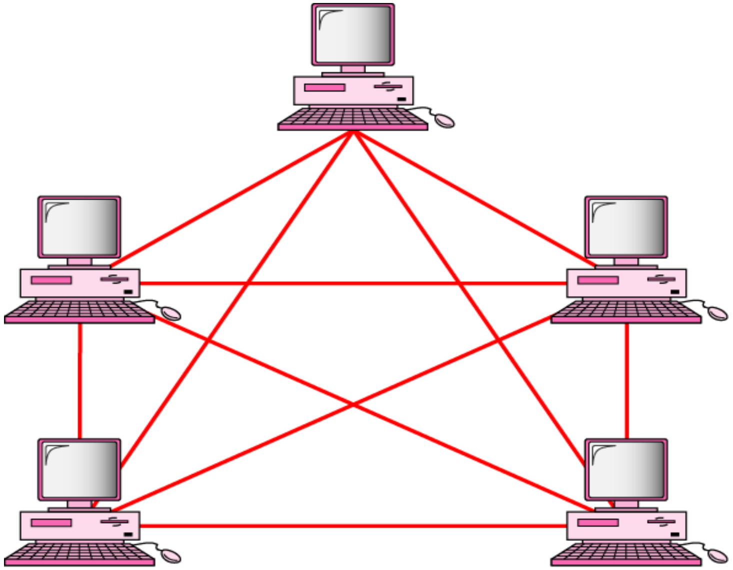


Physical Topology



MESH Topology

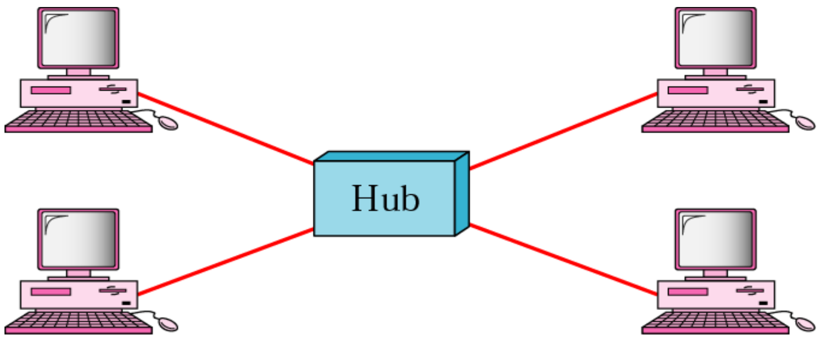
- Every device has a dedicated point-to-point link to every other devices
- Dedicated
  - Link carries traffic only between the two devices it connects
  - A fully connected mesh network has n(n-1)/2 physical channels to link n devices
  - Every device on the network must have n-1 input/output (I/O)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



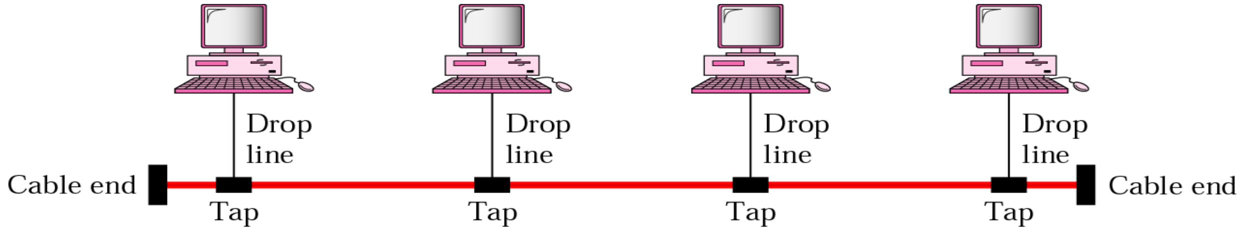
n(n-1)/2 physical duplex links

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

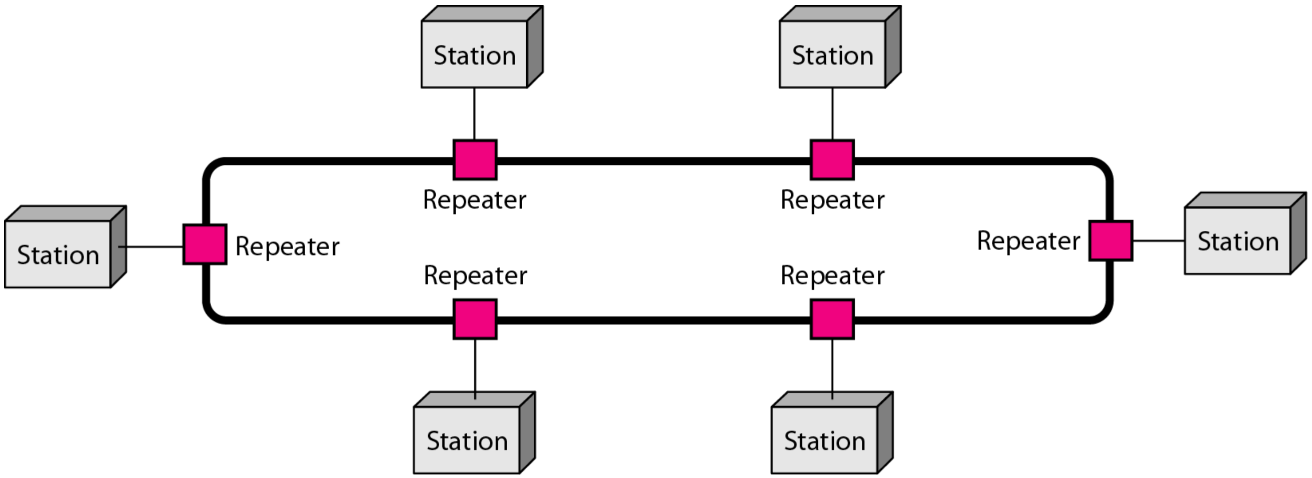


BUS Topology



- 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



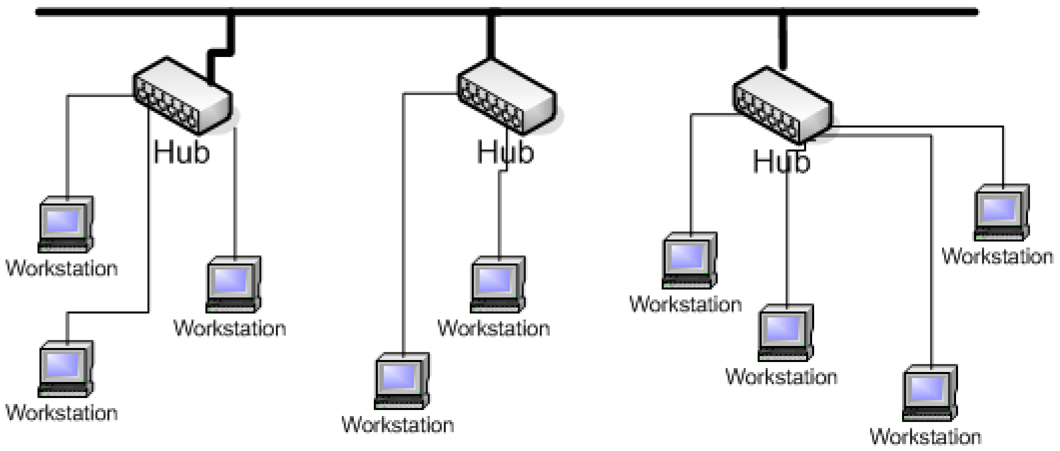
- Each device is dedicated point-to-point connection only with the two devices on either side of it
- A signal is passed along the ring in the direction, from device to device, until it reaches its destination
- Each device in the ring incorporates a repeater

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

Tree Topology

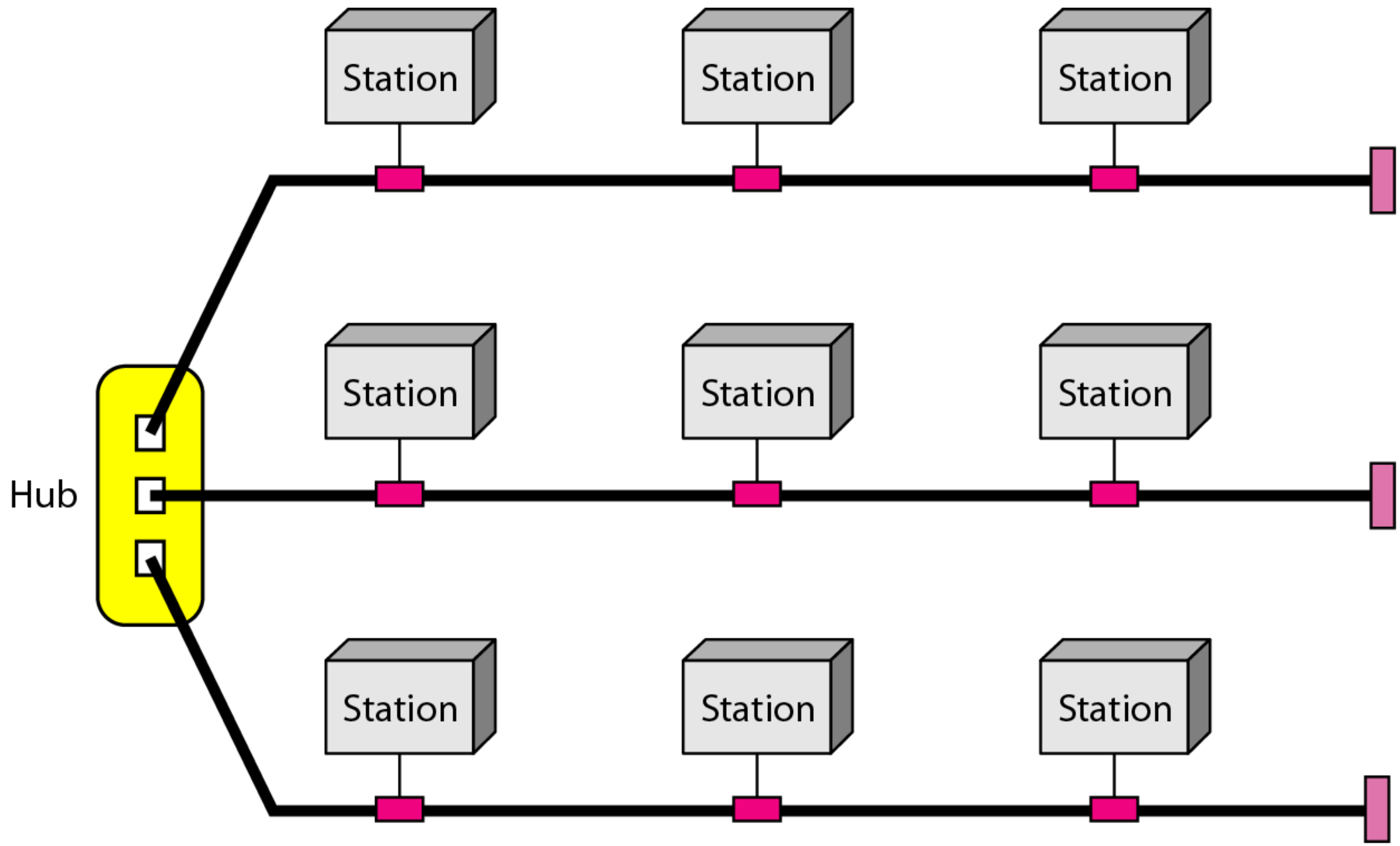
Tree topologies integrate multiple topologies together

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 venders.
- 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.

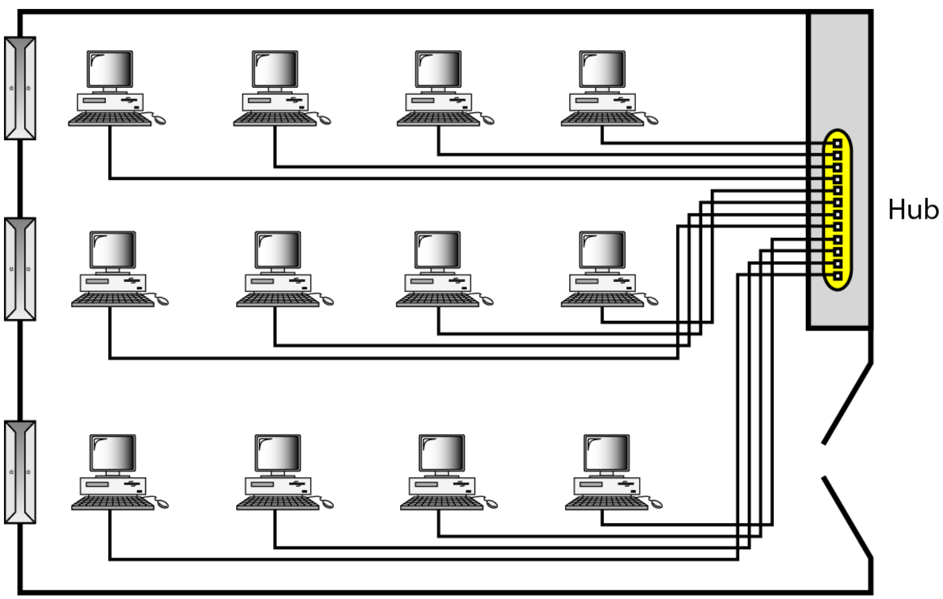
A hybrid topology: a star backbone with three bus networks



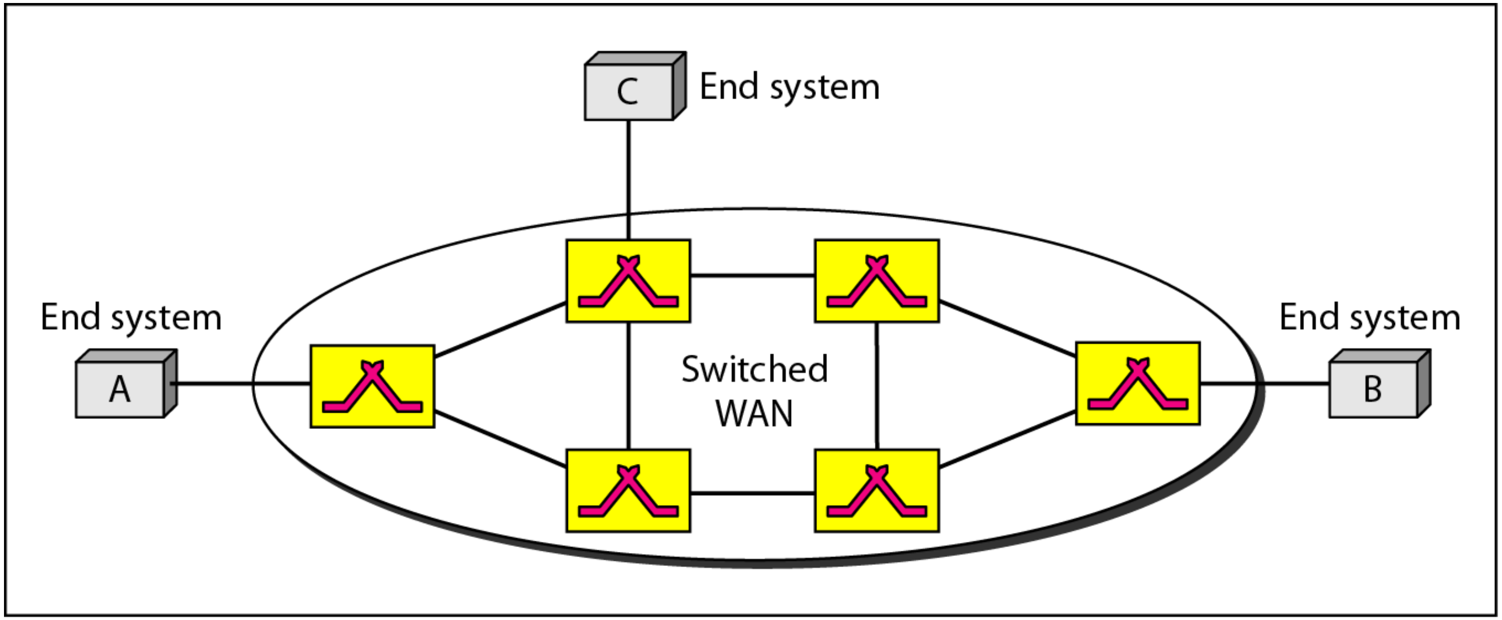
Categories of Networks

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

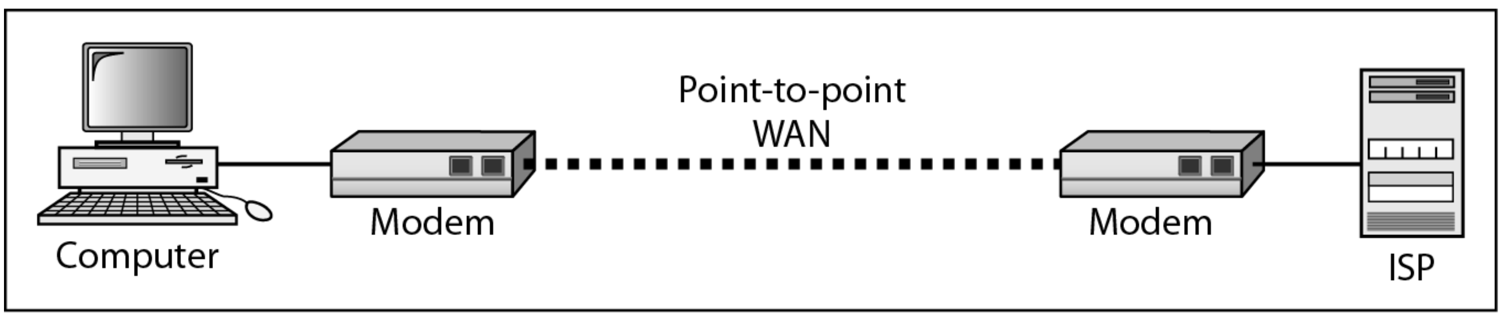
An isolated LAN connecting 12 computers to a hub in a closet



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



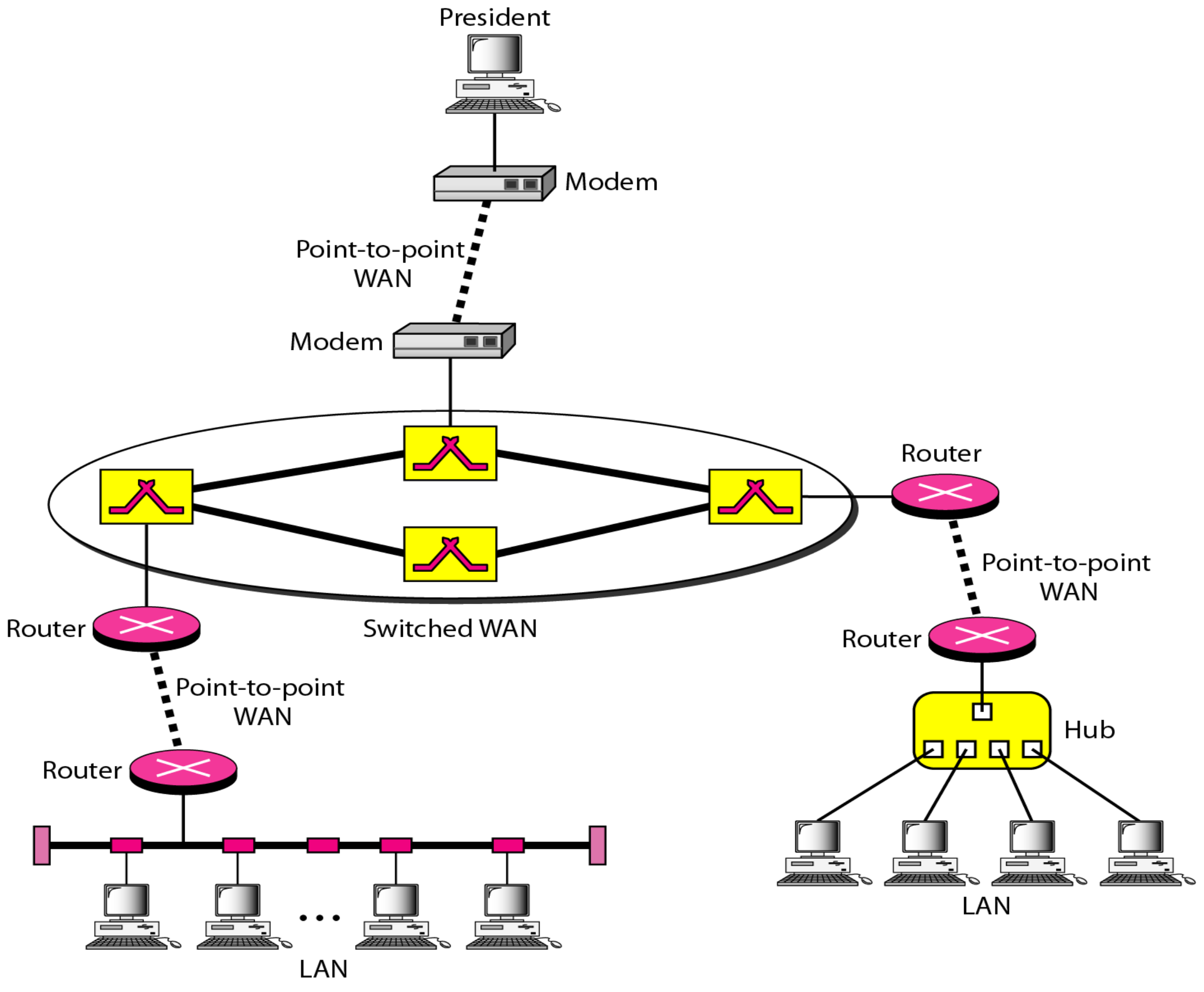
a. Switched WAN



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.

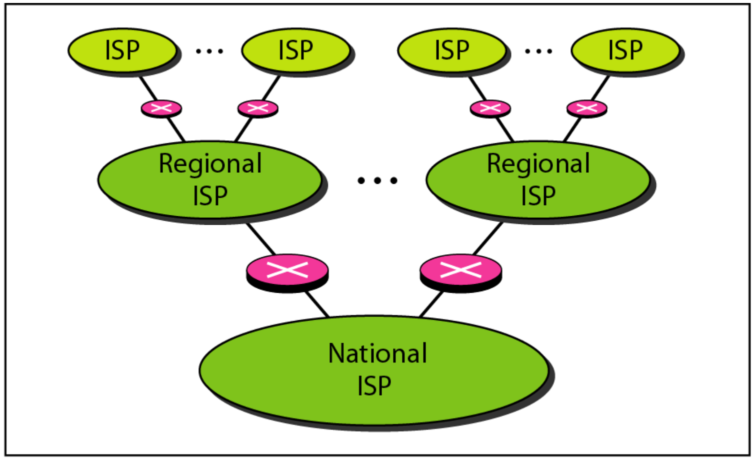
Topics discussed in this section:

A Brief History → ARPANET

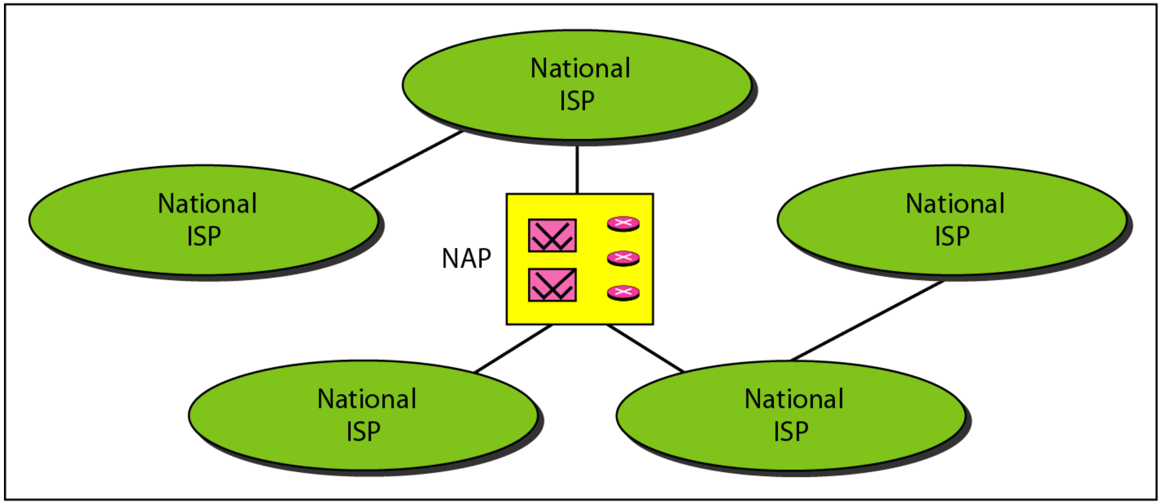
- **1967 ACM**
- **1969 UCLA, UCSB, SRI, UoU**
- **1972 TCP**

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)**

Network Models

Lecture 2

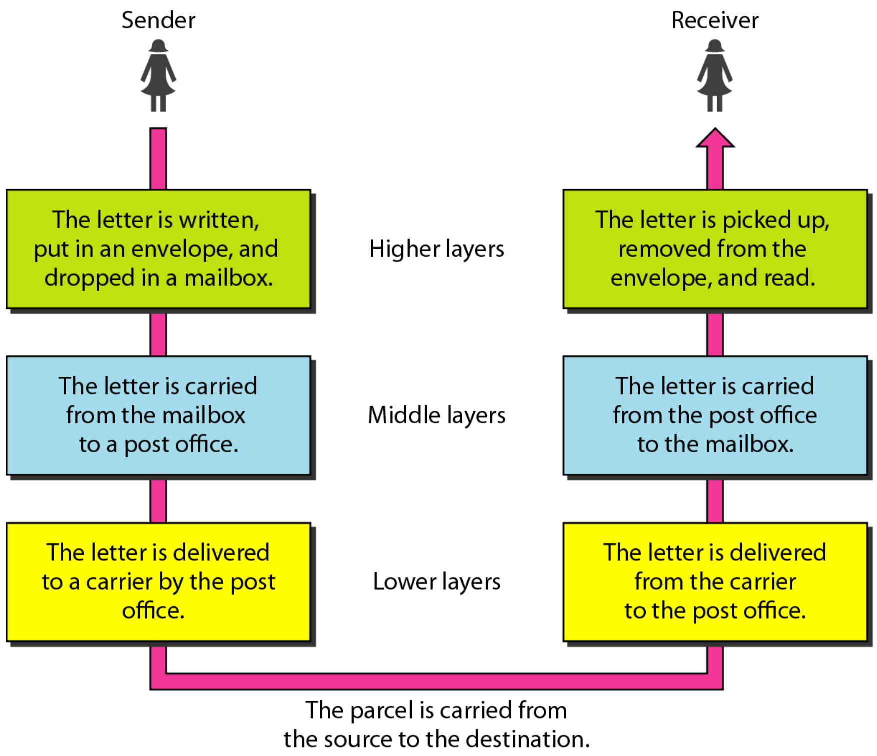
OSI Model

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
Hierarchy (services)

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

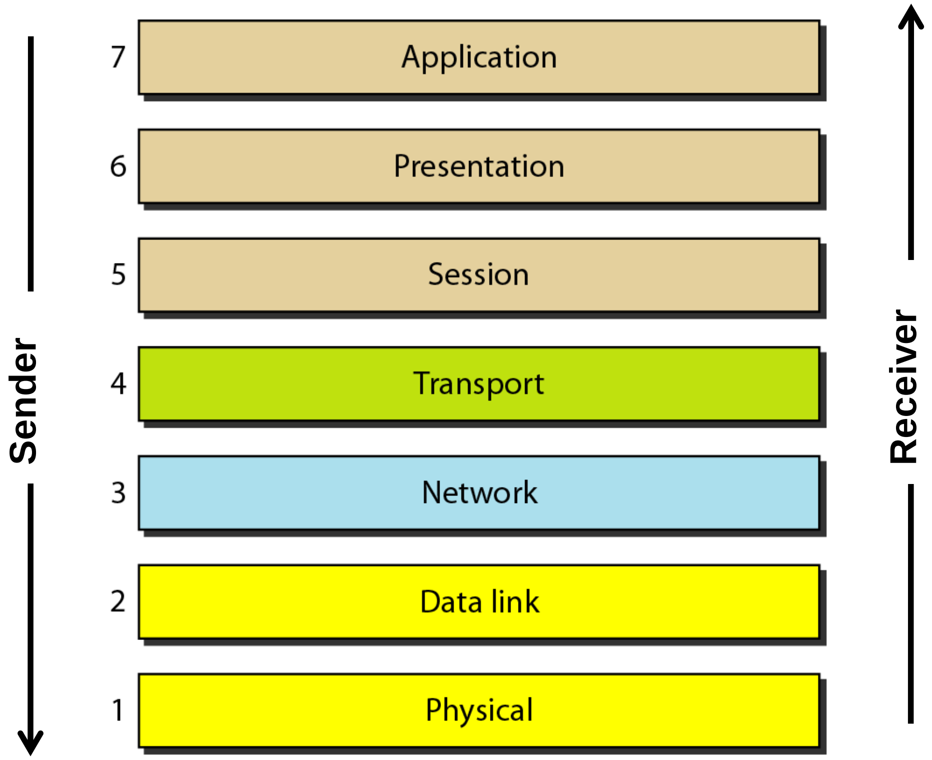
Layer 4. Transport

Layer 3. Network

Layer 2. Data Link

Layer 1. Physical

Seven layers of the OSI model



Layered Architecture

- A layered model
- 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
- The processes on each machine at a given layer are called peer-to-peer process

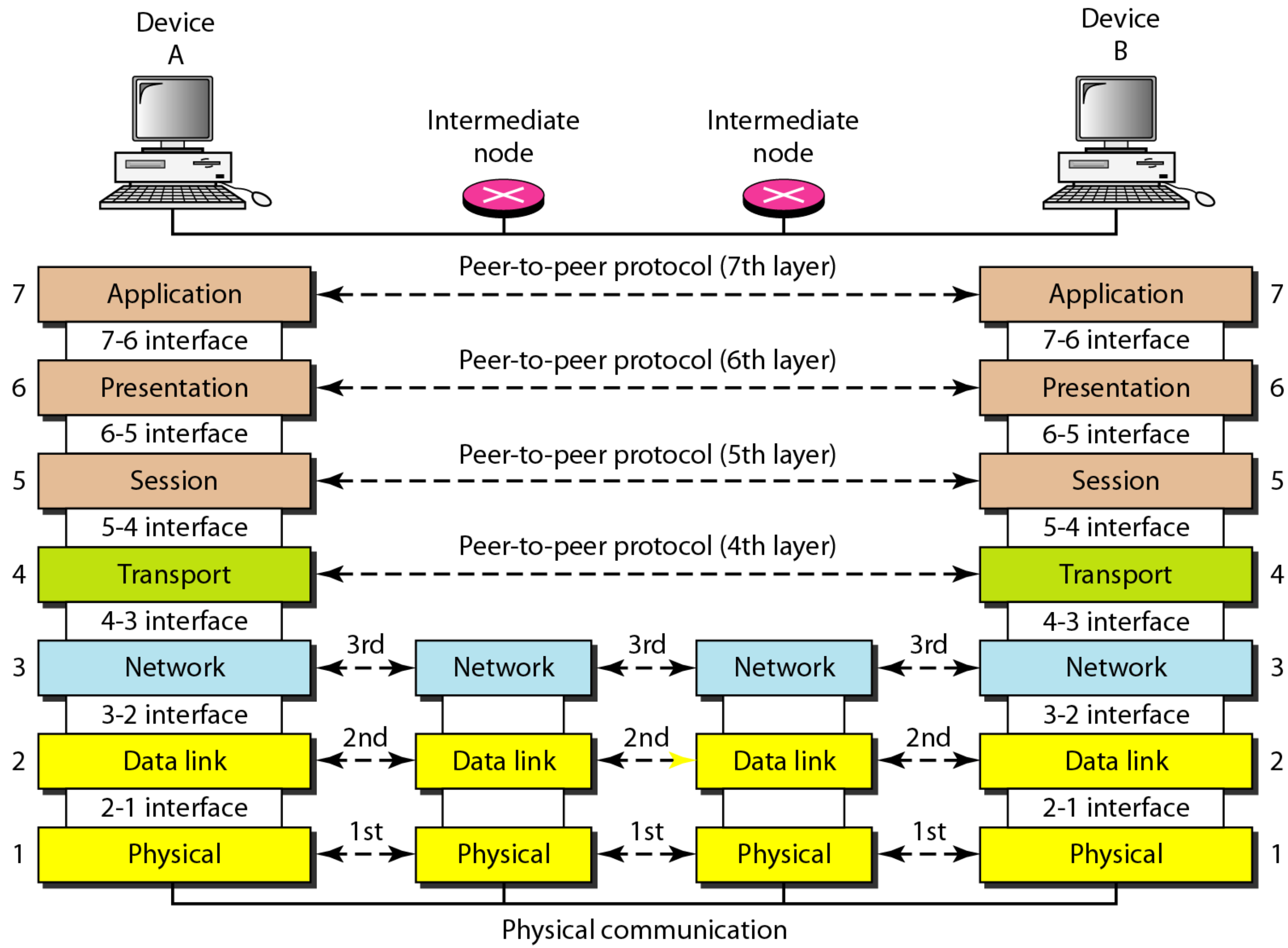
PEER – TO – PEER PROCESS

- 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

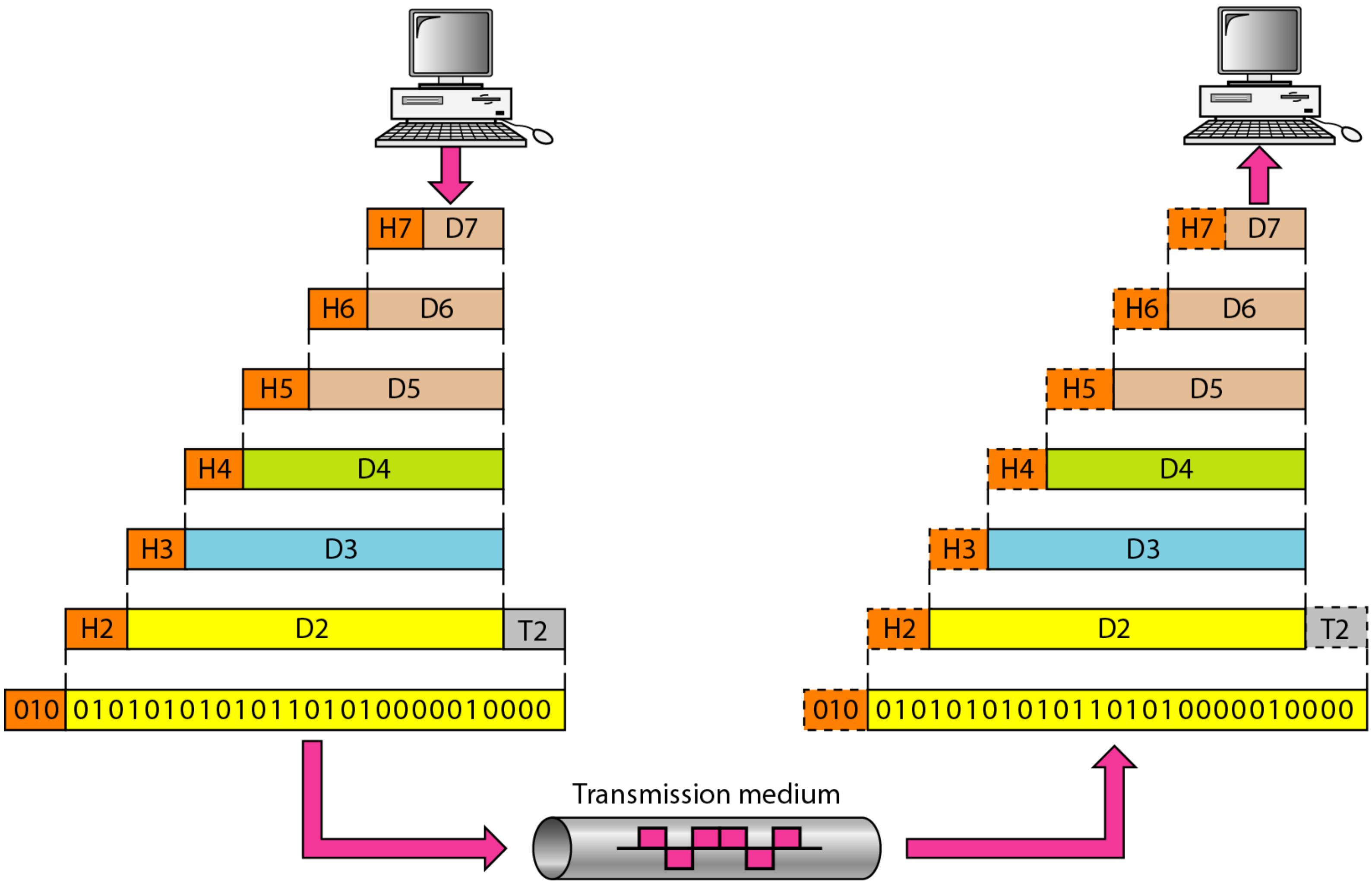
PEER – TO – PEER PROCESS

- 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.

The interaction between layers in the OSI model



An exchange using the OSI model



LAYERS IN THE OSI MODEL

Topics discussed in this section:

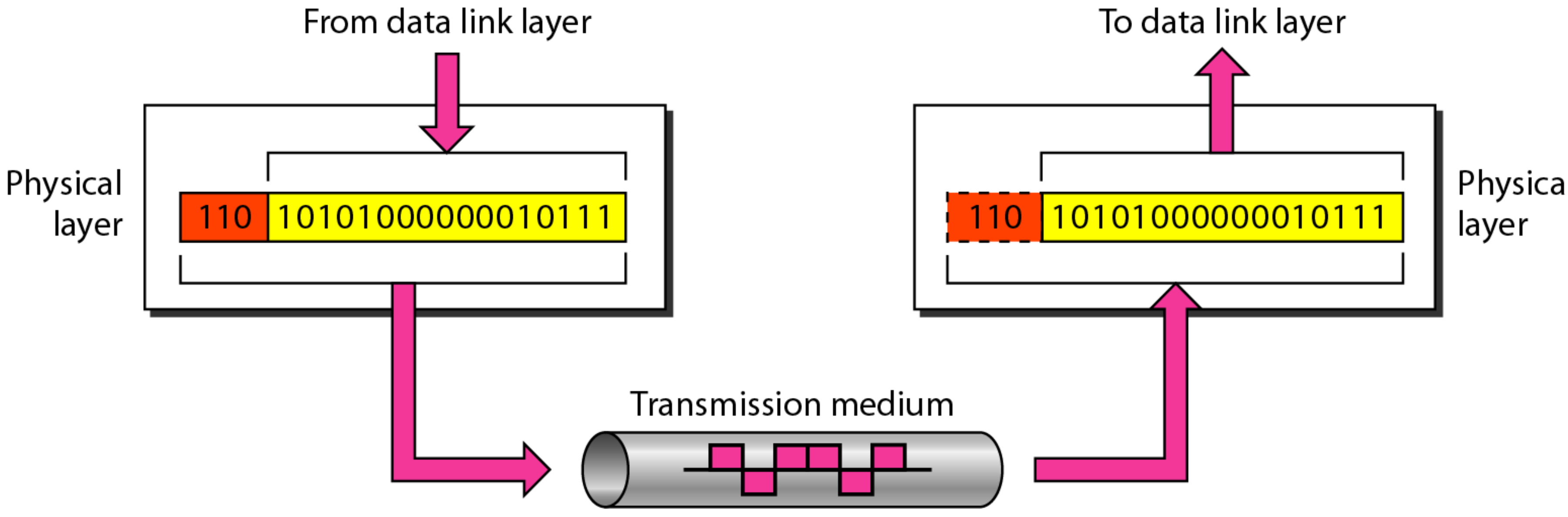
1. **Physical Layer**
2. **Data Link Layer**
3. **Network Layer**
4. **Transport Layer**
5. **Session Layer**
6. **Presentation Layer**
7. **Application Layer**

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

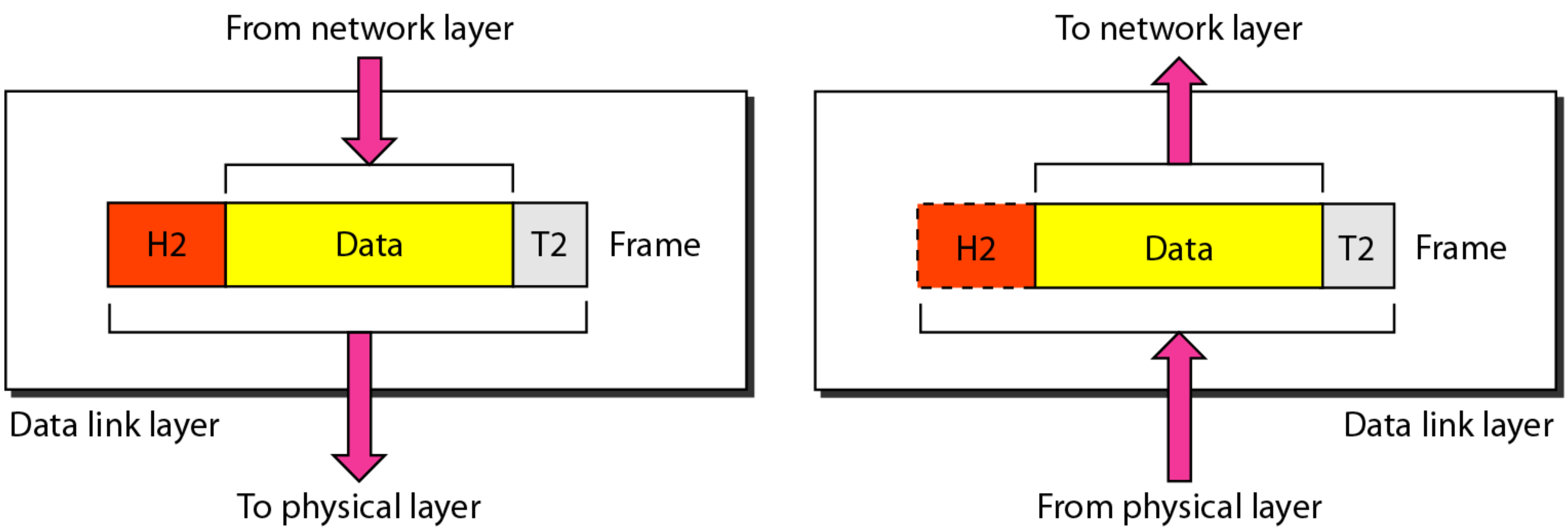


Data Link Layer

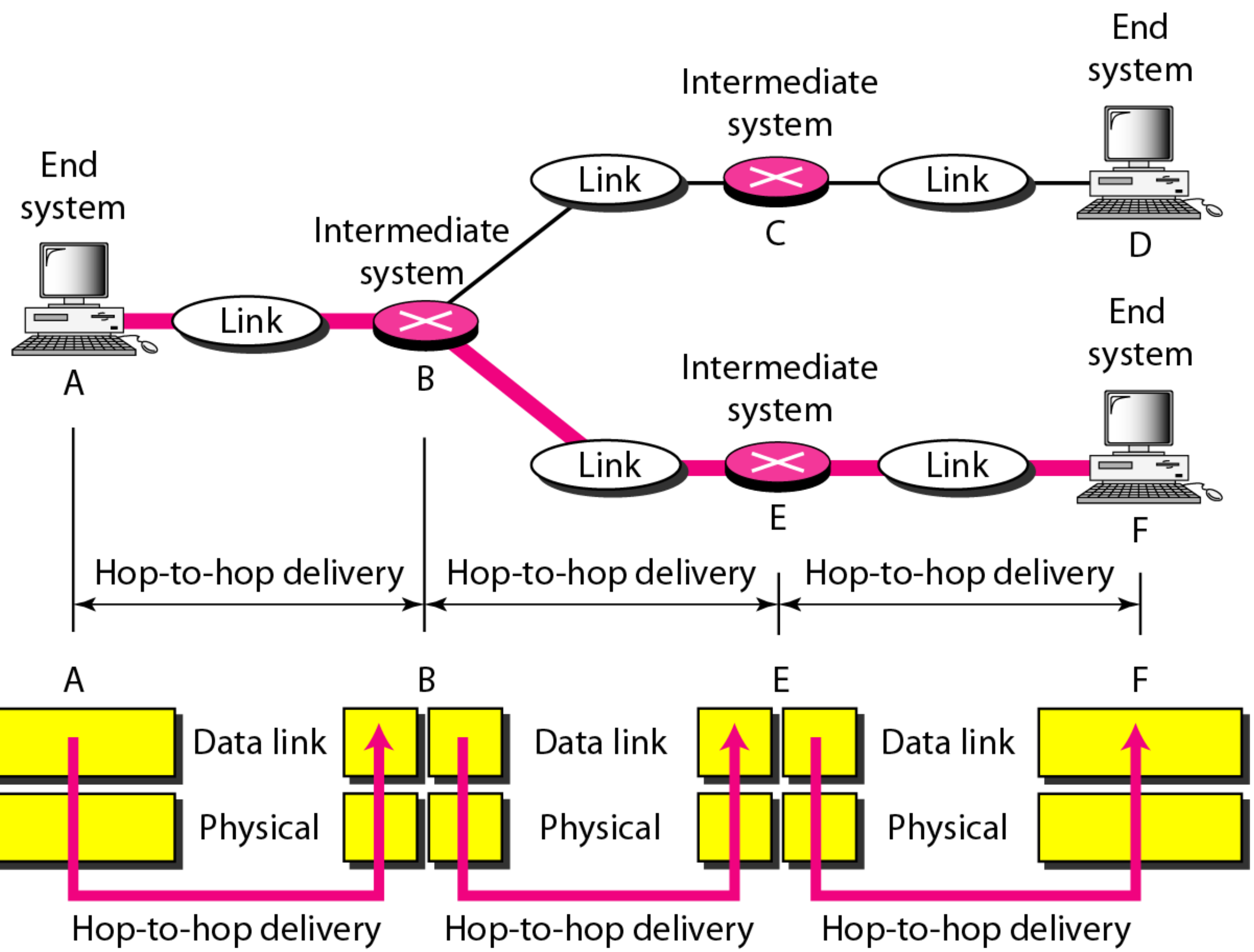
The data link layer is responsible for moving frames from one hop (node) to the next.

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

Data link layer

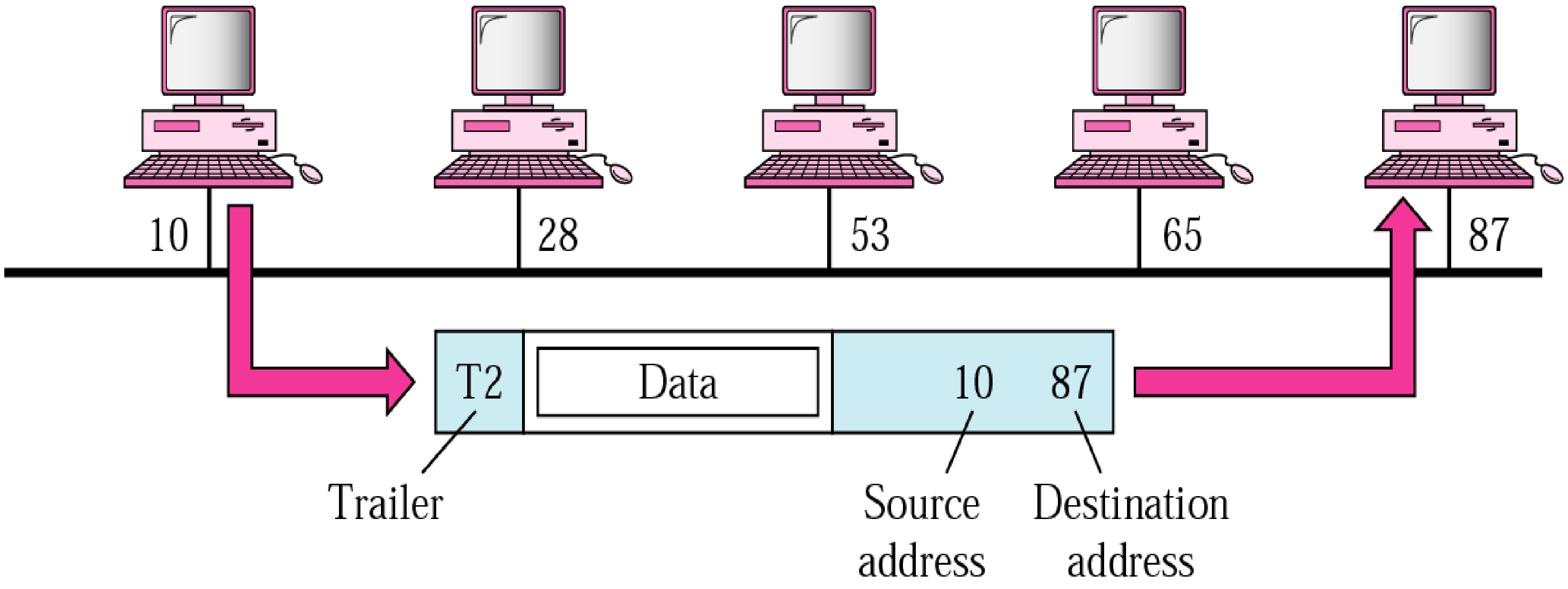


Hop-to-hop delivery



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

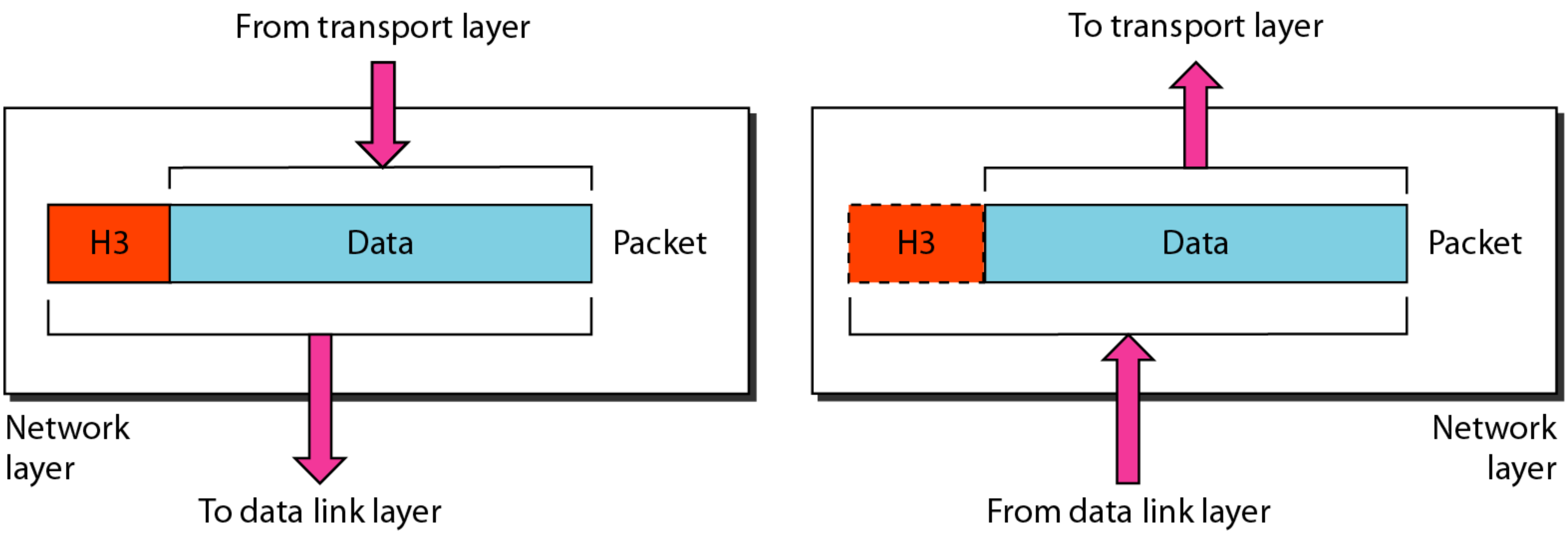


Network Layer

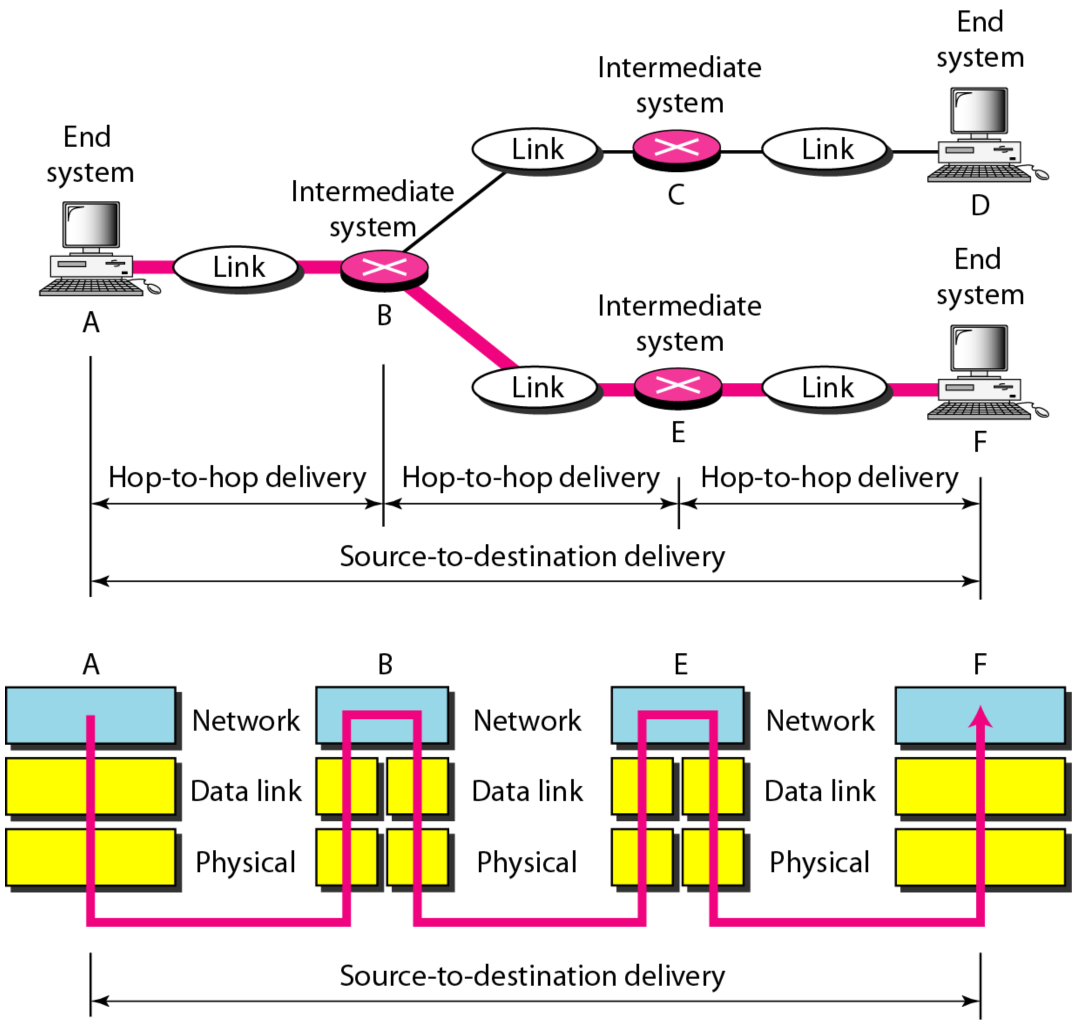
The network layer is responsible for the delivery of individual packets from the source host to the destination host.

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

Network layer

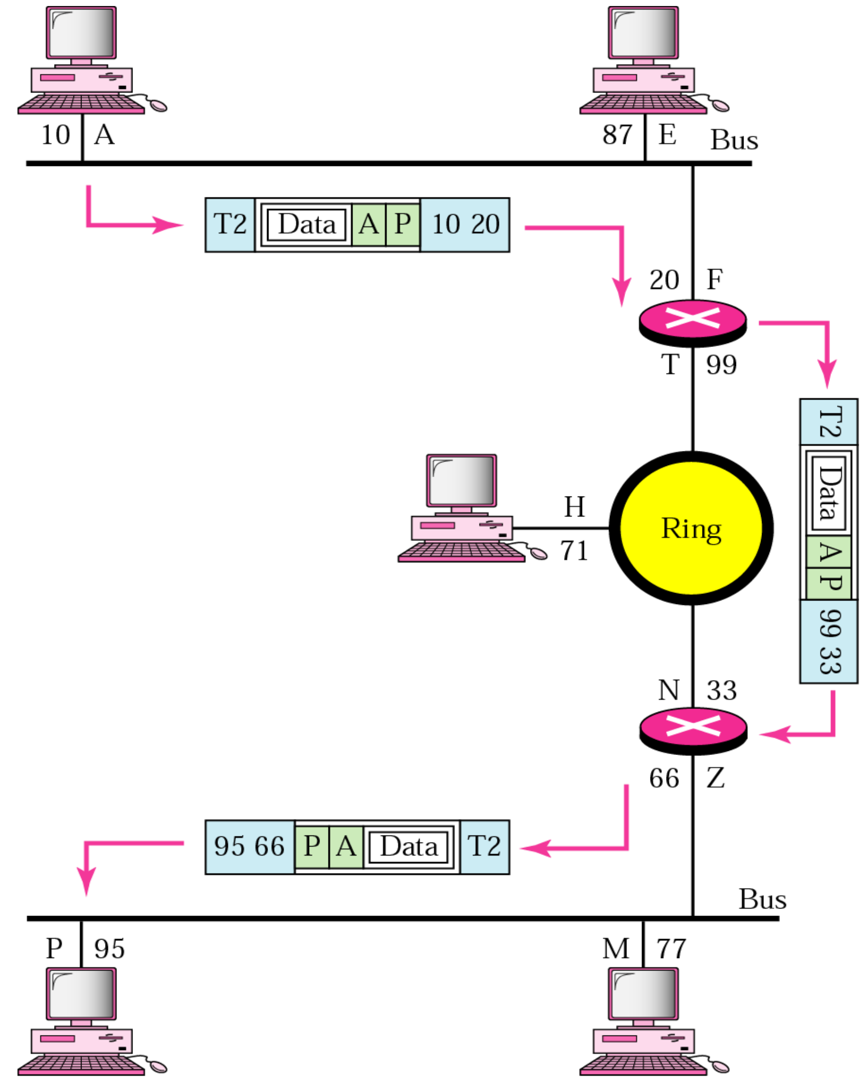


Source-to-destination delivery



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.



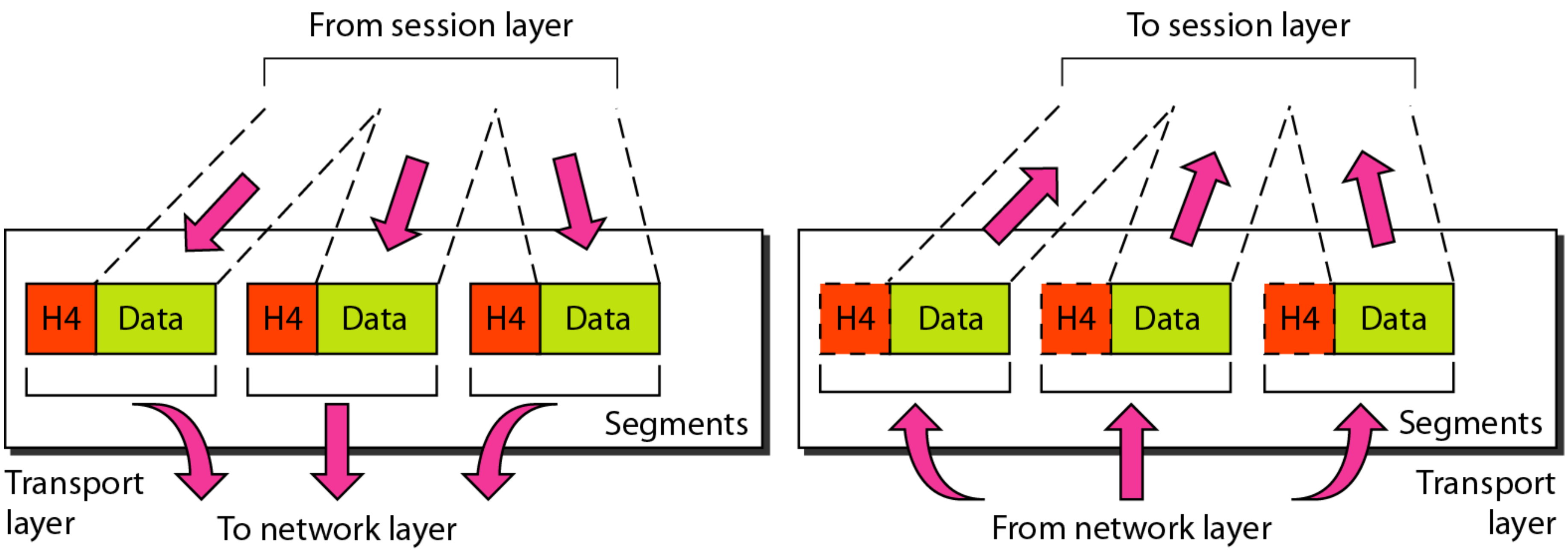
Transport Layer

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

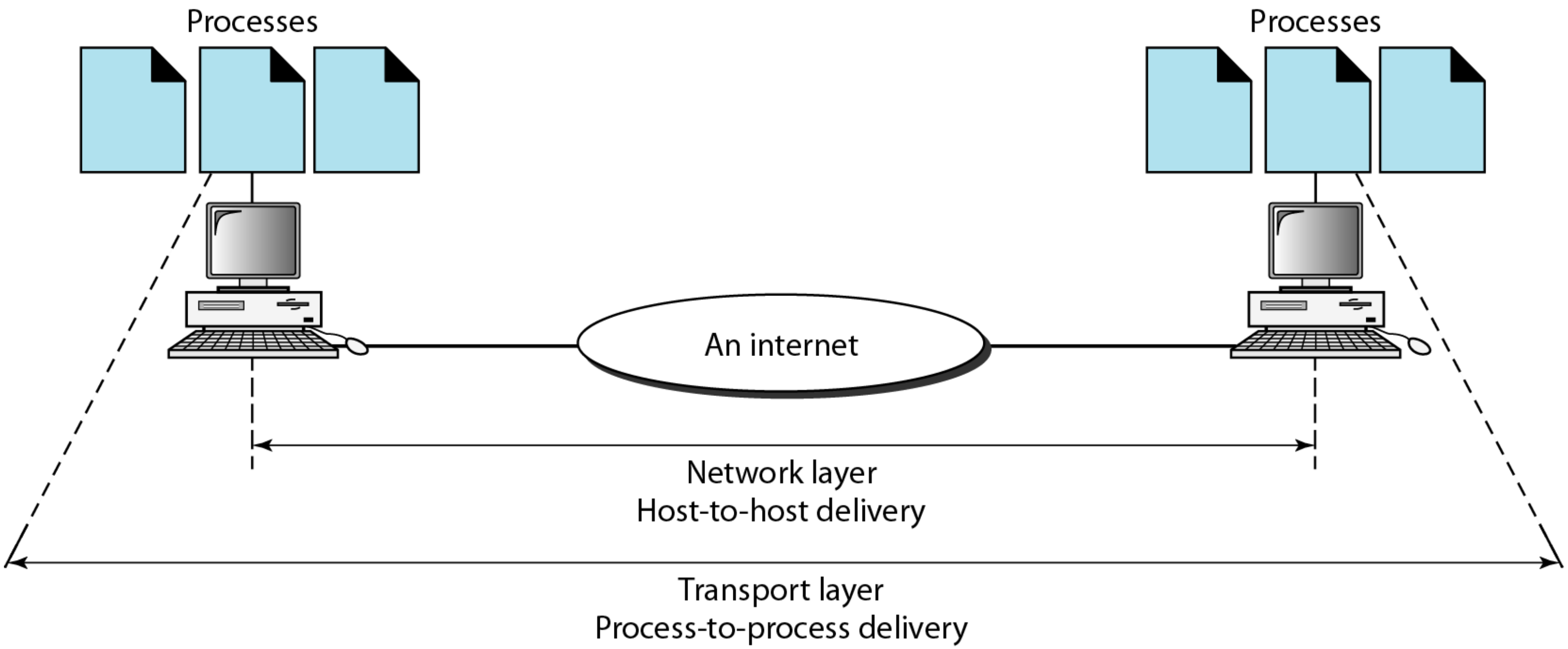
- Process-to- process delivery
- Functions
  - Port addressing
  - Segmentation and reassembly
  - Connection control (Connection-oriented or connection-less)
  - Flow control
  - Error control

Transport layer

Segmentation and reassembly

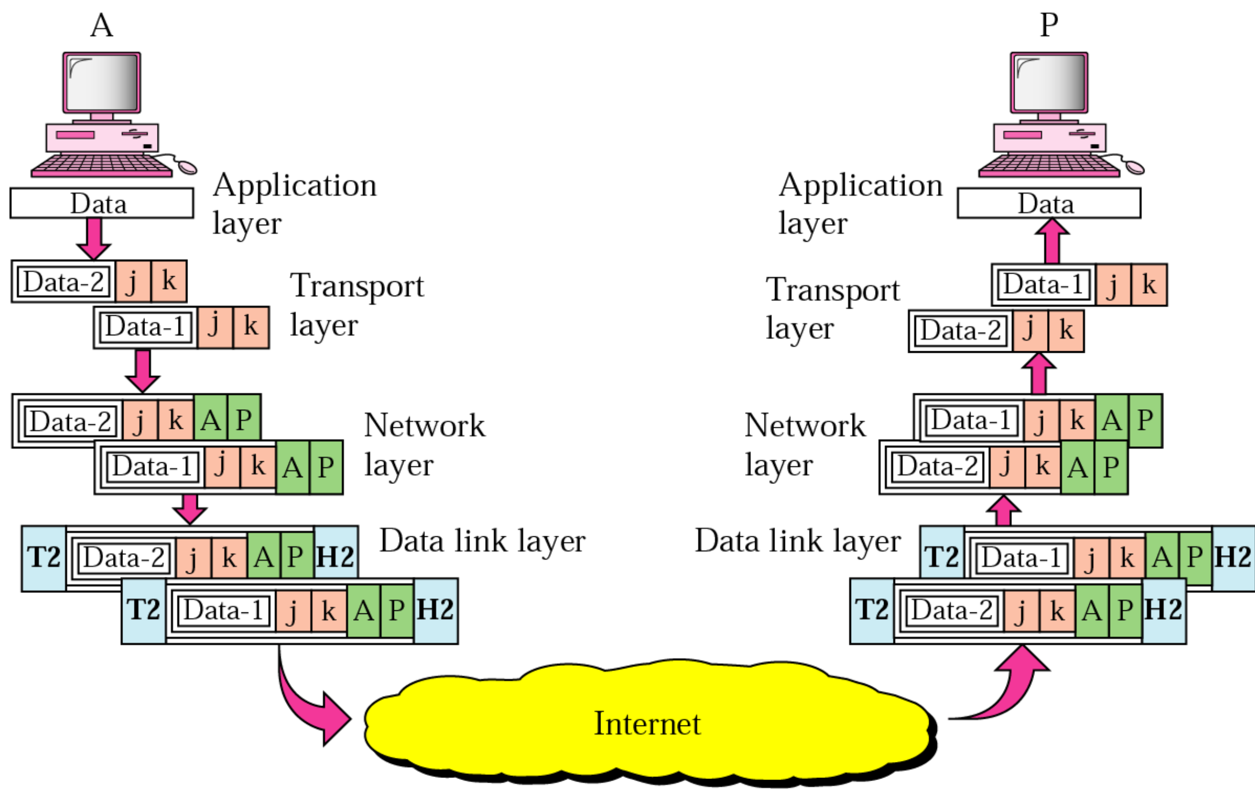


Reliable process-to-process delivery of a message



Example 3

Data coming from the upper layers have port addresses j and k (j is the address of the sending process, and k is the address of the receiving process). Since the data size is larger than the network layer can handle, the data are split into two packets, each packet retaining the port addresses (j and k). Then in the network layer, network addresses (A and P) are added to each packet.



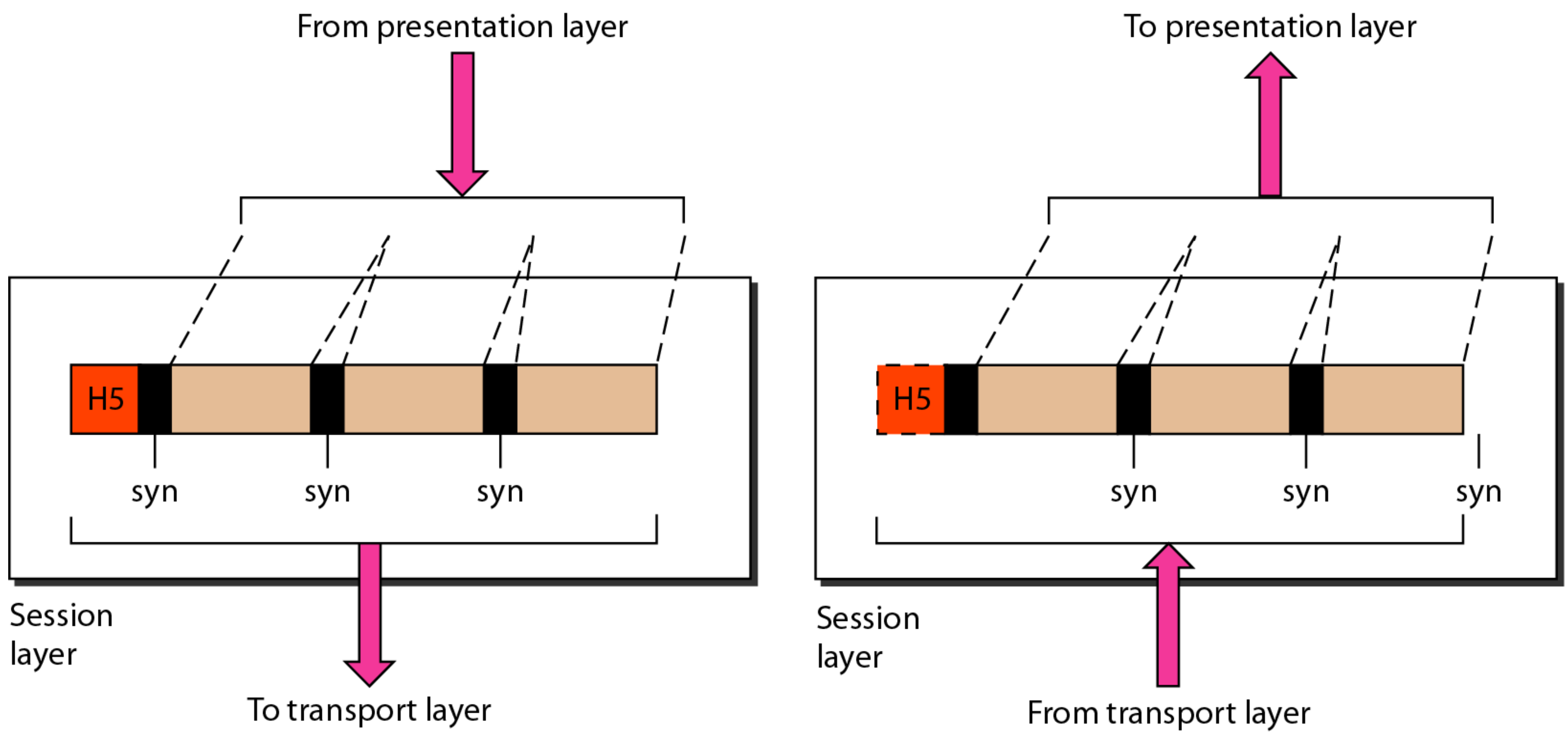
Session Layer

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)**

Session layer

Synchronization

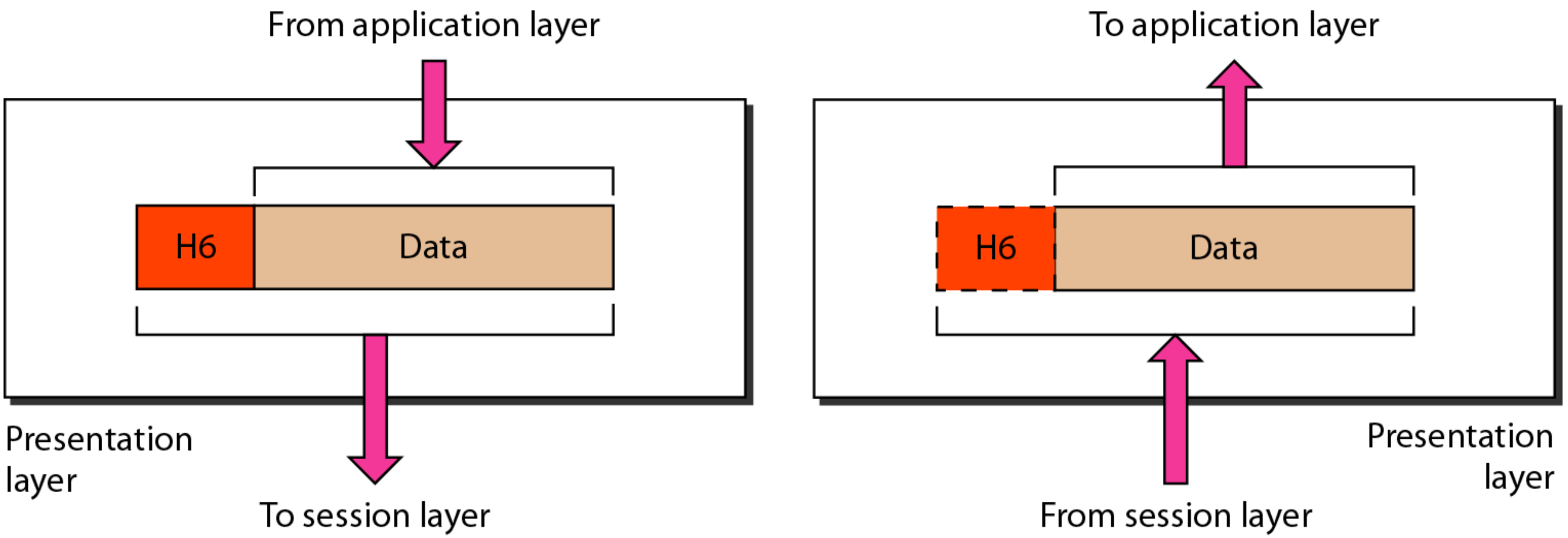


Presentation Layer

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**

Presentation layer

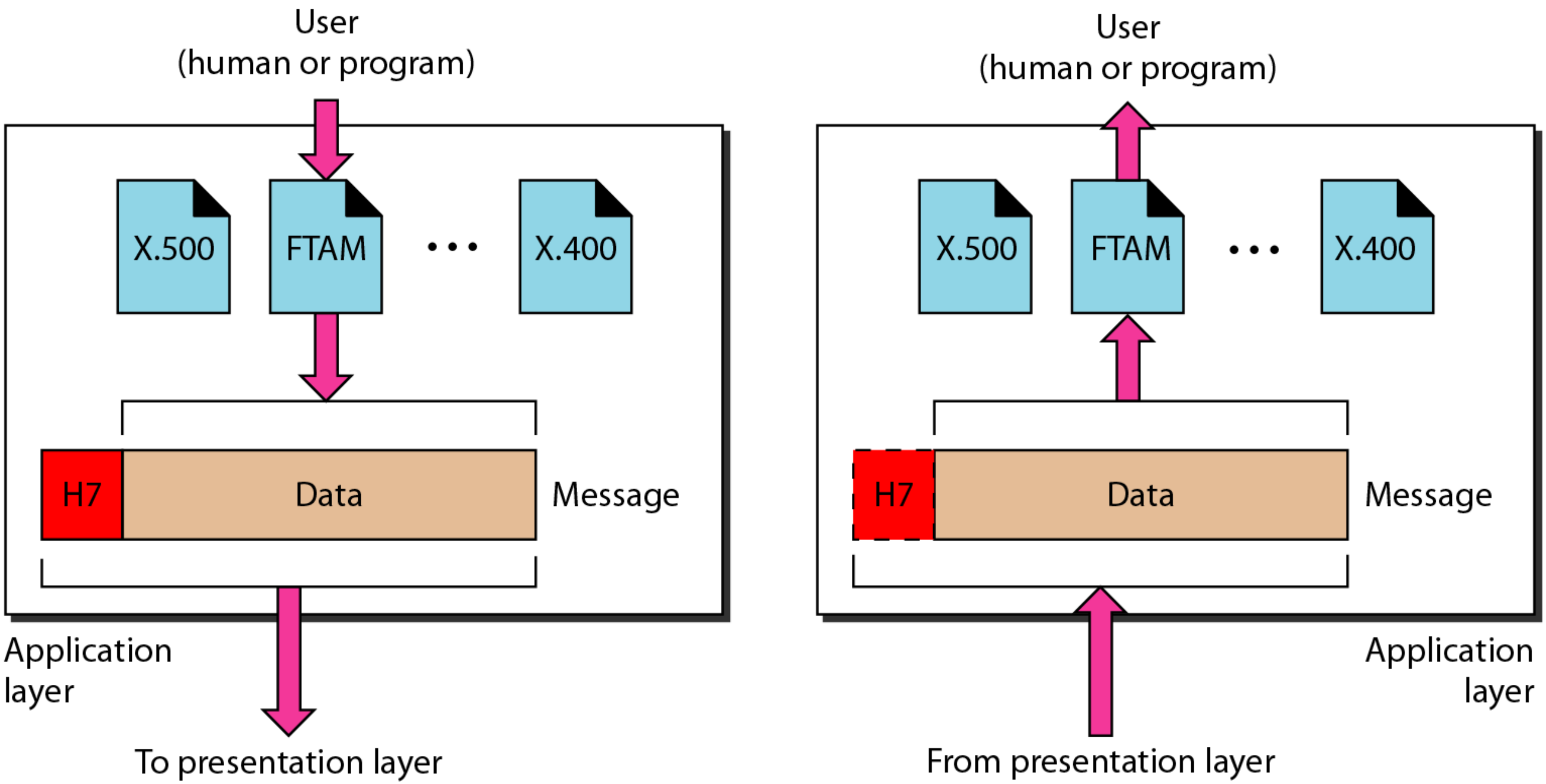


Application Layer

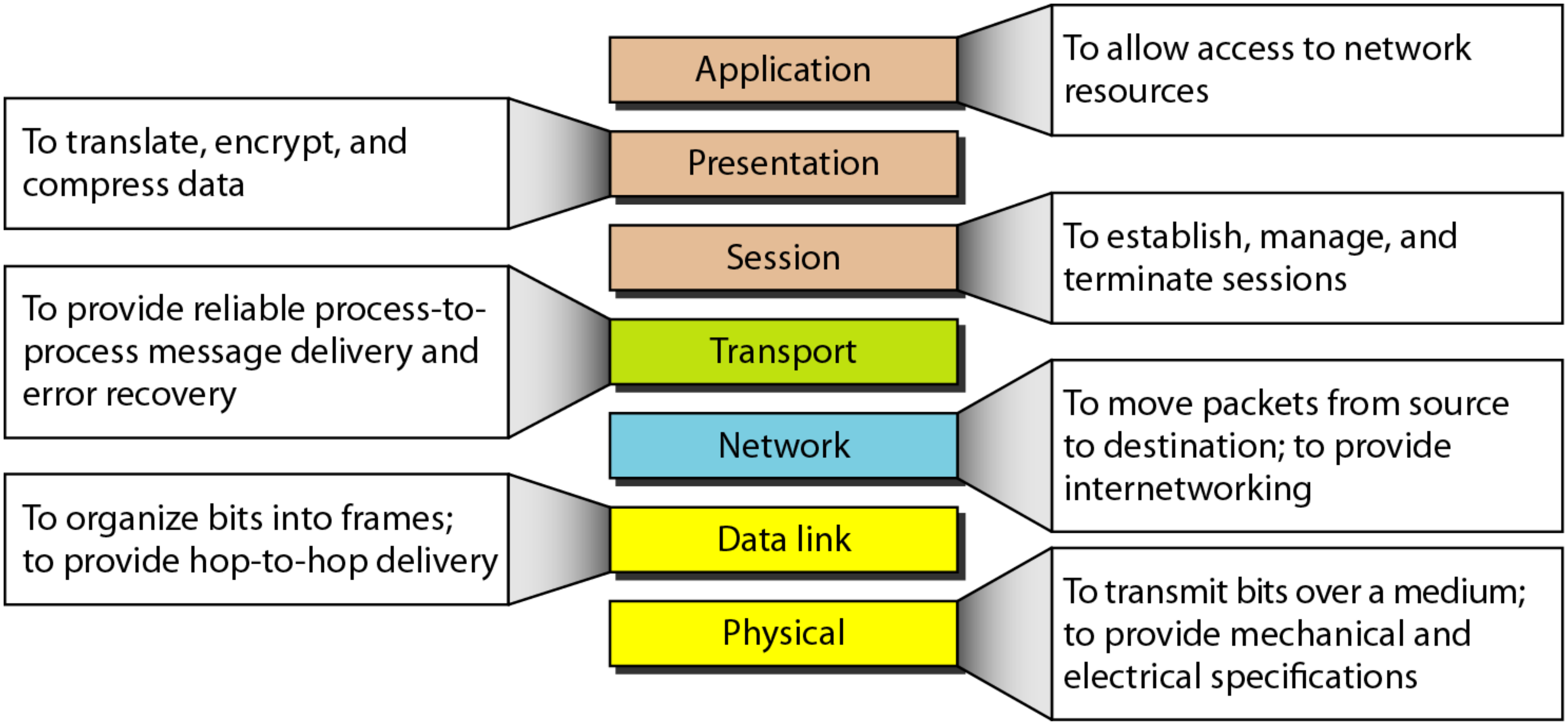
The application layer is responsible for providing services to the user.

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

Application layer



Summary of layers



Summary of layers

Sender

Receiver

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

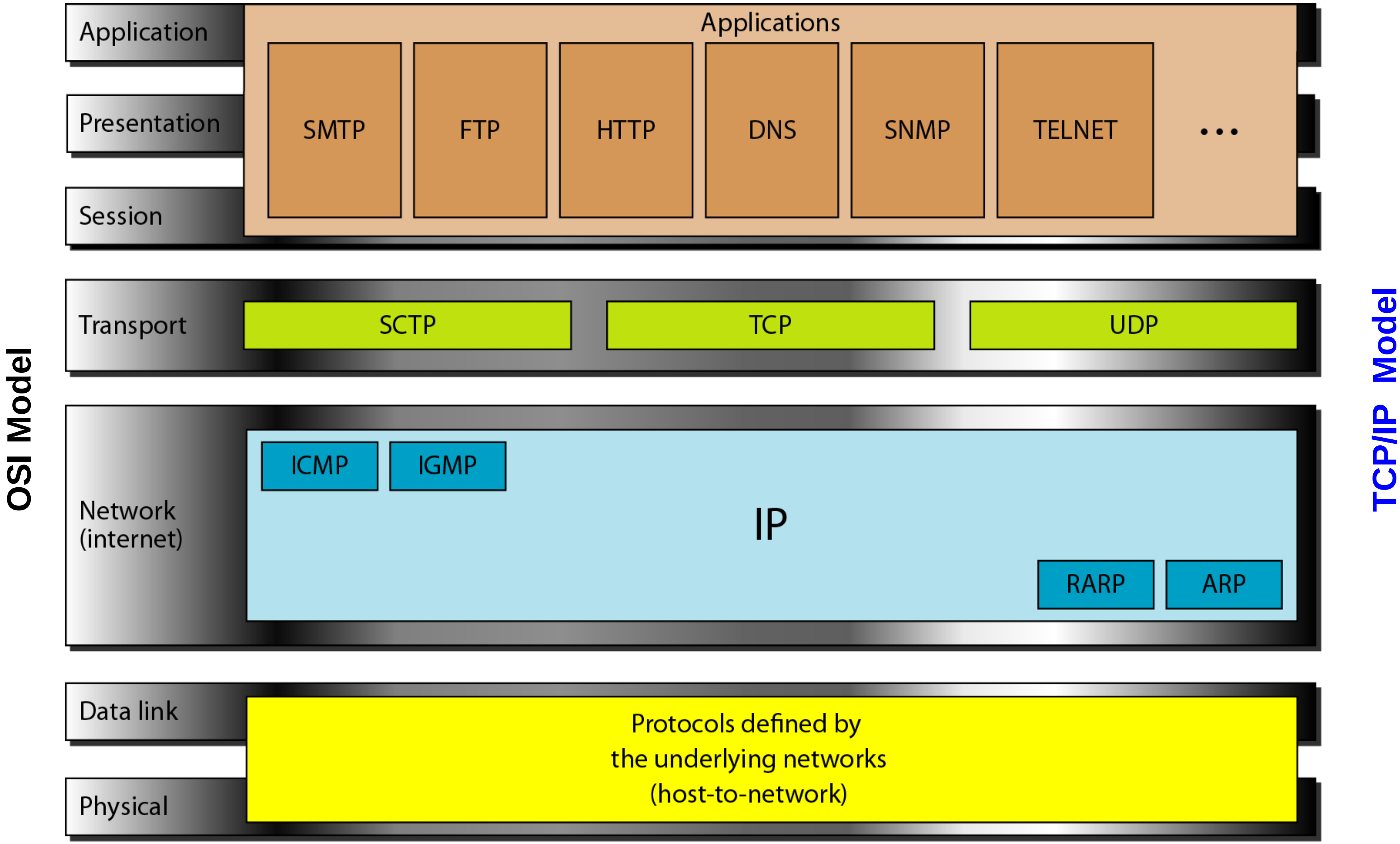
1-5.2 TCP/IP PROTOCOL SUITE

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

TCP/IP and OSI model



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 Massage Protocol (ICMP)
- Internet Group Massage Protocol (IGMP)

Transport Layer

Process-to-process protocol.

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

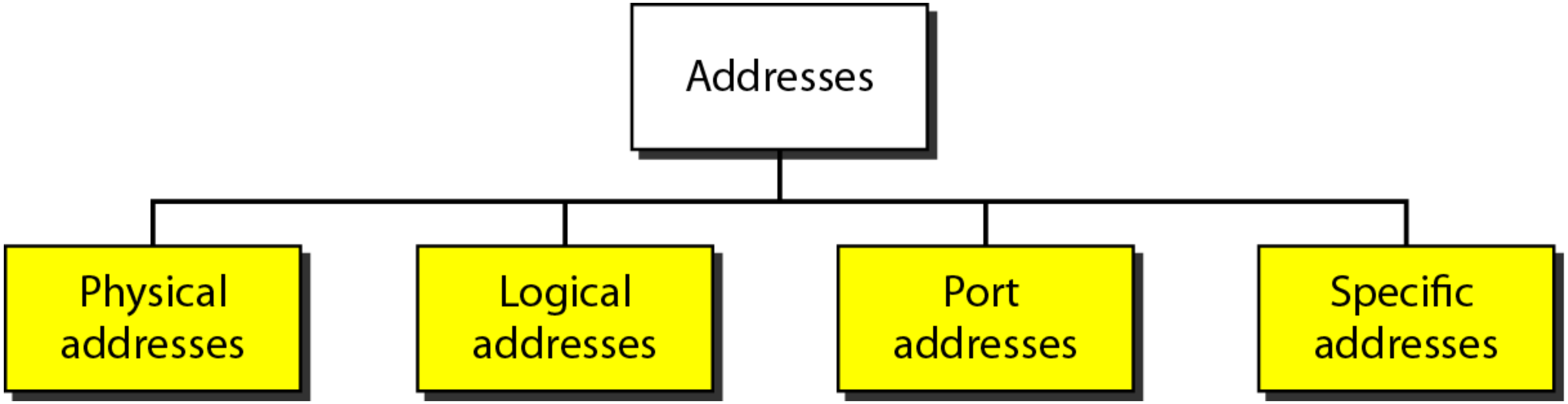
1-6 ADDRESSING

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

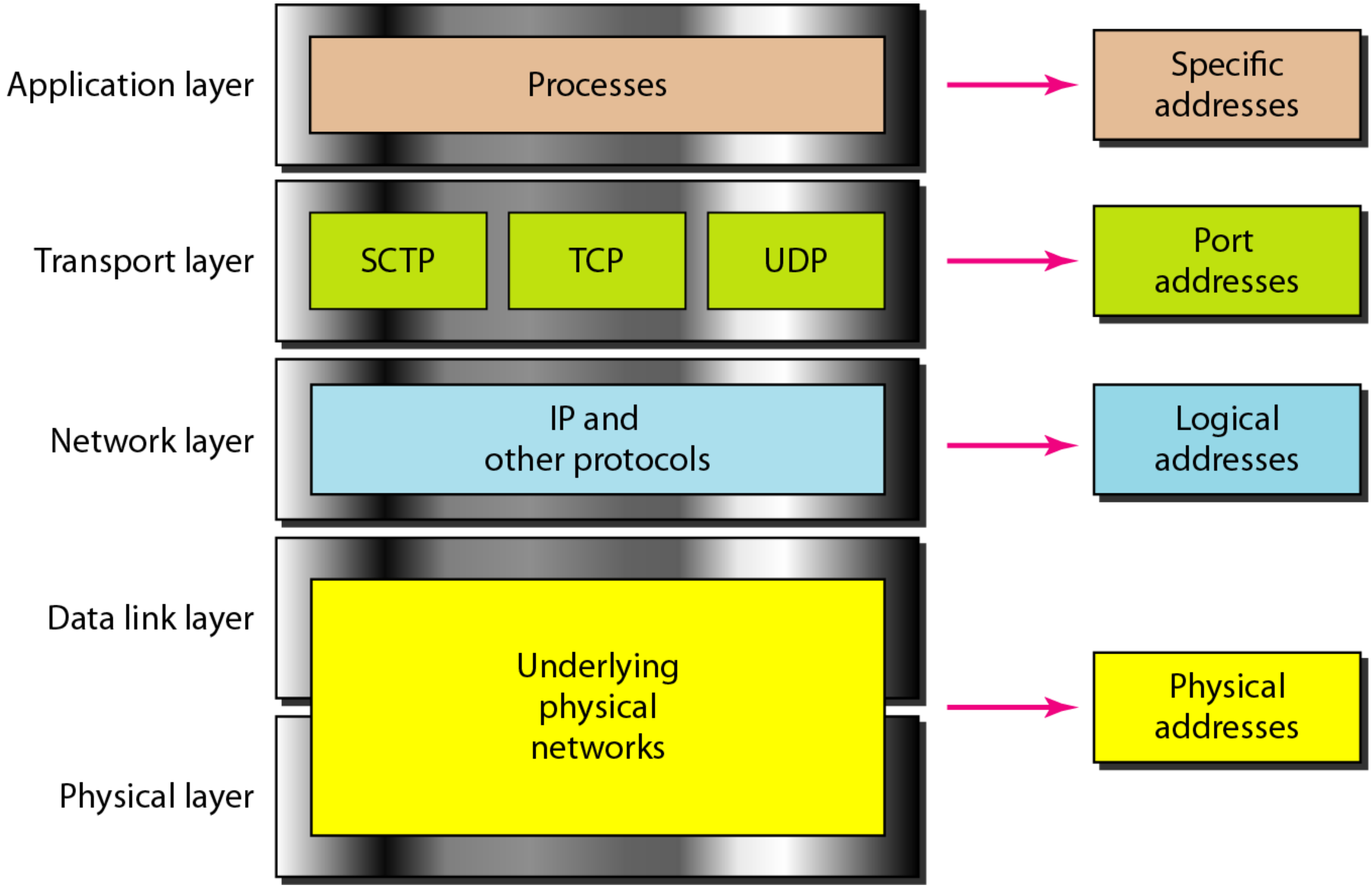
Topics discussed in this section:

Physical Addresses
Logical Addresses
Port Addresses
Specific Addresses

Addresses in TCP/IP



Relationship of layers and addresses in TCP/IP



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.

Port addresses

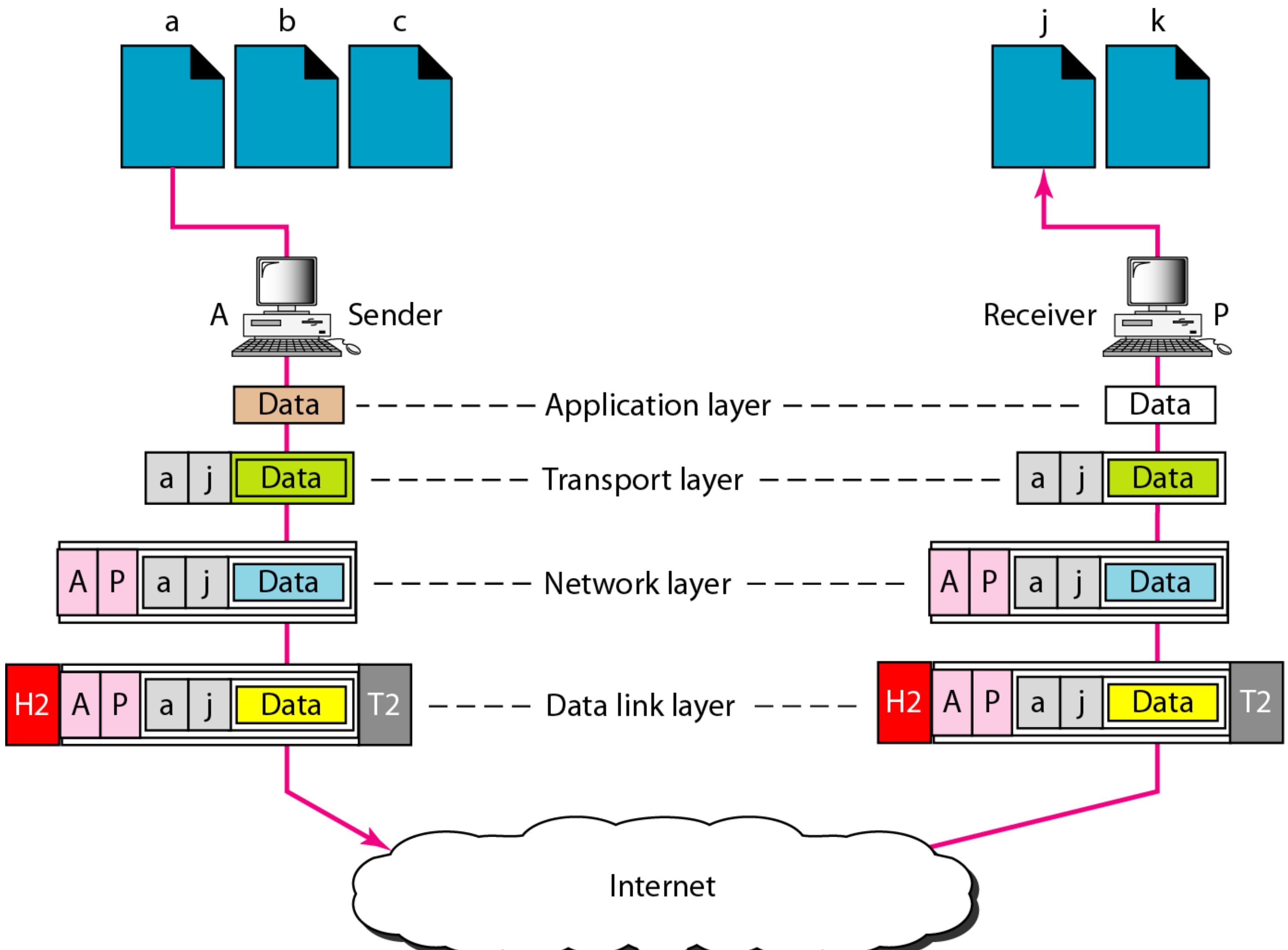
Port address is a 16-bit address represented by one decimal number ranged from (0-65535) to choose a process among multiple processes on the destination host.

- 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 addresses



Specific addresses

E-mail address (user1@ksu.edu.sa)

Universal Resource Locator (URL) (www.ksu.edu.sa)

The Domain Name System (DNS) translates human-friendly computer hostnames (URL) into IP addresses. For example, *www.example.com* is translated to *208.77.188.166*