Chapter 1
Introduction to computer Network

Contents

- Definition, merits, demerits
- Network Models
- LAN, MAN, WAN
- Topological Models
- Client server, Peer to Peer
- ISP, NSP
- 1G, 2G, 3G, 4G, 5G

1-1 DATA COMMUNICATIONS

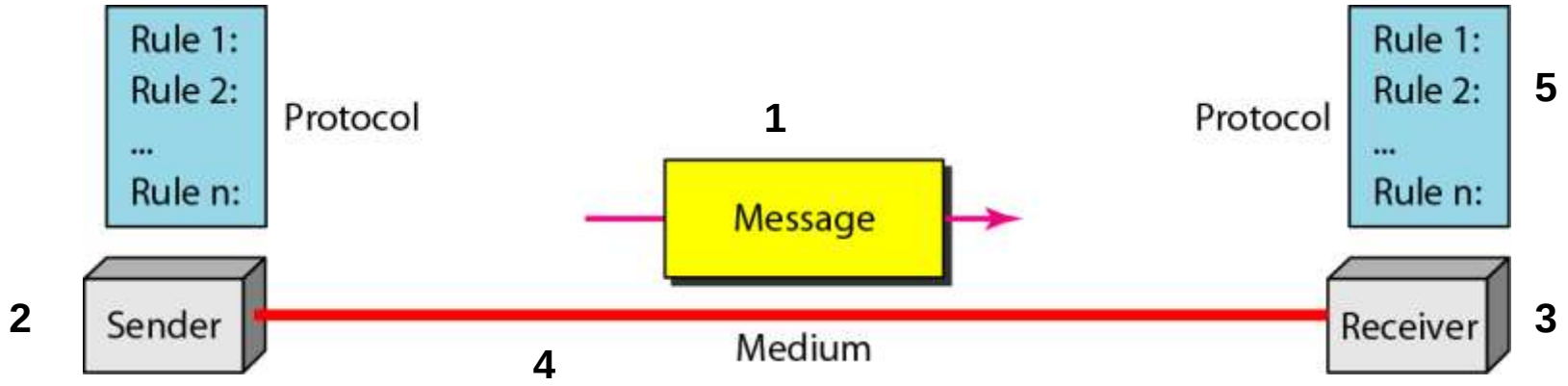
The term telecommunication means communication at a distance. The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.

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*

Components

Figure 1.1 *Five components of data communication*

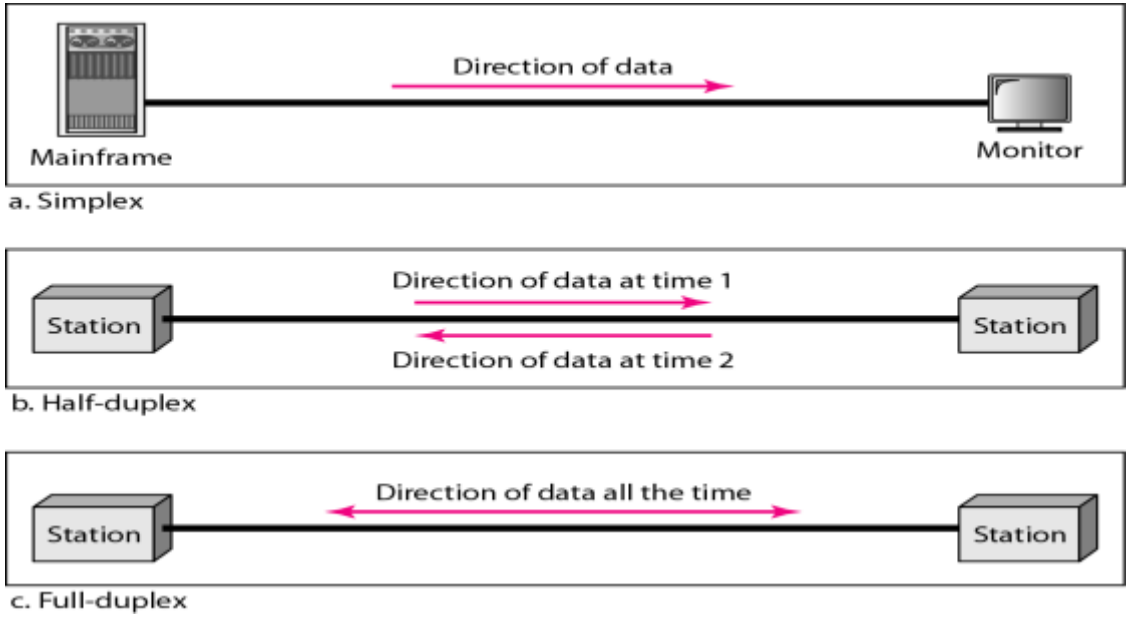


Data Representation

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

Data flow

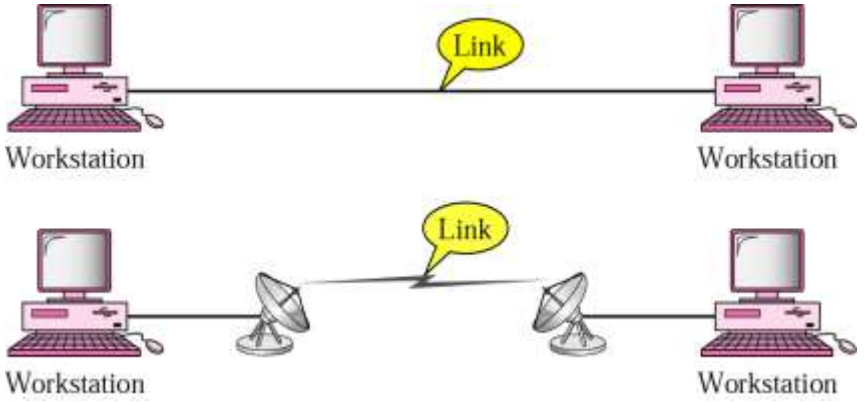
- ***Simplex***
- ***Half-duplex***
- ***Full-duplex***



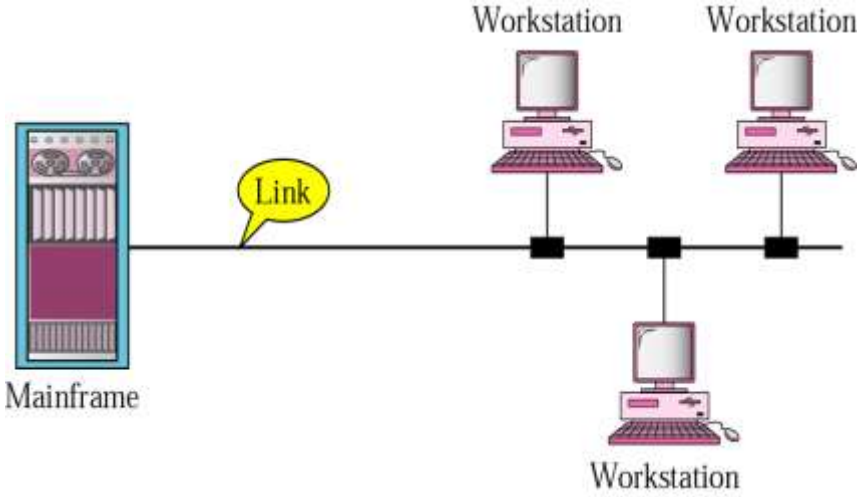
A network is a set of devices (nodes) connected by communication links. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.

Types of connections

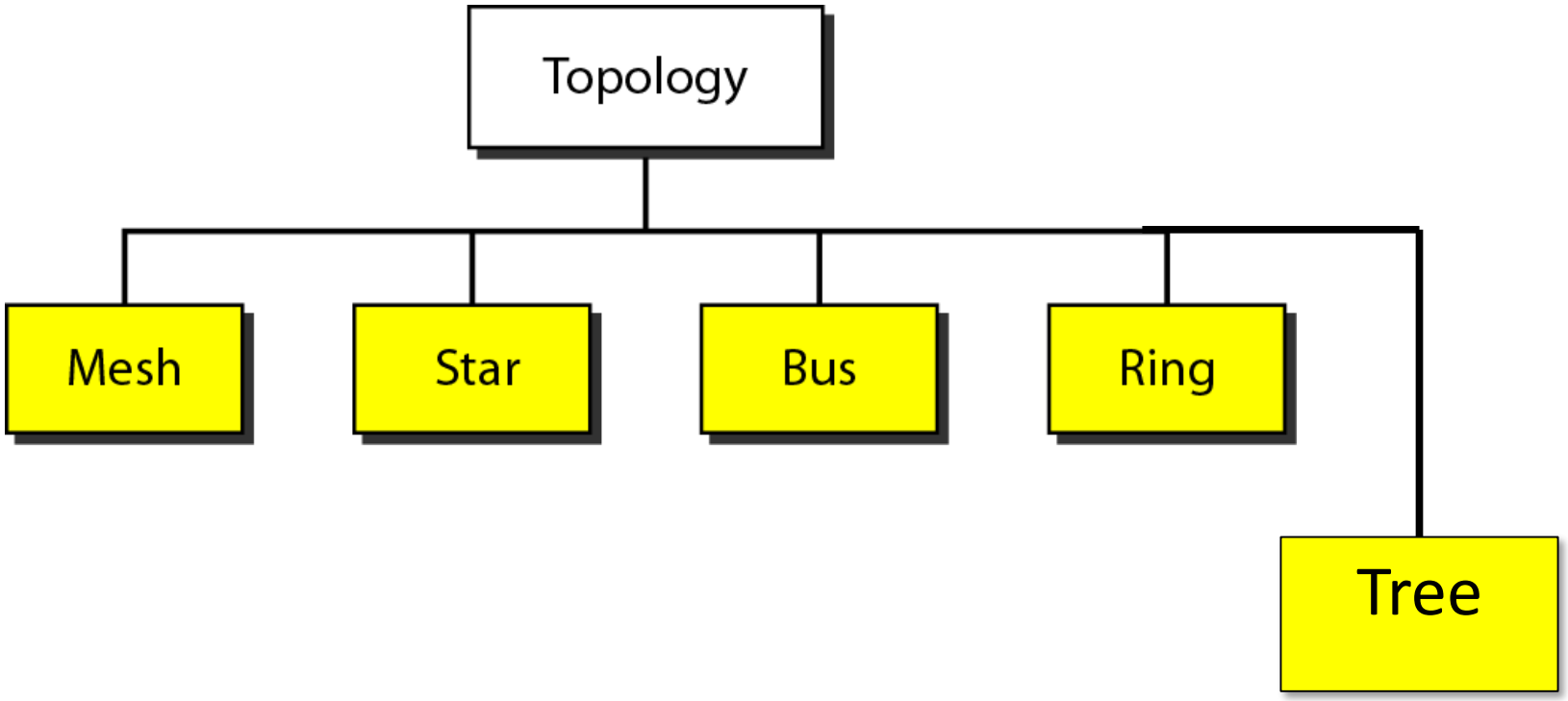
- Point to point
  - A dedicated link is provided between two devices



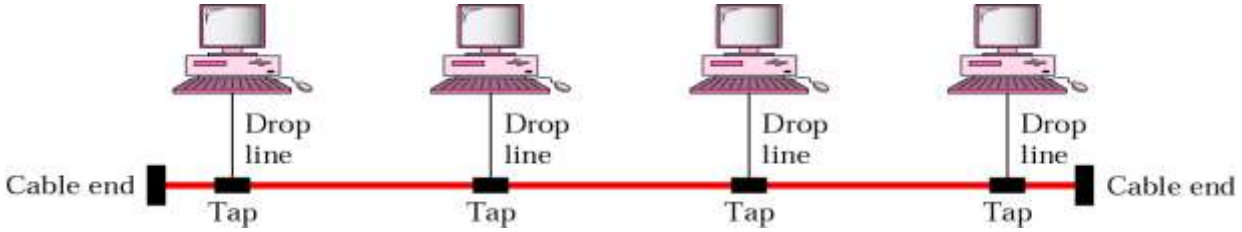
- Multipoint
  - More than two specific devices share a single link



Physical Topology



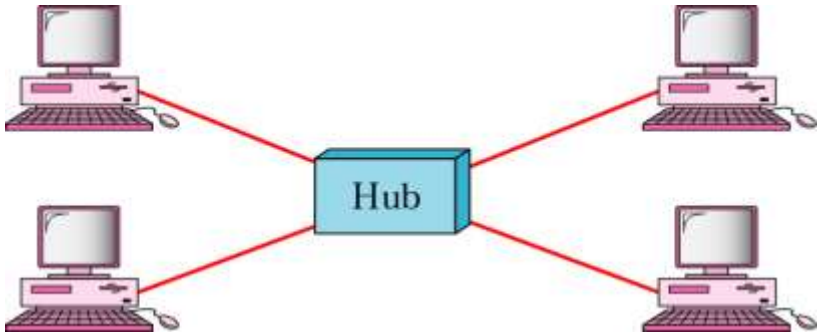
BUS Topology



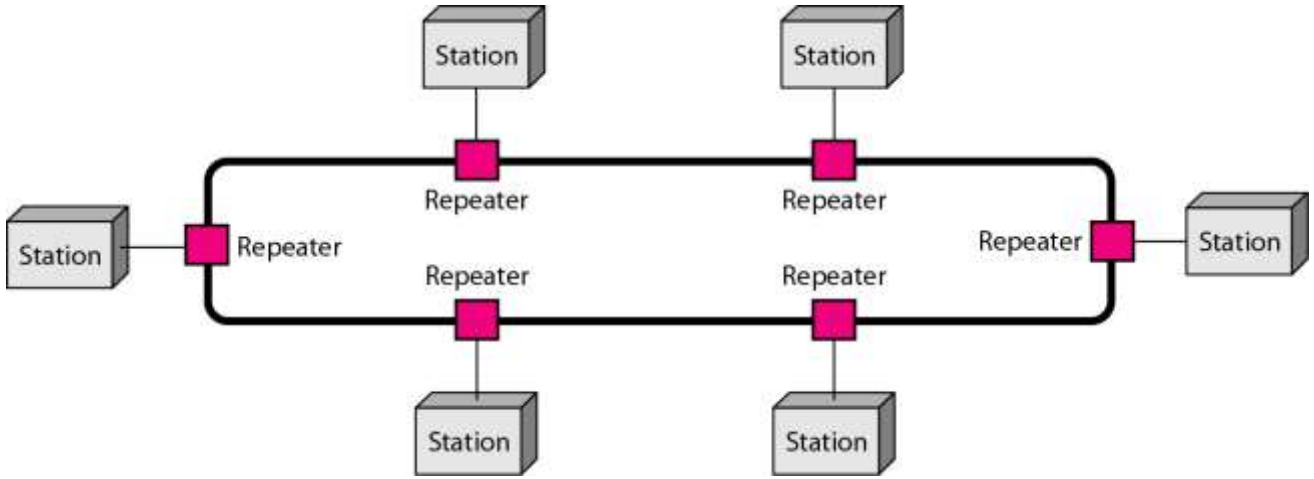
- A multipoint topology
- All devices are linked through a *backbone* cable
- Nodes are connected to the bus cable by drop lines and taps.
  - Drop line
    - A connection running between the device and the main cable
  - Tap
    - A connector that either splices into the main cable or punctures the 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

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



RING Topology



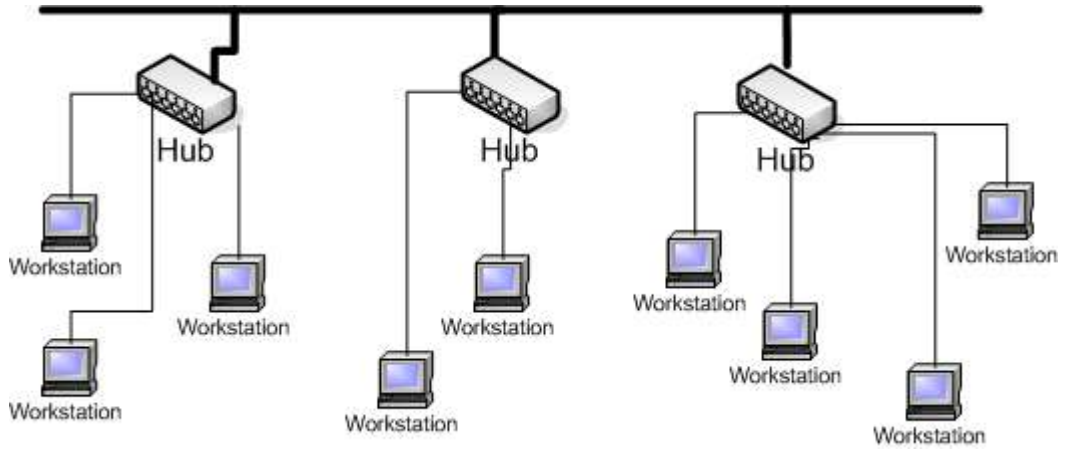
- Each device is dedicated point-to-point connection only with the two devices on either side of it
- A signal is passed along the ring in the direction, from device to device, until it reaches its destination
- Each device in the ring incorporates a repeater

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

Tree Topology

Tree topologies integrate multiple topologies together

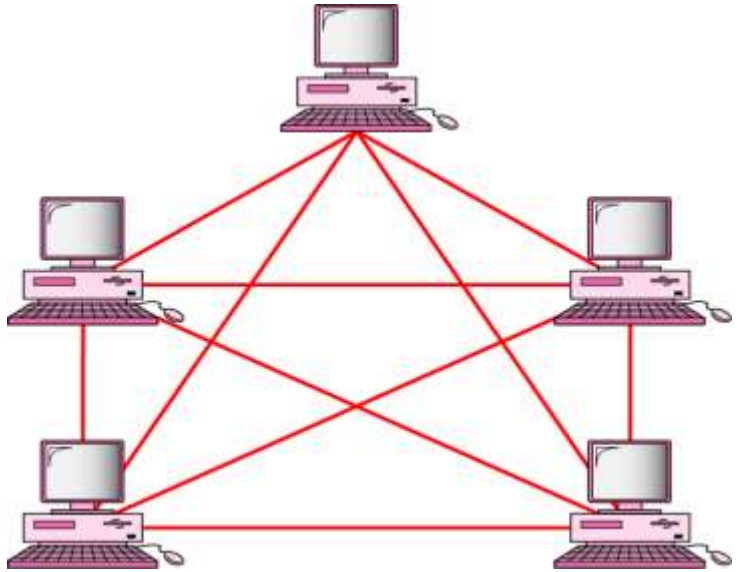
Example: Tree topology integrates multiple star topologies together onto a bus



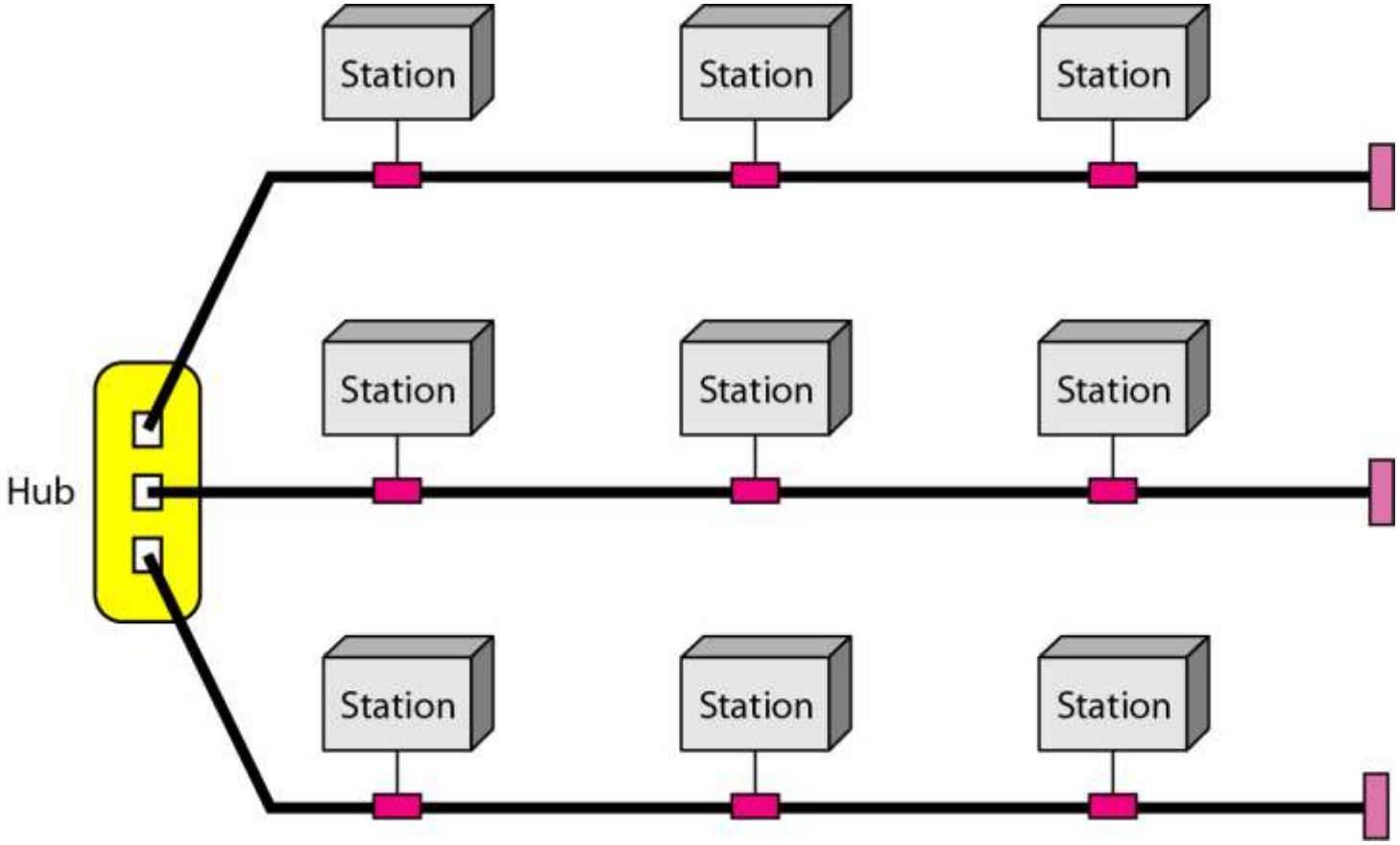
- Advantages:
  - Point-to-point wiring for individual segments.
  - Supported by several hardware and software venders.
- Disadvantages:
  - Overall length of each segment is limited by the type of cabling used.
  - If the backbone line breaks, the entire segment goes down.
  - More difficult to configure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

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



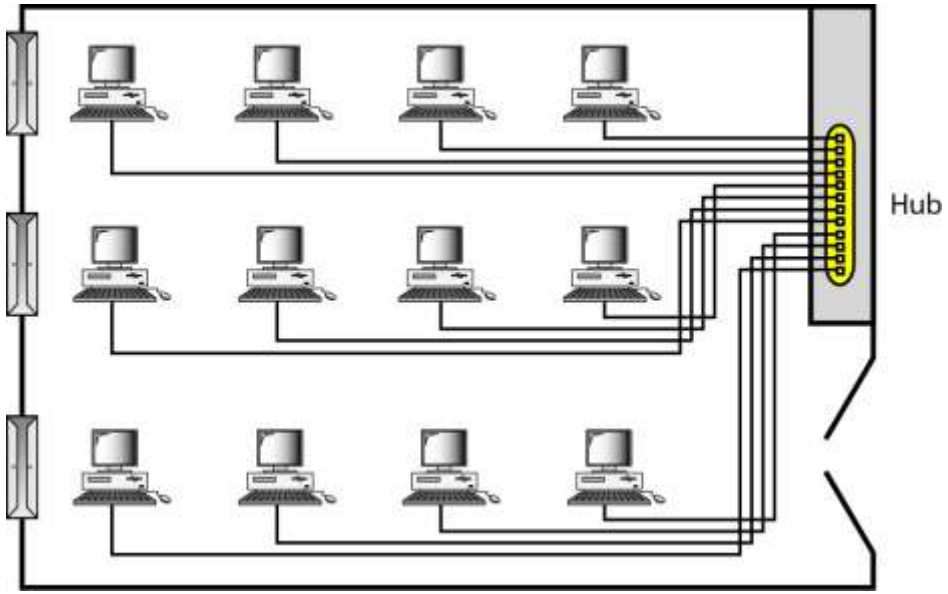
A hybrid topology: a star backbone with three bus networks



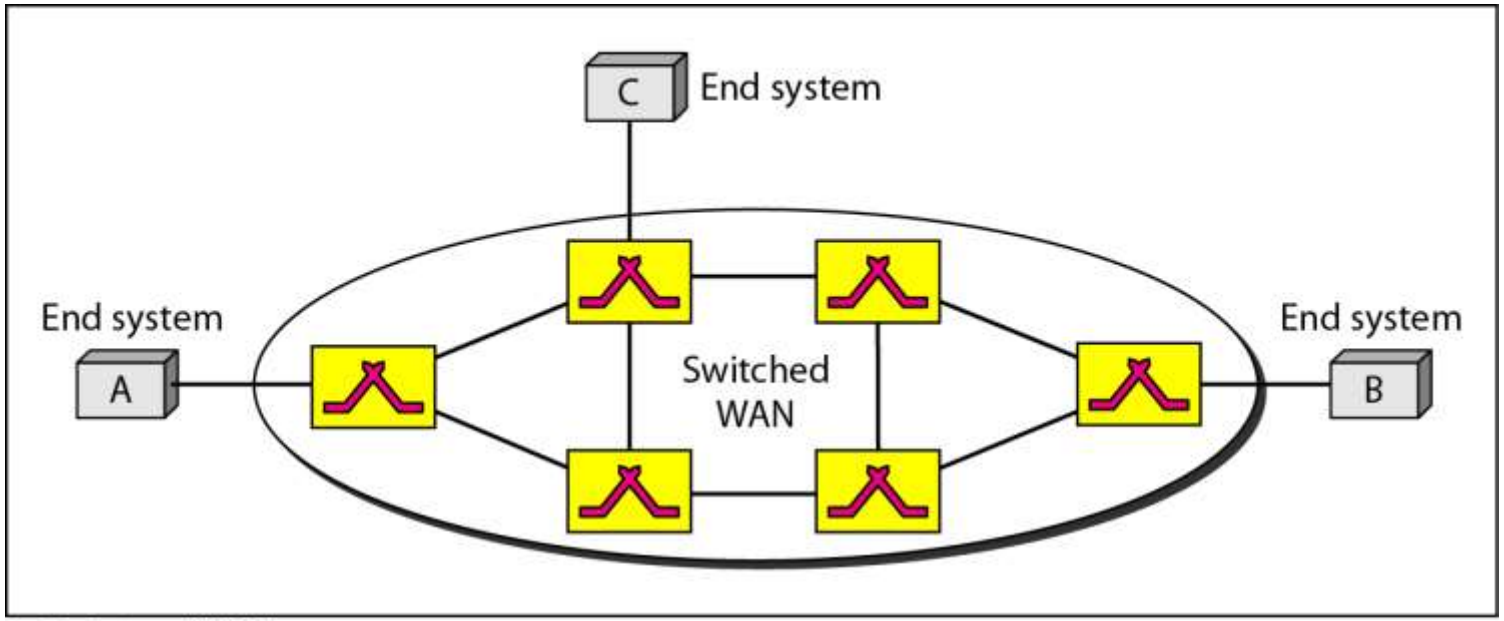
Categories of Networks

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

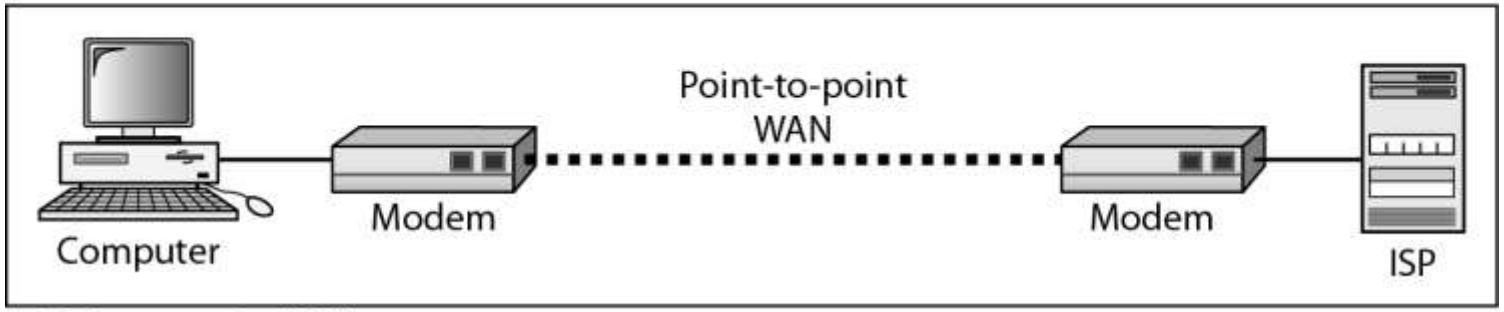
An isolated LAN connecting 12 computers to a hub in a closet



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



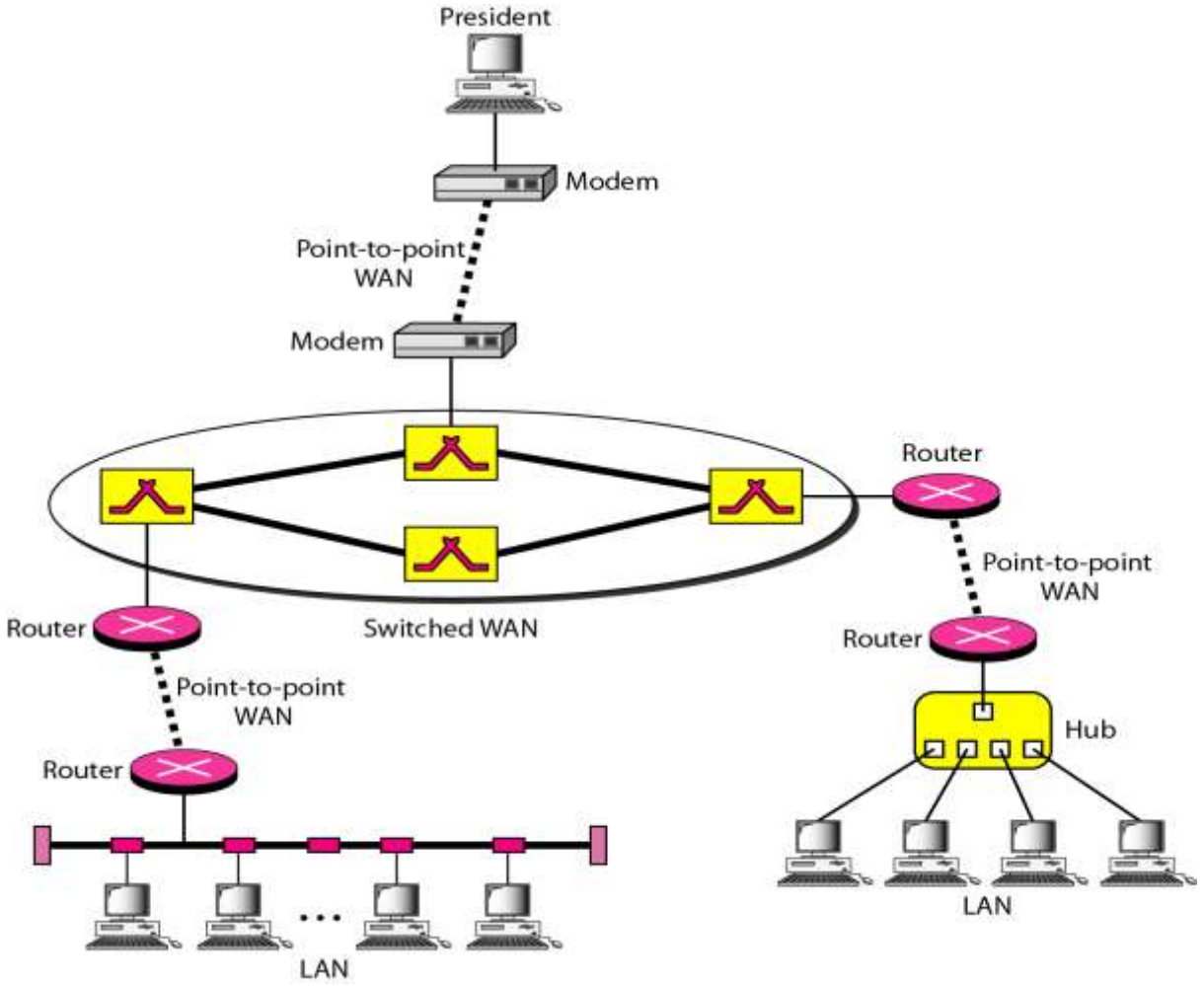
a. Switched WAN



b. Point-to-point WAN

Interconnection of Networks: internet

A heterogeneous network made of four WANs and two LANs



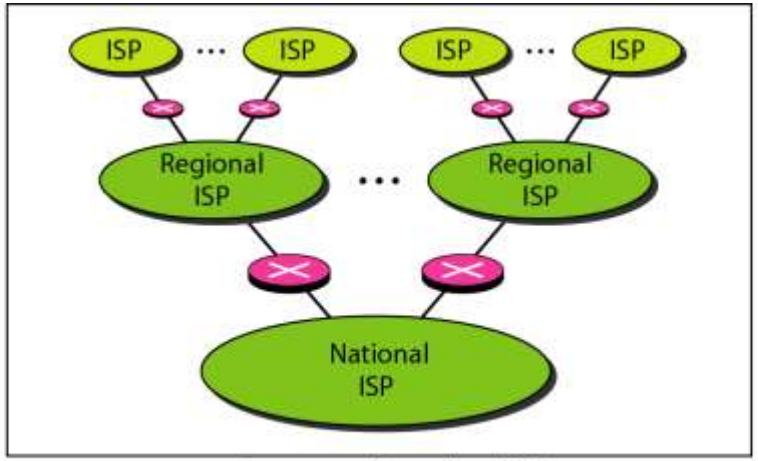
THE INTERNET

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.

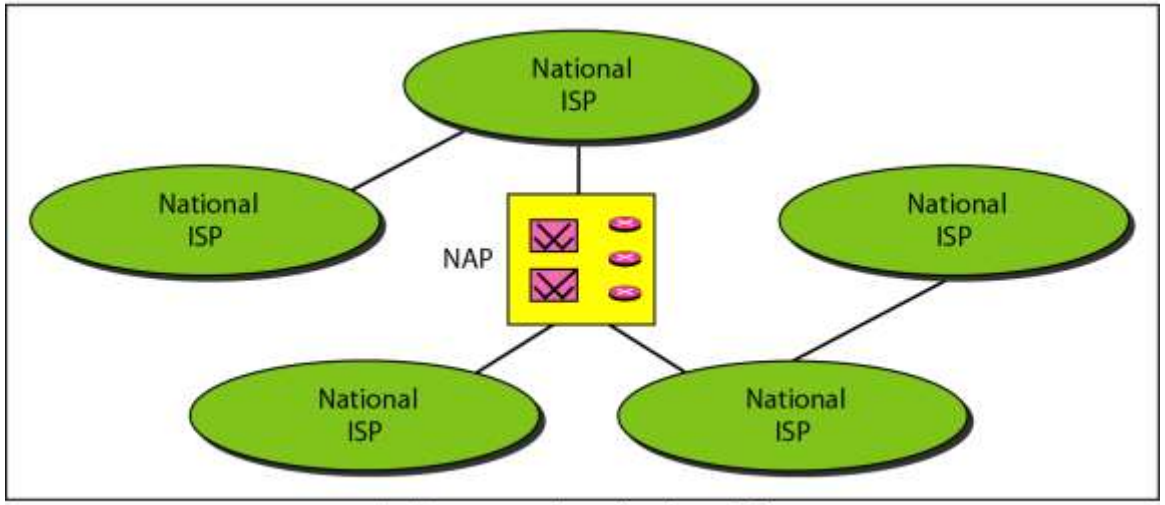
- Internet
- Intranet
- Extranet

The Internet Today (ISPs)

Hierarchical organization of the Internet



a. Structure of a national ISP



b. Interconnection of national ISPs

LAN (Local Area Network)

- Group of interconnected computers withina small area. (room, building, campus)
- Two or more pc's can from a LAN to share files, folders, printers, applications and other devices.
- Coaxial or CAT 5 cables are normally used for connections. Due to short distances, errors and noise are minimum.
- Data transfer rate is 10 to 100 mbps. Example: A computer lab in a school.

MAN (Metropolitan Area Network)

- Design to extend over a large area.
- Connecting number of LAN's to form larger network, so that resources can be shared.
- Networks can be up to 5 to 50 km. Owned by organization or individual. Data transfer rate is low compare to LAN.
- Example: Organization with different branches located in the city.

WAN (Wide Area Network)

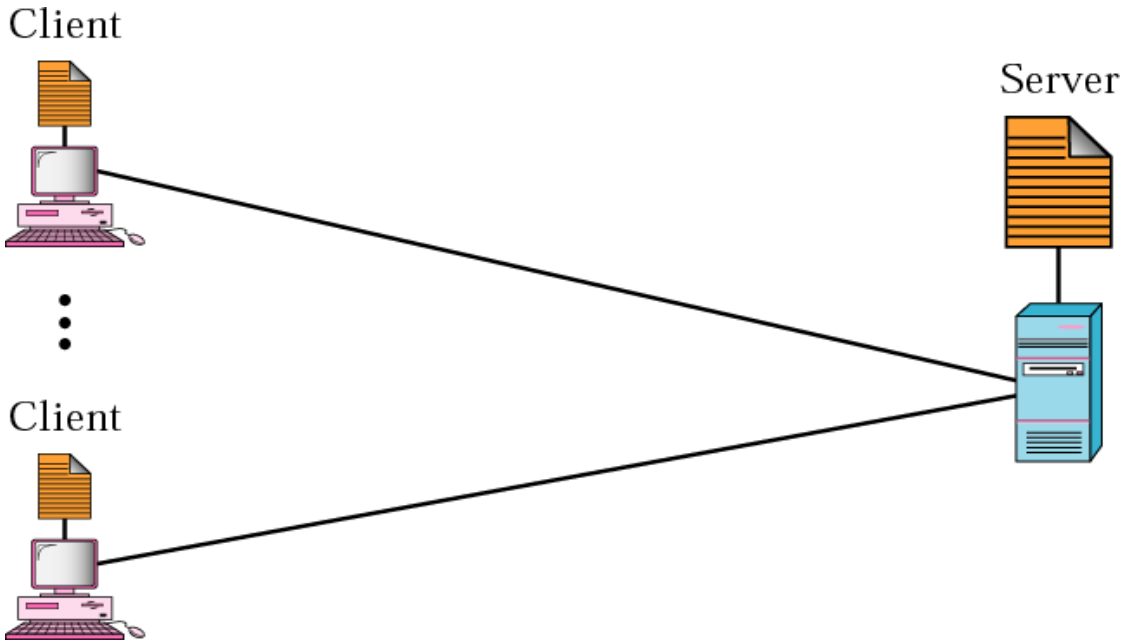
- Are country and worldwide network. Contains multiple LAN's and MAN's.
- Distinguished in terms of geographical range. Uses satellites and microwave relays.
- Data transfer rate depends upon the ISP provider and varies over the location. Best example is the internet.

Network Models: Types

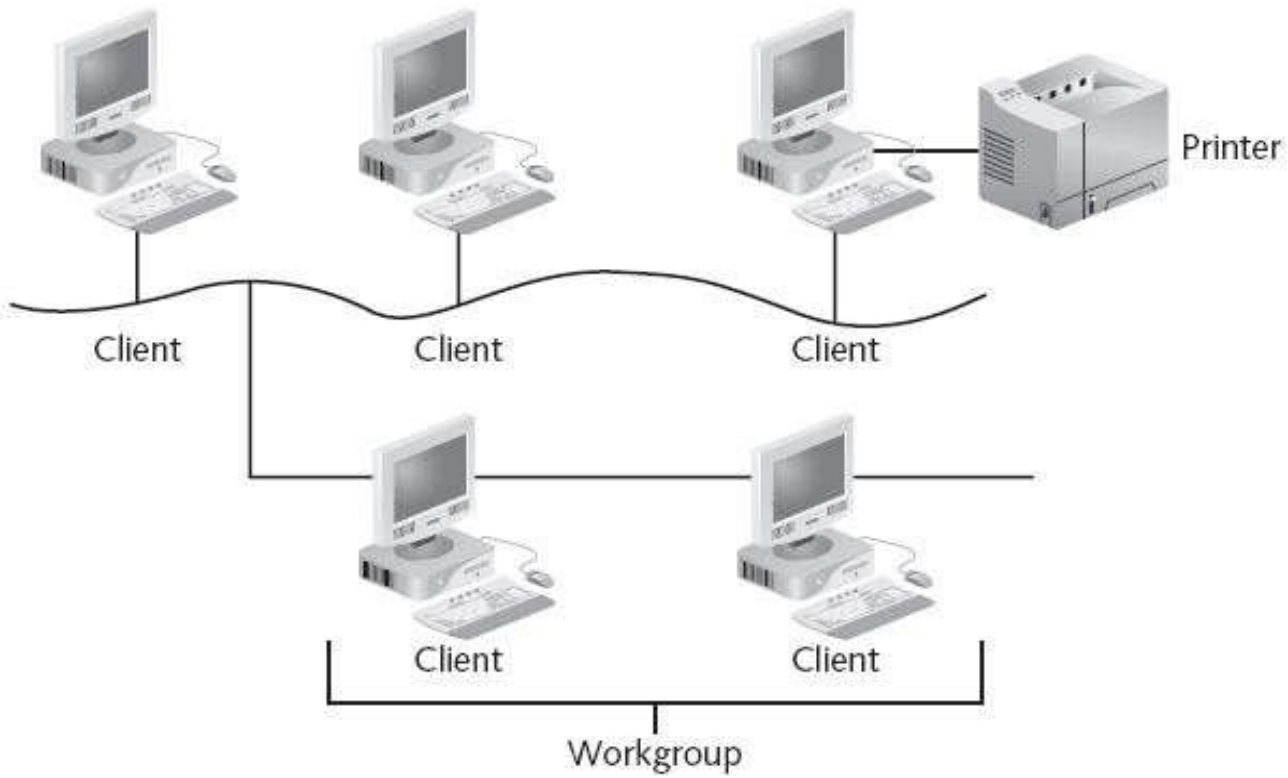
- Client Server Model
  - Client Host Requests for the Service.
  - Example : Browser
  - Server Provides Response.
  - Example : Web Server
  - High End Servers can Process Multiple Requests at a Time.

- Peer to Peer Model
  - No Use of Dedicated Servers.
  - Example : Skype, Bit Torrent

Network Models: Client Server Model



Network Models: Peer to Peer Model



Generation of Wireless Communication

- 1G
- 2G
- 3G
- 4G
- 5G

1G Wireless Communication

- Its speed was about 2.4 kbps
- 1G network use Analog Signal
- The Advanced Mobile Phone System (AMPS) was first launched in the United States on October 13, 1983 in Chicago
- Drawbacks
  - Poor voice quality
  - Poor battery life
  - Large phone size
  - No security
  - Limited capability
  - Poor handoff reliability

2G Wireless Communication

- 2G technology refers to 2nd generation which is based on GSM
- 2G network use digital signal
- Its data speed was up to 64 kbps
- It enables services such as text messages, picture messages and MMS (multimedia service)
- It provides better quality and capacity
- 2G requires strong digital signals to help mobile phone works. If there is no network coverage in any specific area, digital signals would be weak
- These systems are unable to handle complex data such as videos.

2.5G Wireless Communication

- 2.5G is sometimes described as 2G Cellular Technology combined with GPRS (General Packet Radio Service)
- Features includes
  - Phone calls
  - Send/receive email messages, web browsing
  - Speed 64-144kbps
  - Camera phone
  - Take a time of 6 to 9 minutes to download a 3 minutes mp3 song

3G Wireless Communication

- 3G technology refer to 3rd generation which was introduced in the year 2000s
- Data transmission speed increased from 144 Kbps to 2Mbps
- Typically called smart phones and features increased its bandwidth and data transfer rates to accommodate web based applications and audio video files
- Send/receive large email messages
- High speed web/more security
- Video conferencing, 3D gaming, TV streaming, Mobile TV
- Take a time of 11 sec to 1.5 minutes to download a 3 minutes mp3 song

3G Wireless Communication

- Expensive fees for 3G licenses services
- It was a challenge to build the infrastructure for 3G
- High Bandwidth Requirement
- Expensive 3G phones

4G Wireless Communication

- Capable of providing 100Mbps to 1Gbps speed
  - Mobile Multimedia
  - Anytime anywhere
  - Global Mobility Support
  - Integrated Wireless Solution
  - Customized Personal Services
- Also known as Mobile Broadband Everywhere
- Features Include
  - More security
  - High speed
  - High capacity
  - Low cost per bit

5G Wireless Communication

- 5G technology refer to the short name of fifth generation which was started from the late 2010s
- Complete wireless communication with almost no limitation
- Large phone memory, dialing speed, clarity in audio/video
- Support interactive multimedia, voice streaming video, internet and others
- Advantages of 5G is completely endless
  - Latency of 5G network is extremely small. Since the response time is less, remote surgeries can be mad possible

Chapter 2
Reference Model

Contents

- Protocol and Standards
- Interfaces and services
- OSI layers
- TCP/IP layers
- Comparison between TCP/IP
- Networking Hardware

protocols and *standards*.

Protocol is synonymous with rule.
Standards are agreed-upon rules.

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)

Standards Organizations

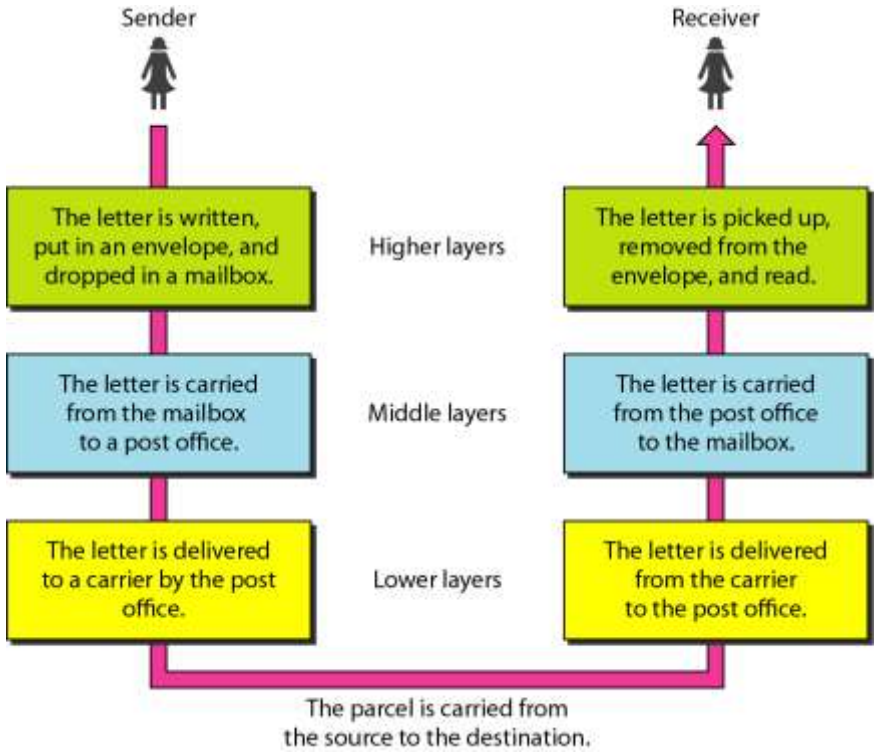
- International Organization for Standardization (ISO)
- International Telecommunication Union - Telecommunication Standards (ITU-T)
- Institute of Electrical and Electronics Engineers (IEEE)
- American National Standards Institute (ANSI)
  - Electronic Industries Association (EIA)
  - Telecommunication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

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)

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.

Layered Architecture

Layers

Layer 7. Application

Layer 6. Presentation

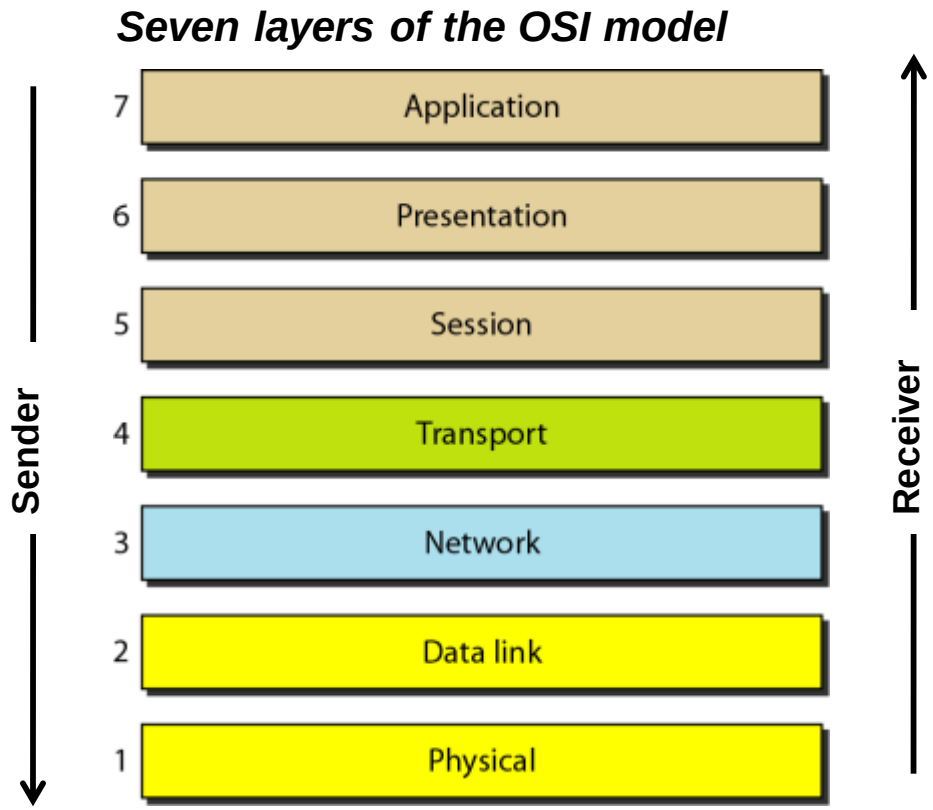
Layer 5. Session

Layer 4. Transport

Layer 3. Network

Layer 2. Data Link

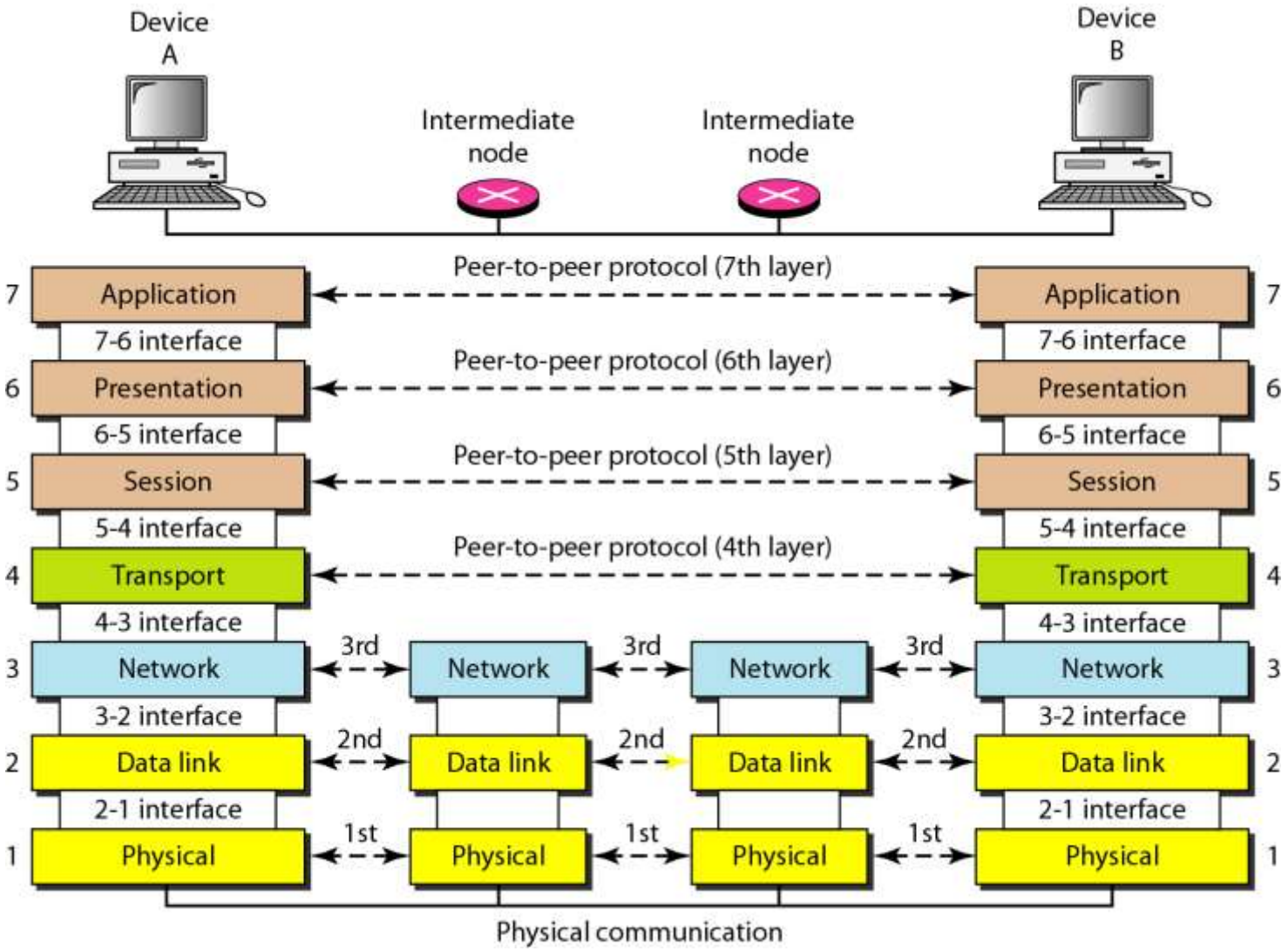
Layer 1. Physical



Why layering is used in Network?

- To handle the whole network task in a single module, it is very difficult and complicated
- A complex system is broken down into smaller, more understandable parts and each smaller task can be handled by an specialist team
- Provides ease for standardization and standard interfaces between network functions
- Provides a modular structure which permits flexibility for upgradation and reconfiguration.

The interaction between layers in the OSI model

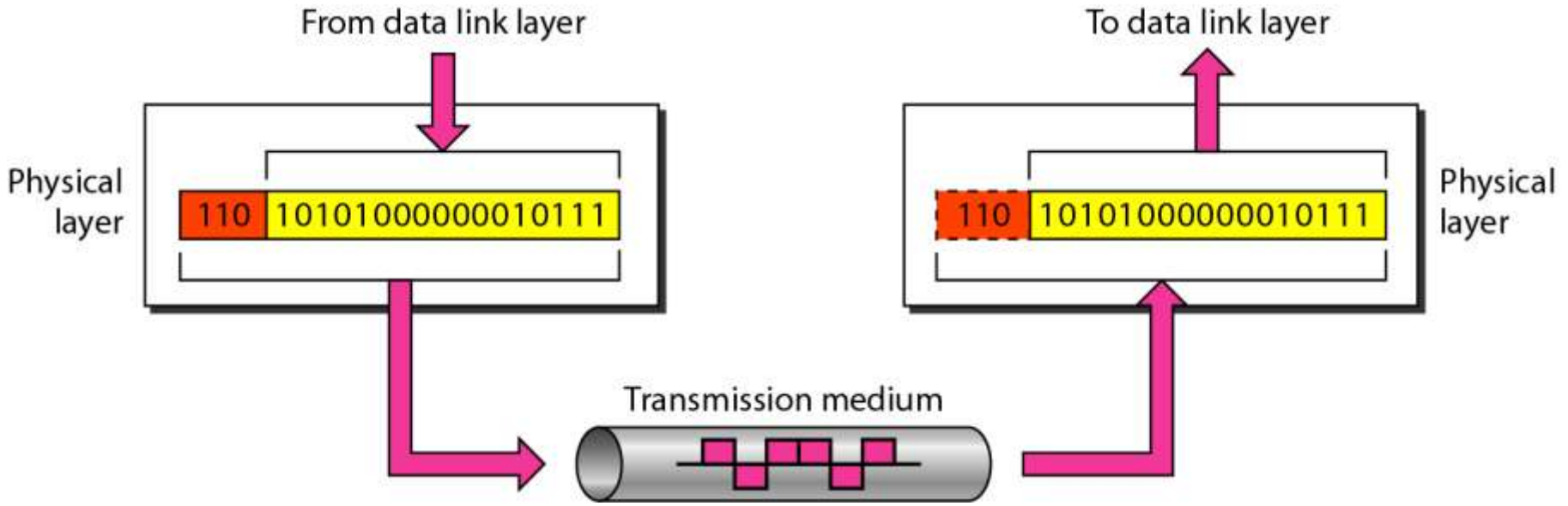


Physical Layer

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

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

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

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.

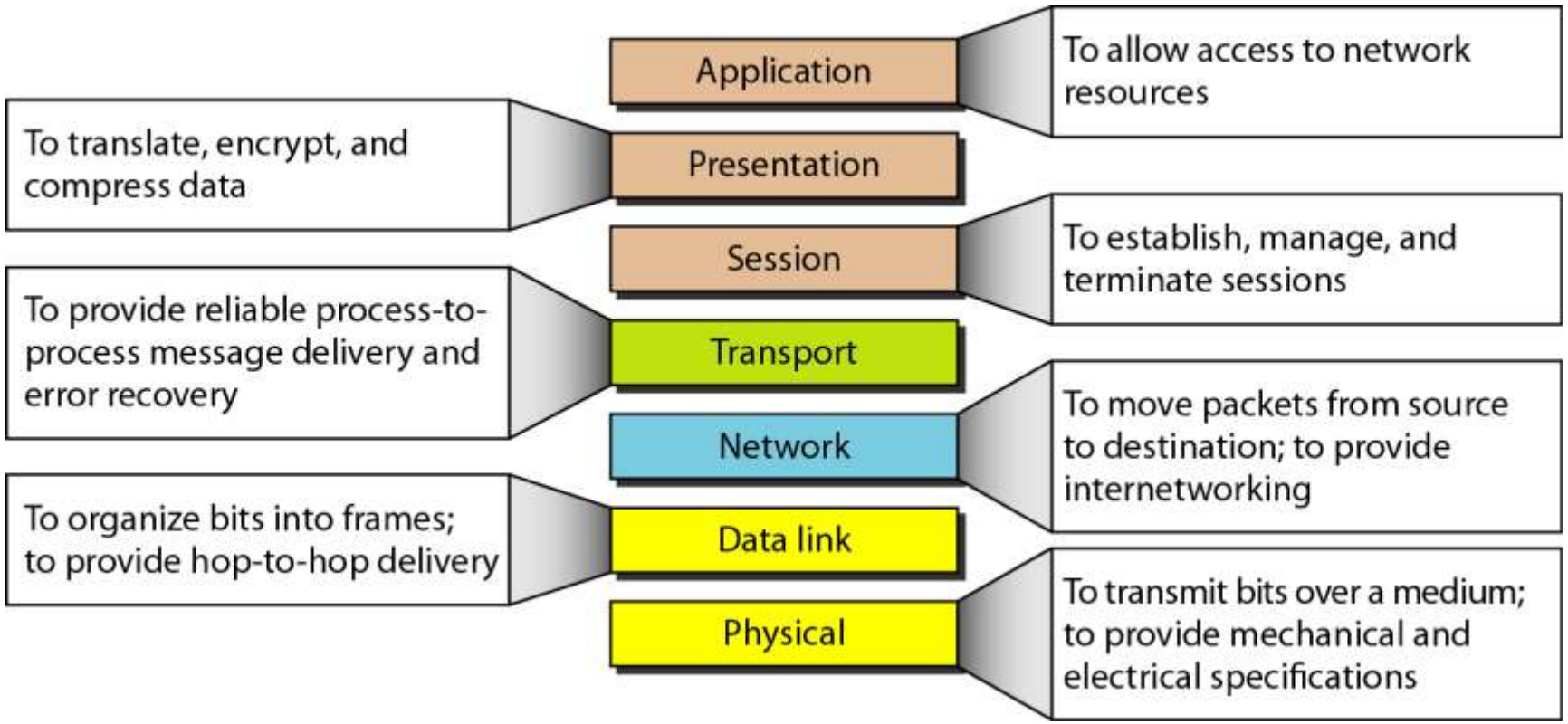
- **Concerned with the syntax and semantics of the information exchanged between two system**
- **Functions**
  - **Translation** (EBCDIC-coded text file → ASCII-coded file)
  - **Encryption and Decryption**
  - **Compression**

Application Layer

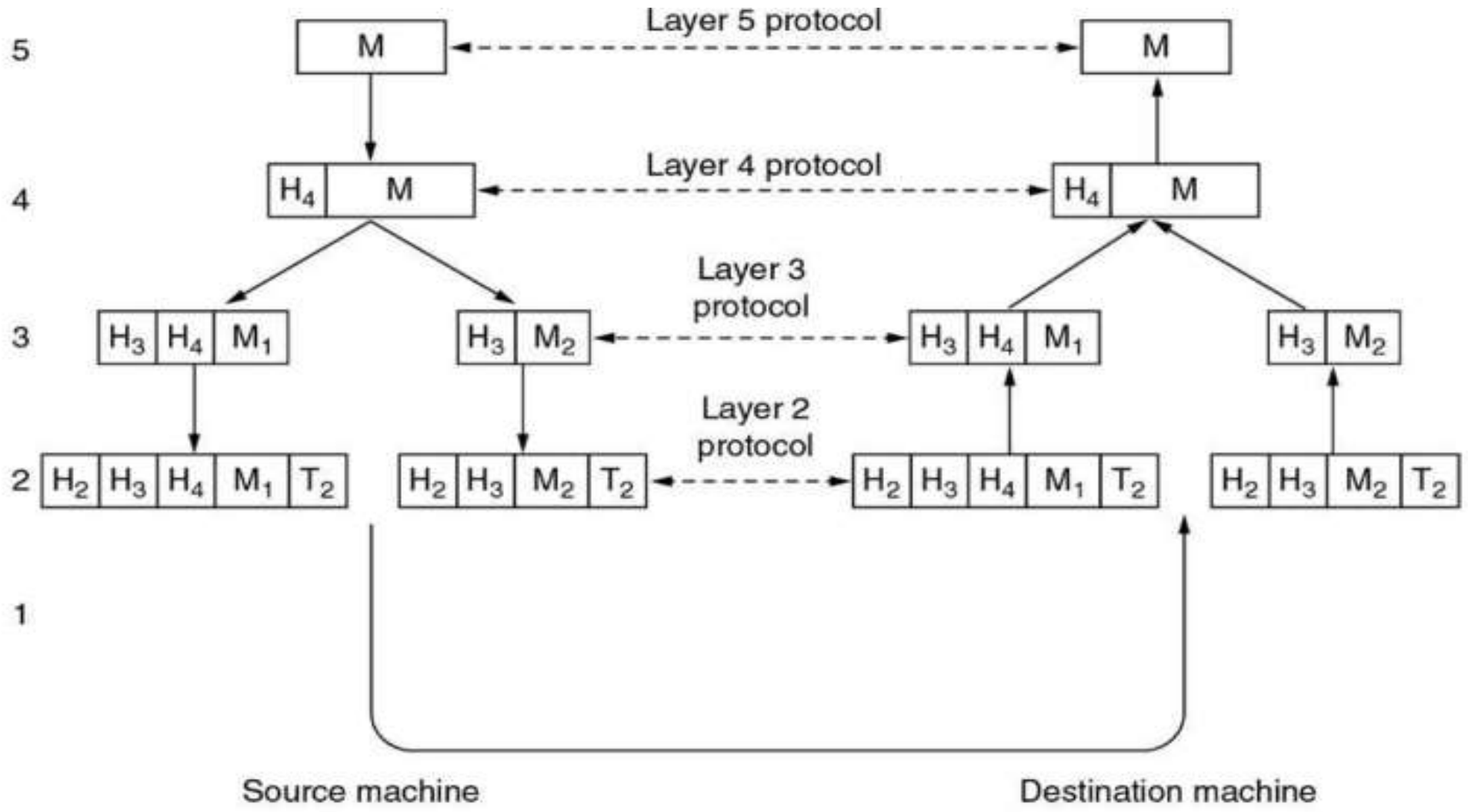
The application layer is responsible for providing services to the user.

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

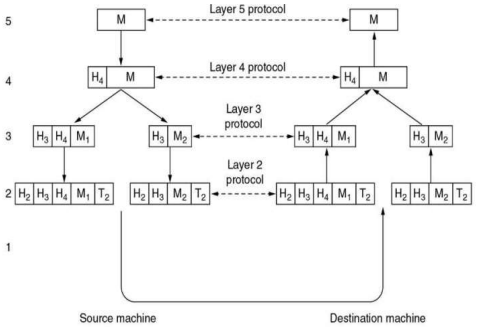
Summary of layers



Virtual Communication between layers

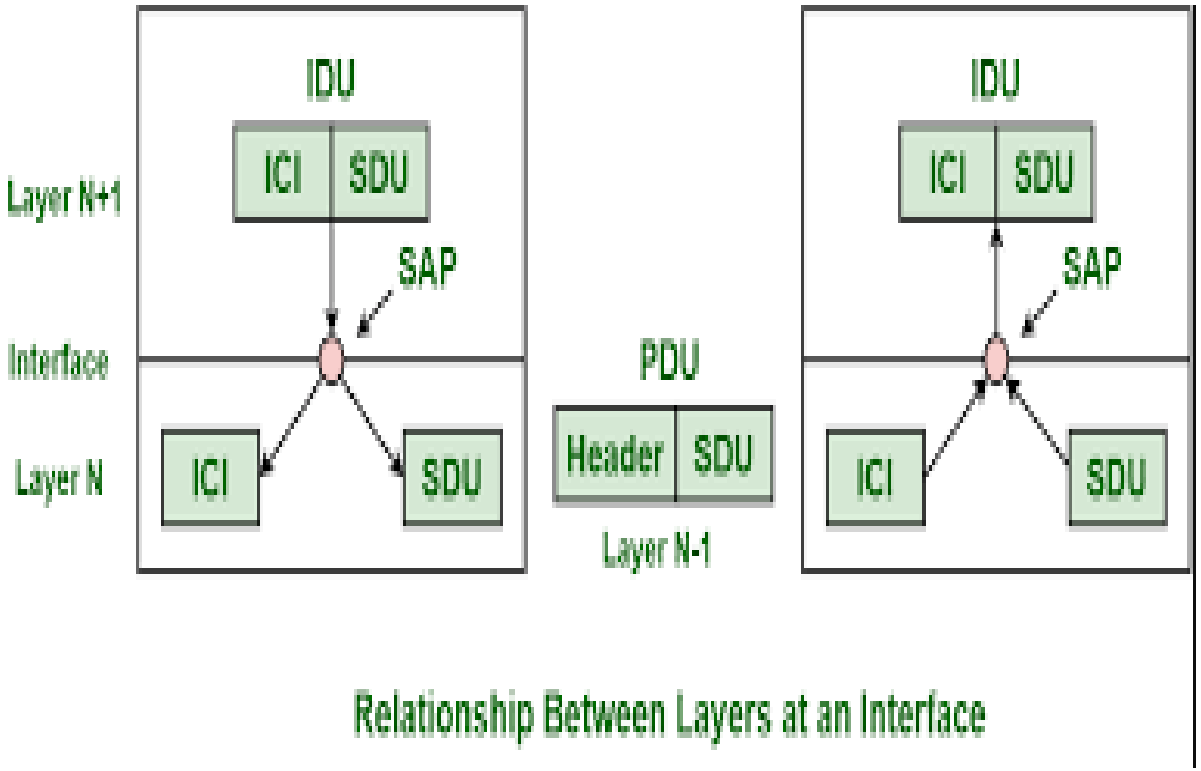


Virtual Communication between layers



- A message M is produced by an application process running in layer 5 and is given to the layer 4 for transmission
- Layer 4 puts the header h4, in front of the message to identify the message and passes the result to layer 3
- Layer 3 breaks up the incoming messages into smaller units called packets and puts a layer 3 header to each packet. Here message M is split into two parts i.e. M1 and M2
- Layer 3 decides which of the outgoing lines to use and passes the packets to layer 2
- Layer 2 not only adds a header to each piece, but also a trailer and gives the resulting unit to layer 1 for physical transmission
- At the receiving machine, the message movies upward from layer to layer with headers being stripped off as it progresses.

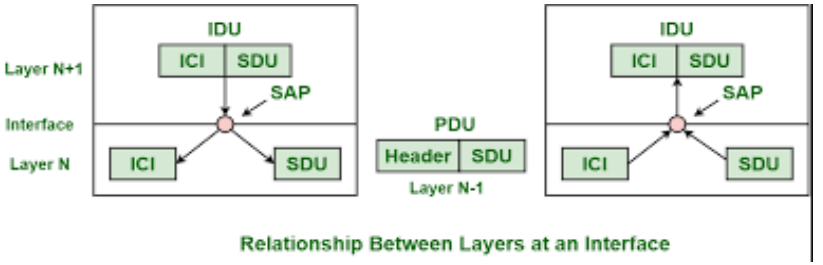
Interface and services



Relationship Between Layers at an Interface

- IDU – interface data unit
- ICI – interface control information
- SAP – service access point
- SDU – service data unit
- PDU – protocol data unit

Interface and services



Relationship Between Layers at an Interface

- The function of each layer is to provide service to the layer above it. In this case, layer n is the service provider and the layer n+1 is the service user.
- Services are available at the SAP
- In order for the two layers to exchange information, set of rules about the interface has to be agreed.
- In the figure above, the layer n+1 entity passes an IDU to the layer n through the SAP
- IDU consists of ICI and SDU
- The SDU is the information passed across the network to the peer entity and then upto the layer n+1
- To transfer the SDU, the layer n entity may have to fragment it into several pieces, each of which is given a header and sent as separate PDU such as the packet

Connection oriented service

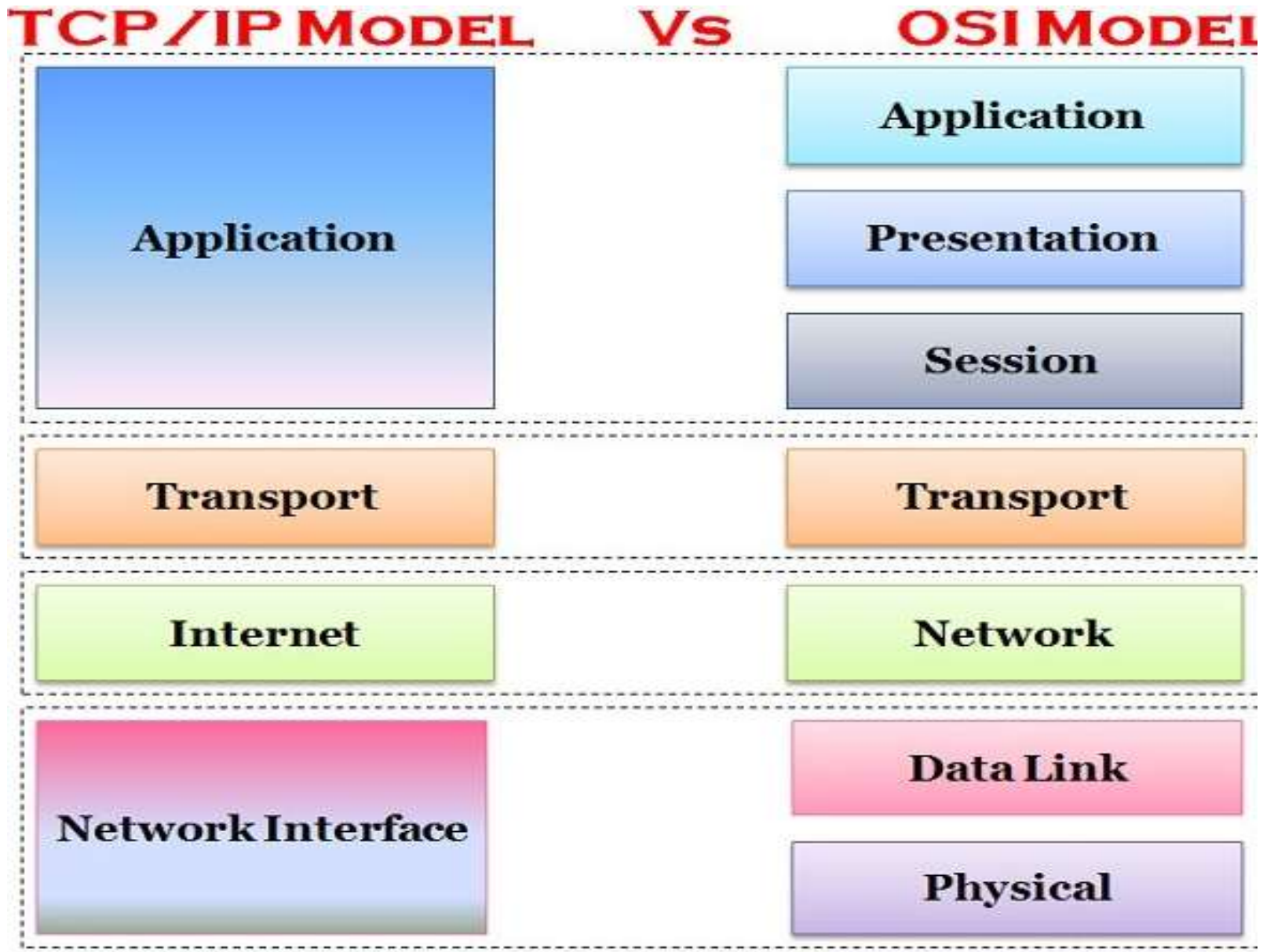
- Connection oriented system is analogous/modeled after the telephone system
- To use a connection oriented network service, the service first establishes the connection, uses the connection, and then releases the connection
- Eg. TCP (transmission control protocol) is based on connection oriented system.

Connectionless service

- Connectionless service is modeled after the postal system
- Here each message (letter) carries the full destination address, and each one is routed through the system independent of all the others
- Normally when two messages are sent to the same destination, the first one sent will be the first one to arrive. However it’s possible that the first one sent can be delayed so that the 2nd one arrives first. But with a connection oriented service this is not possible
- Eg. Remote loging, UDP (User datagram protocol) is based on connection oriented system.

TCP/IP Layer

- The TCP/IP model was developed by The Advanced Research Projects Agency Network (ARPANET)
- The TCP/IP suite defines a set of rules to enable computers to communicate over a network
- Four layers are termed as
  - Application layer - HTTP
  - Transport Layer- TCP, UDP
  - Internet layer – IP (IPV4, IPV6)
  - Link layer – Ethernet, ISDN device drivers etc


TCP/IP Model
Vs
OSI Model
Application
Application
Presentation
Session
Transport
Transport
Internet
Network
Network Interface
Data Link
Physical

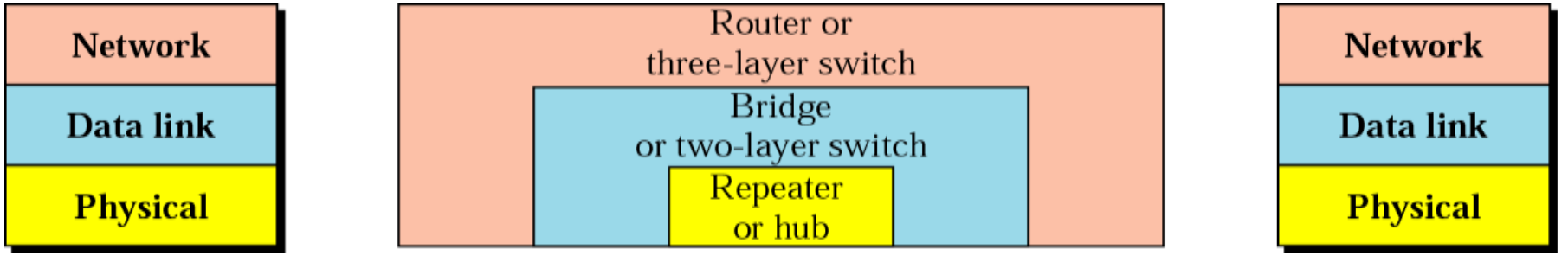
Networking Hardware

- Hub
  - Center of a star network
  - All nodes receive transmitted packets
  - Slow and insecure
- Repeater
  - Amplifies and regenerates the signal
  - 10base2 – 10mbps signal can move to maximum length approaching 185 m
- Bridge
  - Connects two or more LANs together
  - Packets sent to remote LAN cross
    - Other packets do not cross
  - Segments the network on MAC addresses

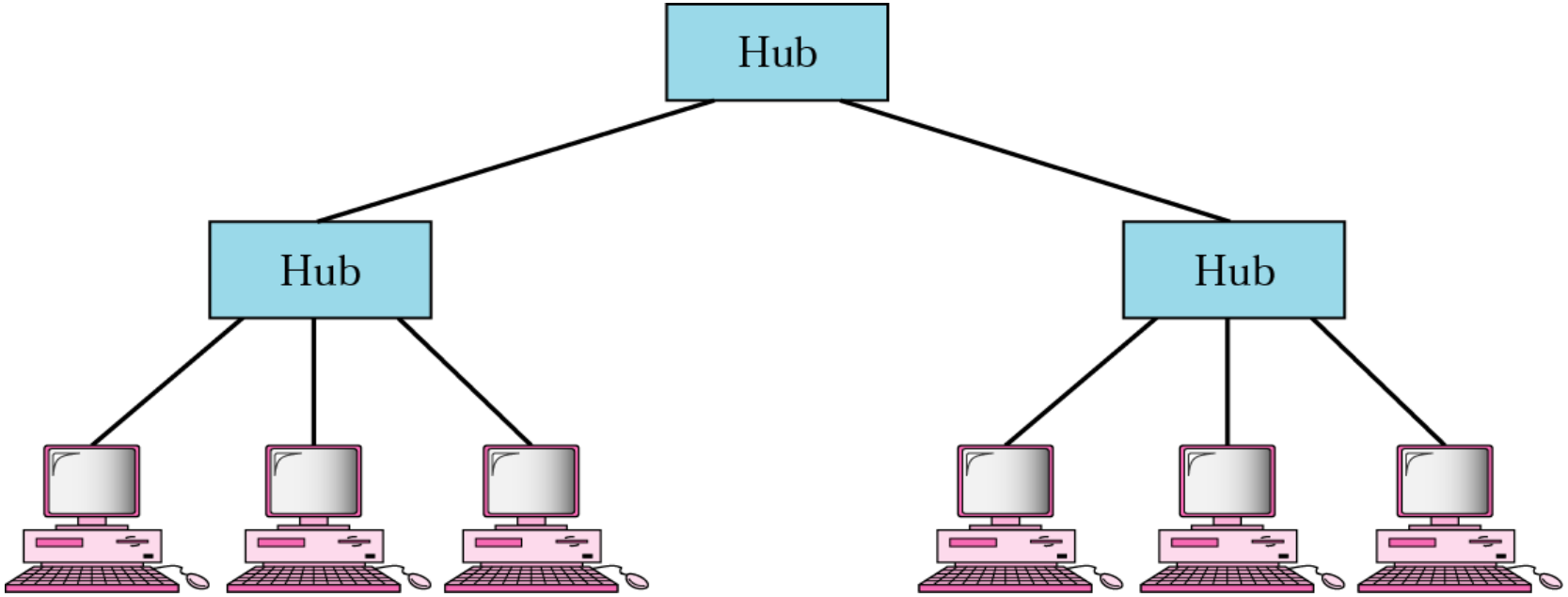
Networking Hardware

- Switch
  - Replacement for hubs
  - Only intended node receives transmission
  - Fast and secure
- Router
  - Network is segmented by IP address
  - Connect internal networks to the Internet
  - Need configured before installation
- Gateway
  - Connects two dissimilar networks
  - Most gateways contained in other devices

Networking Hardware : Hub and Repeaters

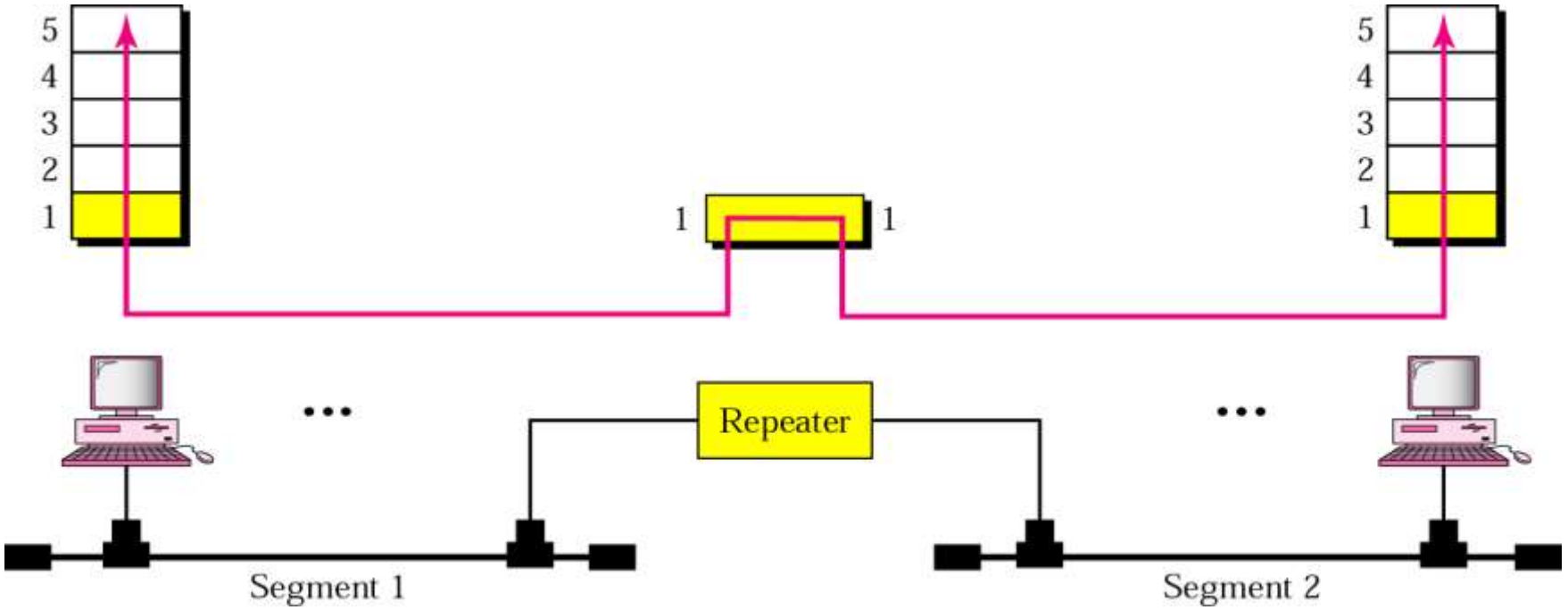


Physical Layer Devices : Hubs



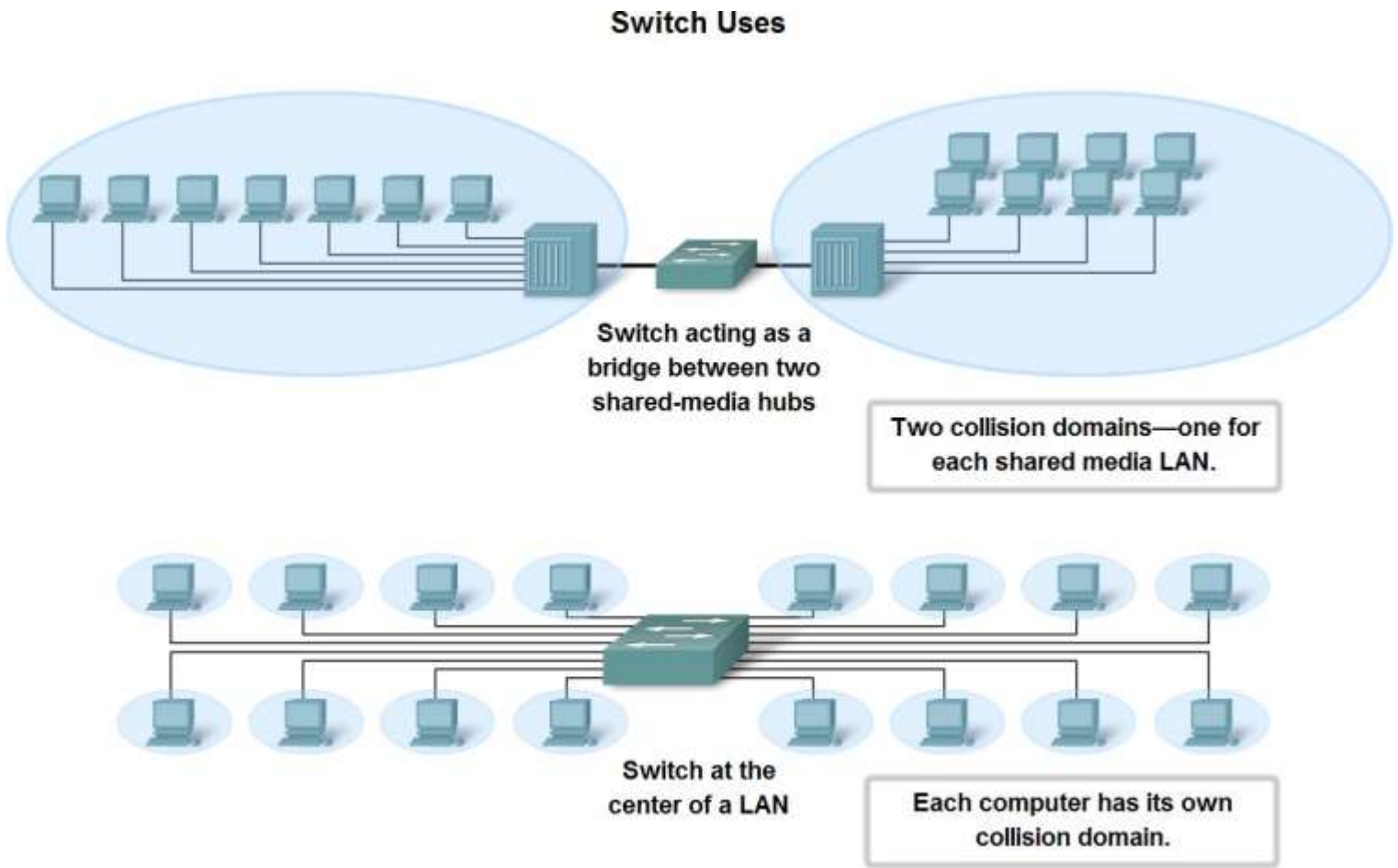
- Physical Topology => Star
- Logical Topology => Bus
- Extends Collision Domain.

Physical Layer Devices : Repeaters



- Repeater Forwards Each Frame.
- It has No Filtering Capability
- Repeater is a Regenerator NOT an Amplifier.

Link Layer Devices : Switch



Tutorial
Computer Network
Deadline of submission:

1. Define computer network. What are the merits and demerits of using computer network? Explain.
2. What do you mean by network model? Explain LAN, MAN and WAN in details.
3. Compare and contrast the various topological models.
4. What do you mean by active network? Explain how can we mitigate social issues due to computer network.
5. How effective networking provides a better workplace within an organization. Justify.
6. Why layering is necessary in computer network? Explain.
7. Briefly explain the seven layers of OSI protocol stack.
8. Compare and contrast between TCP/IP and OSI reference model.
9. Define interface and services. Explain how virtual communication exists between layers in a network.
10. Explain the working principle of different types of network devices: hub, switch, bridge and router.
11. Explain why TCP/IP reference model is used most instead of OSI reference model
12. Write short notes on
    a. Client server Model
    b. Peer to Peer Model
    c. 4G and 5G Network
    d. Connection oriented service
    e. Connectionless service
    f. Protocols and Standards
    g. ISPs