Chapter-6

Data Communication & Networks

Data Communications

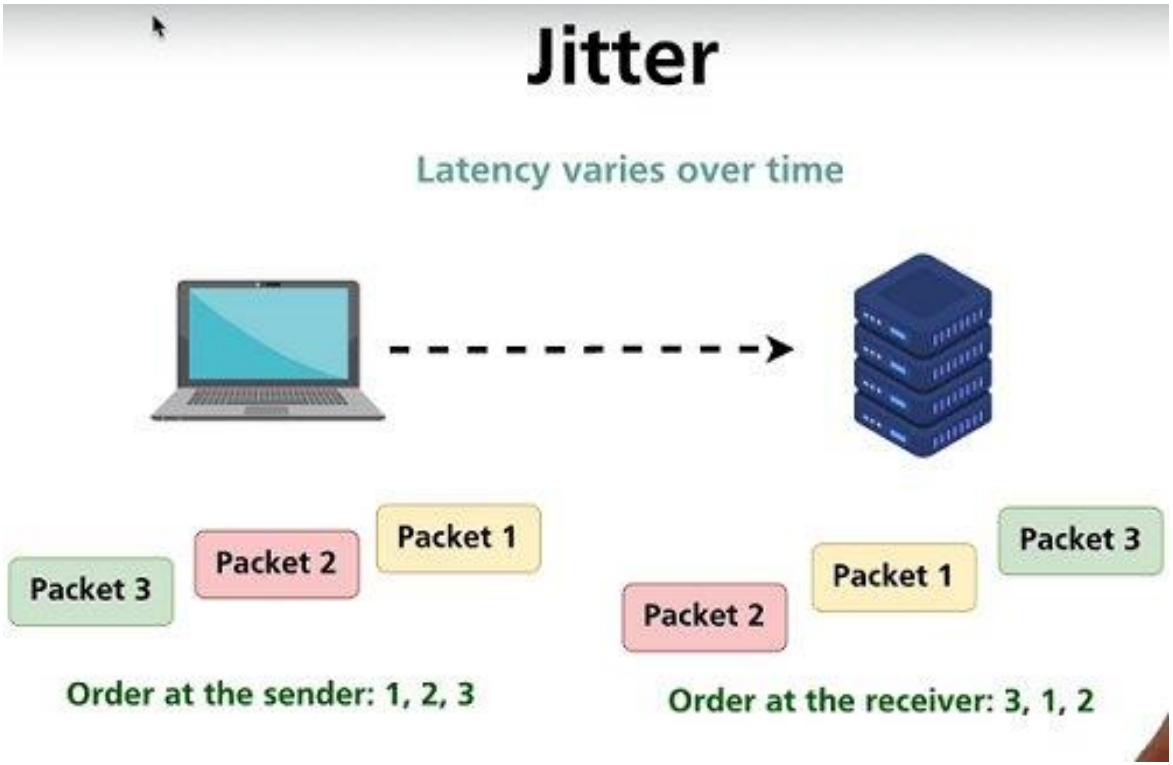
- The term telecommunication means communication at a distance.
- The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.

Fundamental Characteristics

- The effectiveness of a data communication system depend on four fundamental characteristics:
  - Delivery
    System must deliver data to correct destination. Data must be received by only intended device or user.
  - Accuracy
    The system must deliver data accurately.
  - Timelines
    The system must deliver data in a timely manner.
  - Jitter
    Variation in the packet arrival time.

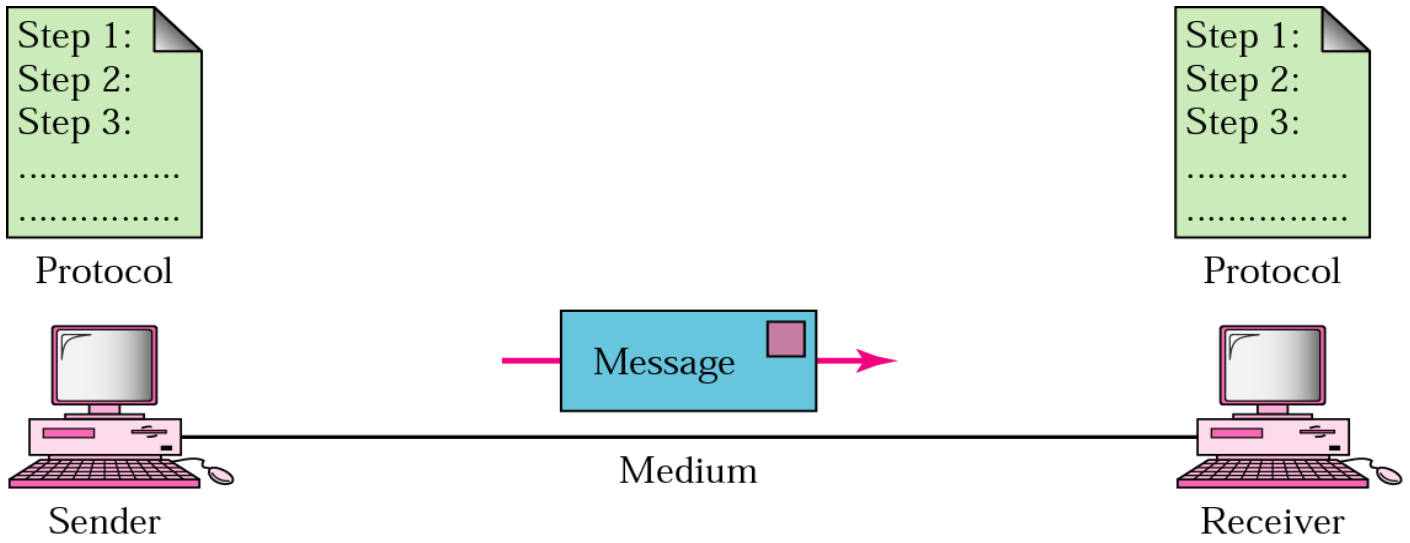
Fundamental Characteristics (cont.)

- Jitter



Basic Communication System

Components of Data Communication



1. **Message**
2. **Sender**
3. **Receiver**
4. **Medium**
5. **Protocol**

Components of Data Communication (cont.)

1. Message: A message is a piece of information that is to be transmitted from one person to another. It could be a text file, an audio file, a video file, etc.
2. Sender: It is simply a device that sends data messages. It can be a computer, mobile, telephone, laptop, video camera, or workstation, etc.
3. Receiver: It is a device that receives messages. It can be a computer, telephone mobile, workstation, etc.
4. Transmission Medium / Communication Channels: It is the path through which the message travels between source and destination. It is also called medium or link which is either wired or wireless.
5. Set of rules (Protocol): It is a set of rules that need to be followed by the communicating parties in order to have successful and reliable data communication.

Transmission Protocol

- TCP(Transmission Control Protocol)
  - It is responsible for dividing messages into packets on the source computer and reassembling the received packet at the destination or recipient computer.
- IP(Internet Protocol)
  - IP is responsible for handling the address of the destination computer so that each packet is sent to its proper destination.

Data Representation

- Text, numbers, images, audio, and video.
  - Text
    - ✓ ASCII: 7-bit pattern (128 different symbols)
    - ✓ Extended ASCII: 8-bit pattern (with an extra 0 at left from 00000000 to 0111111
    - ✓ Unicode: 32 bits pattern (65,536,216) symbols, which is definitely enough to represent any symbol in the world.
  - Numbers

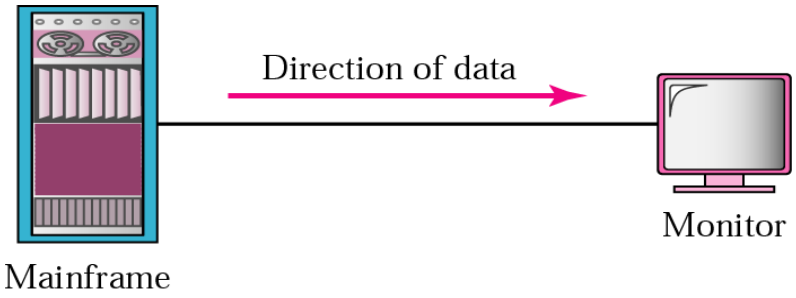
    represented by bit pattern (binary number).
  - Images

    represented by matrix of pixels (picture element), small dot. The size of pixel represent the resolution.
  - Audio

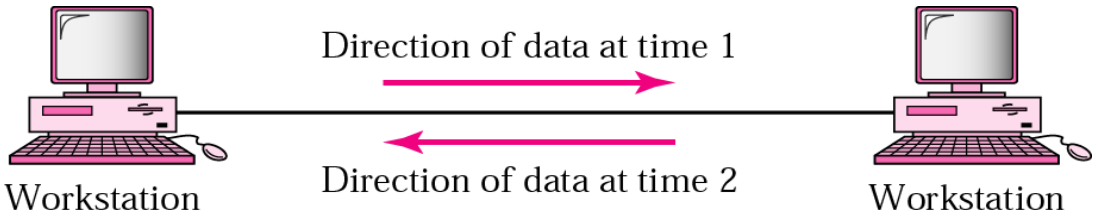
    represent sound by continuous (analog) signal.
  - Video

    can be analog or digital signal.

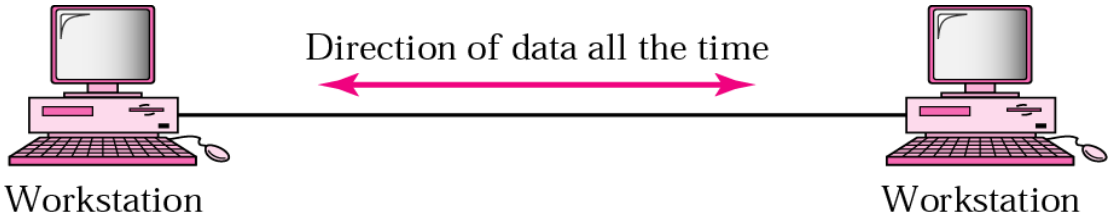
Types of Data Communication



Simplex



Half Duplex



Full Duplex

Types of Data Communication

- Simplex Communication: It is one-way communication or we can say that unidirectional communication in which one device only receives and another device only sends data and devices uses their entire capacity in transmission. For example, IoT, entering data using a keyboard, listing music using a speaker, etc.
- Half Duplex communication: It is a two-way communication or we can say that it is a bidirectional communication in which both the devices can send and receive data but not at the same time. When one device is sending data then another device is only receiving and vice-versa. For example, walkie-talkie.
- Full-duplex communication: It is a two-way communication or we can say that it is a bidirectional communication in which both the devices can send and receive data at the same time. For example, mobile phones, landlines, etc.

Transmission Medium Concepts

- We can group the communication media into two categories:
  - Guided media transmission [Wired Technology]

    In this transmission medium, the physical link is created using wires or cables between two or more computers or devices, and then the data is transmitted using these cables in terms of signals.
  - Unguided media transmission [Wireless Technology]

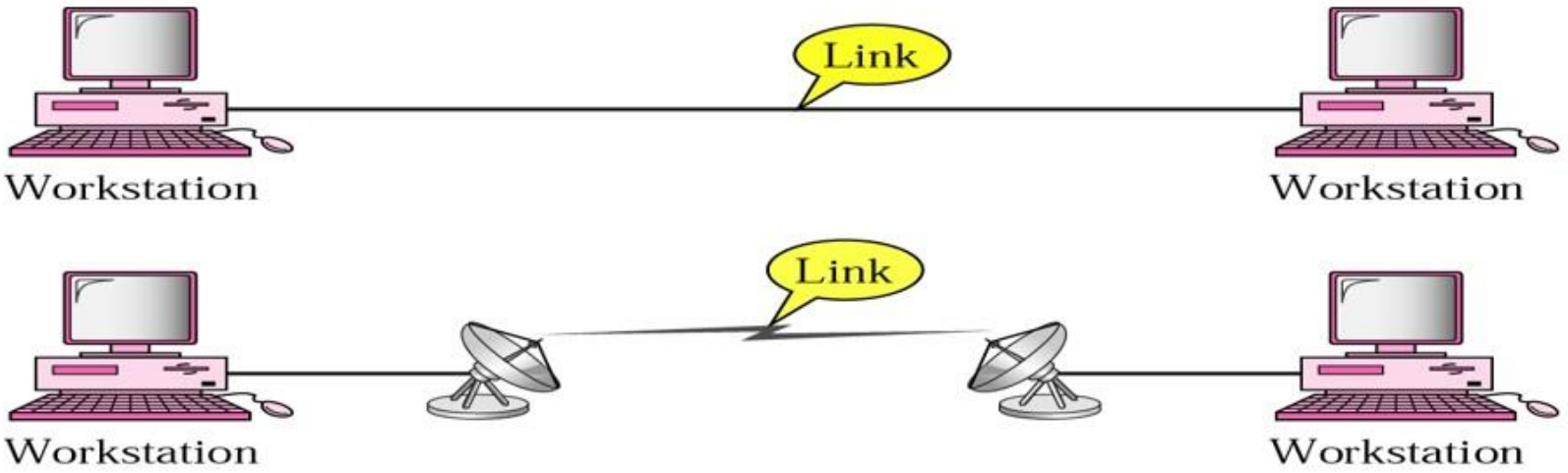
    The unguided transmission media is a transmission mode in which the signals are propagated from one device to another device wirelessly.

Transmission Medium Concepts(cont.)

- Guided media transmission
  - Twisted pair Cable
  - Coaxial Cable
  - Fiber Optic Cable
- Unguided media transmission
  - Microwave
  - Radio wave
  - Infrared

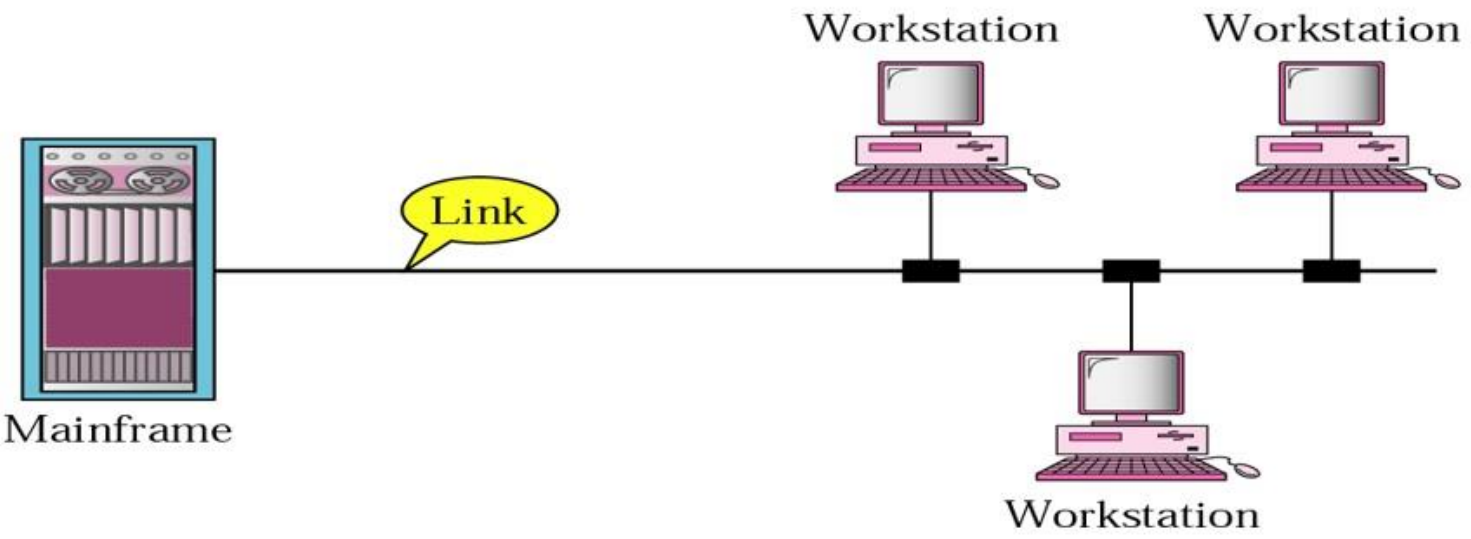
Types of Connections

- **Point to Point - single transmitter and receiver**



Types of Connections (cont.)

- **Multipoint (multidrop) connection:**



Data Transmission Speed

- Bandwidth
  - ✓ Range of frequencies available for data transmission.
  - ✓ It refers to data transmission rate.
  - ✓ Higher the bandwidth, the more data it can transmit.
- Baud
  - ✓ Unit of measurement of data transfer rate.
  - ✓ Measured in bits per second (bps)

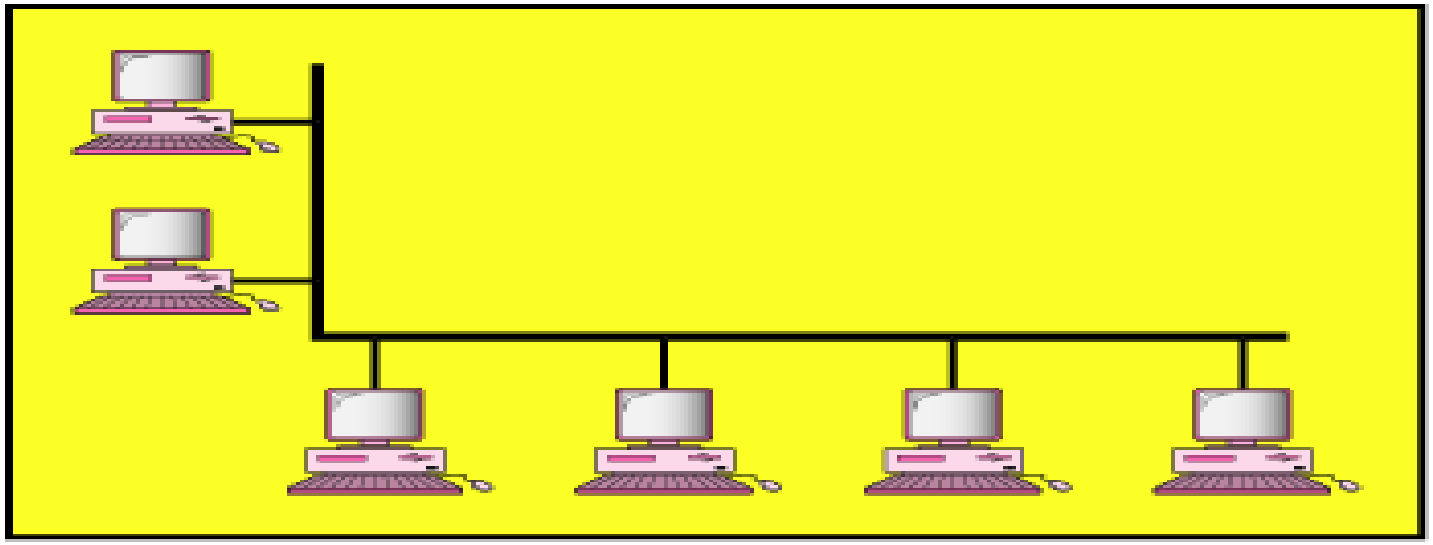
Data Transmission Speed Category

- Narrowband
  - ✓ Sub-voice grade channels in range from 45 to 300 baud.
  - ✓ Mainly used for telegraph lines and low-speed terminals.
- Voiceband
  - ✓ Voice grade channels with speed up to 9600 baud.
  - ✓ Mainly used for ordinary telephone voice communication and slow I/O devices
- Broadband
  - ✓ High speed channels with speed up to 1 million baud or more.
  - ✓ Mainly used for high-speed computer-to-computer communication or for simultaneous transmission of data.

Categories of Network

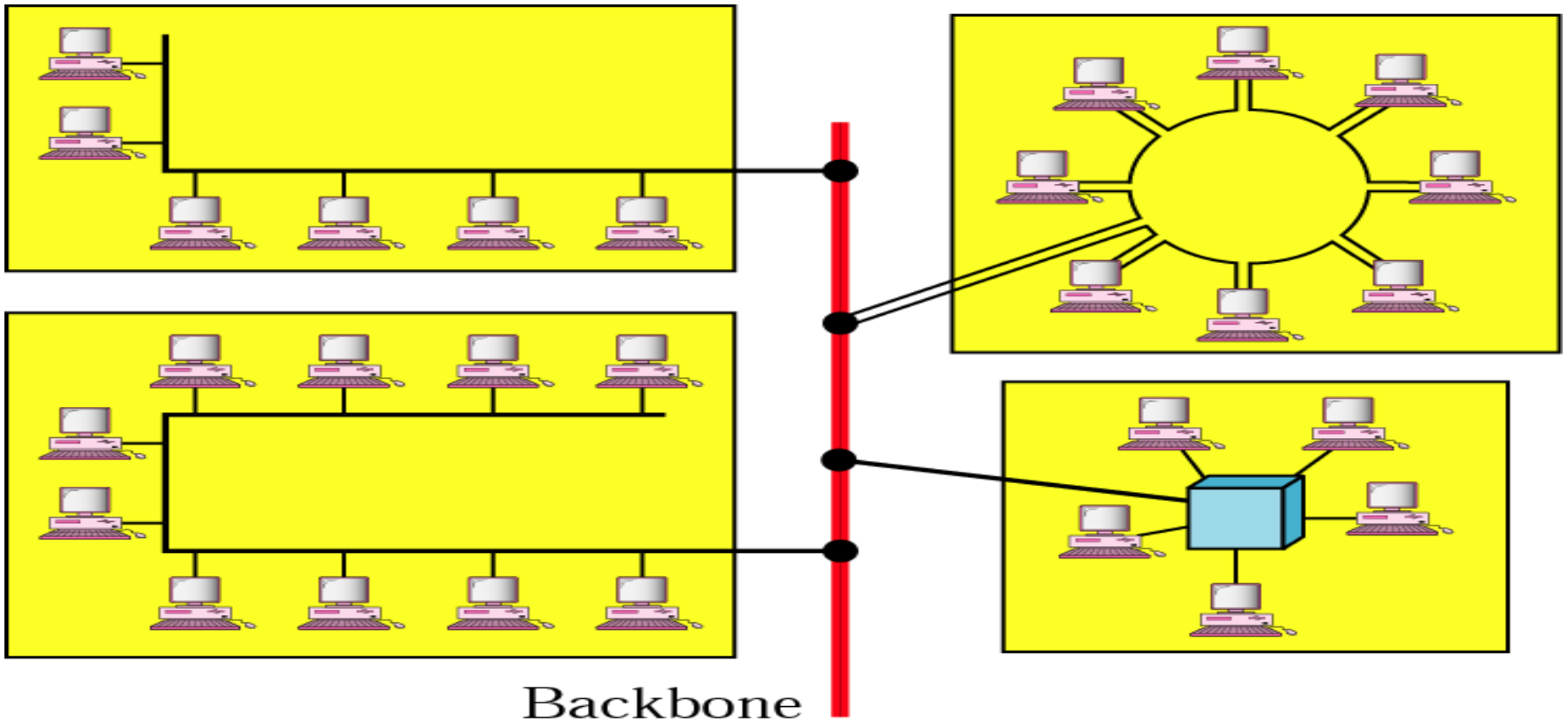
- **Local Area Networks (LANs)**
  - Short distances
  - Designed to provide local interconnectivity
- **Metropolitan Area Networks (MANs)**
  - Provide connectivity over areas such as a city, a campus
- **Wide Area Networks (WANs)**
  - Long distances
  - Provide connectivity over large areas

Single Building LAN



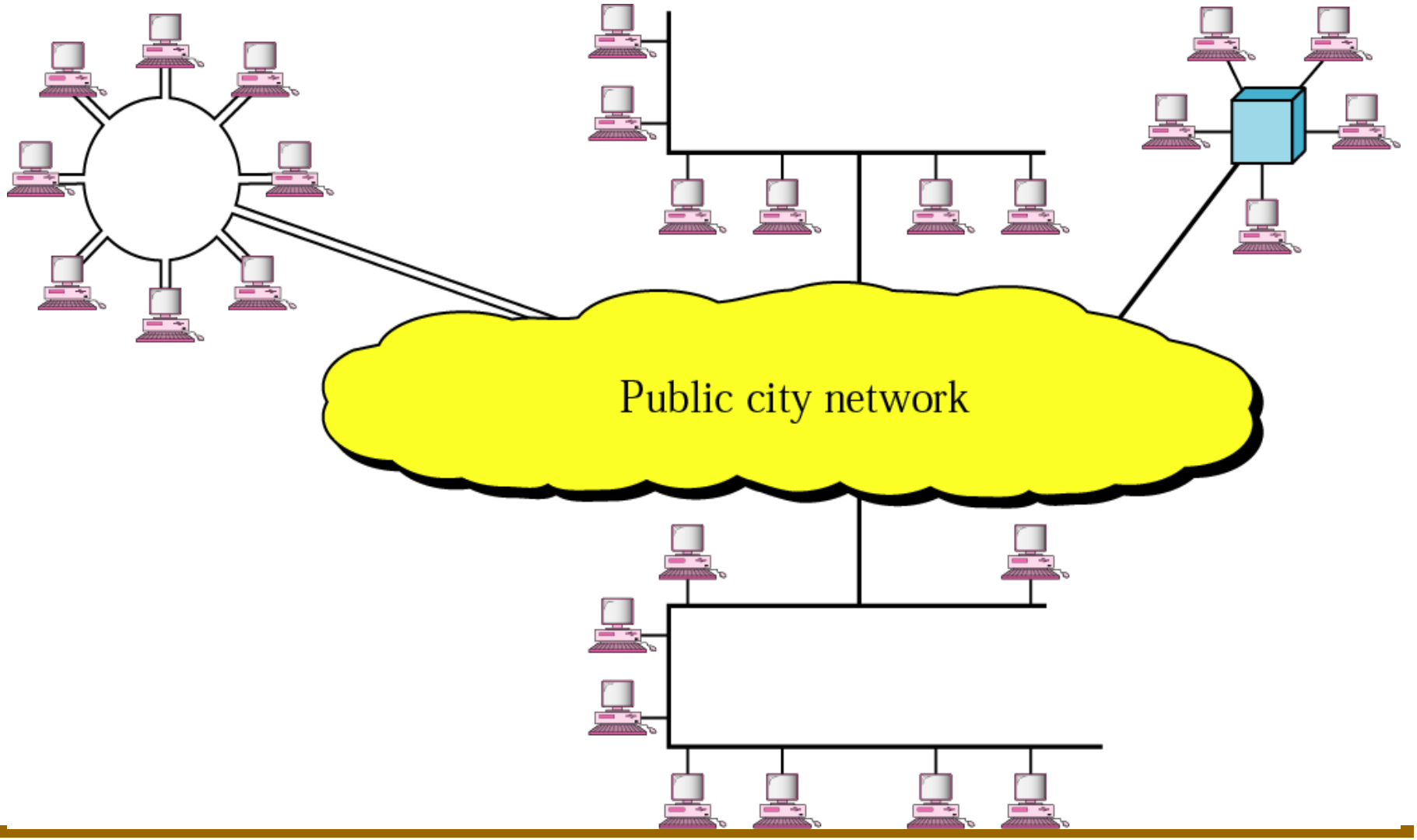
a. Single-building LAN

Multiple Building LAN

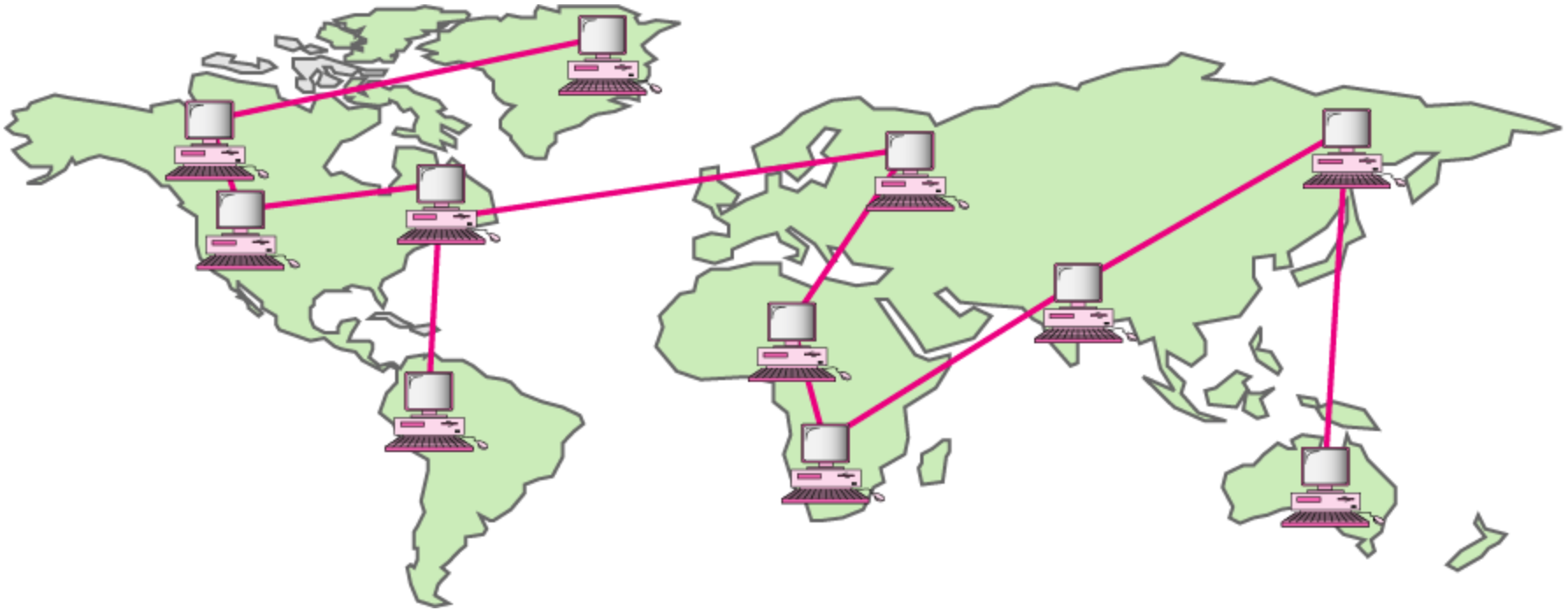


b. Multiple-building LAN

Metropolitan Area Networks (MAN)



Wide Area Networks (WAN)

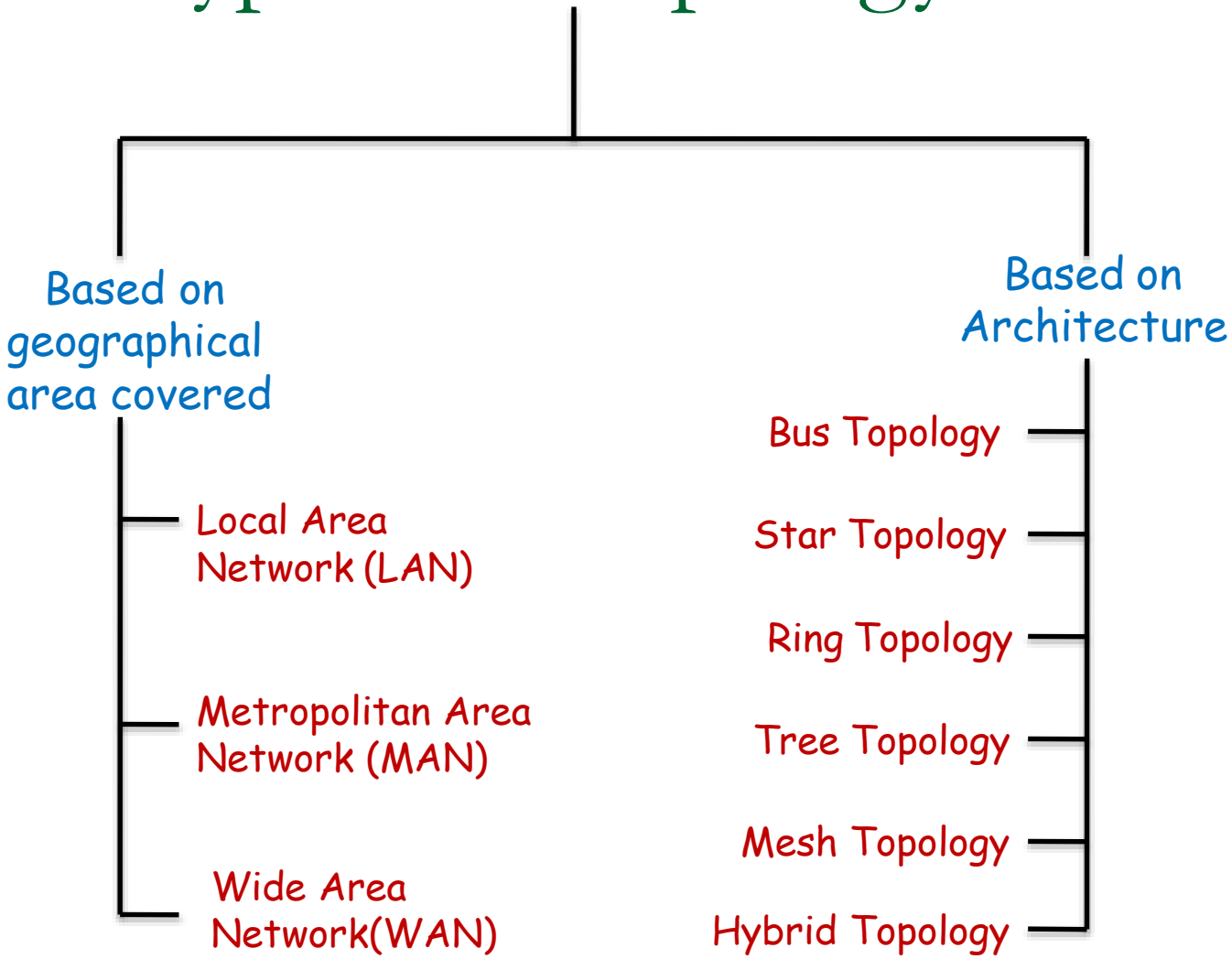


Network Topology

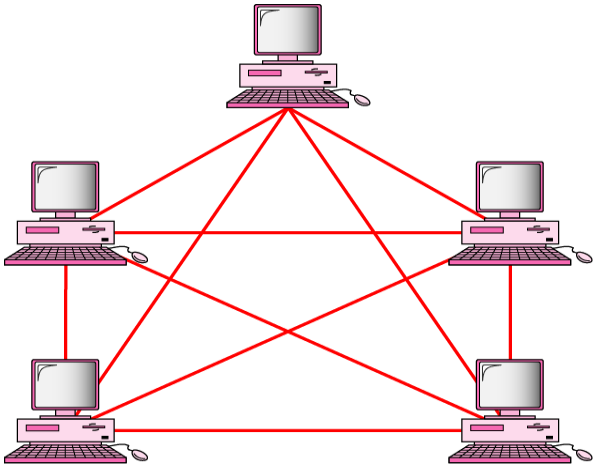
What is Network Topology?

- A computer network is a collection of two or more computers which are connected together to share information and resources.

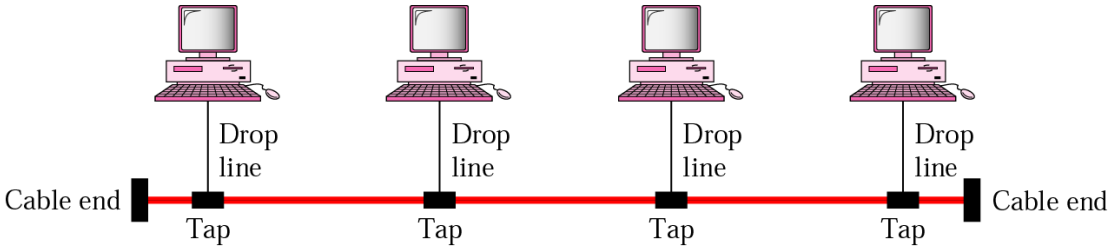
Types Of Topology



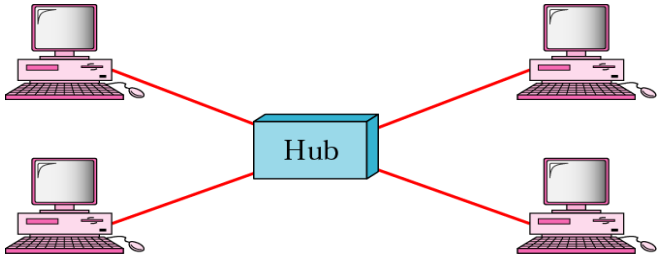
Mostly used network topologies



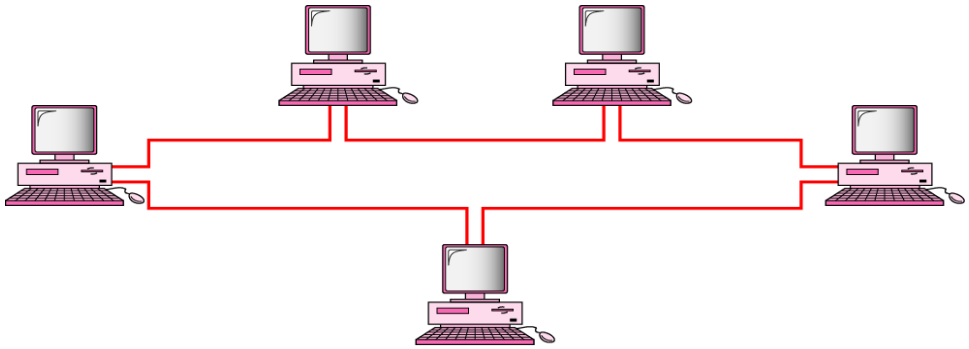
mesh



bus



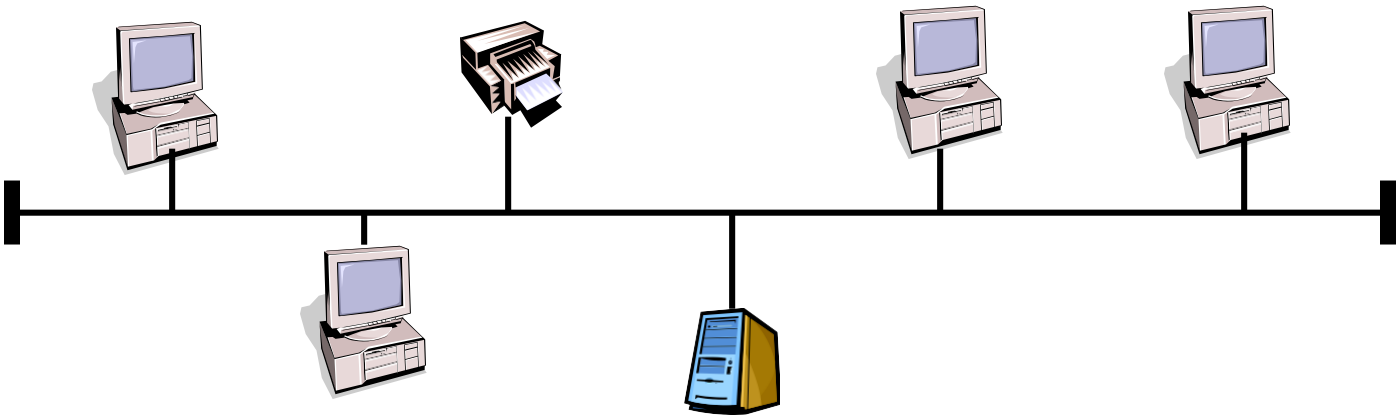
star



ring

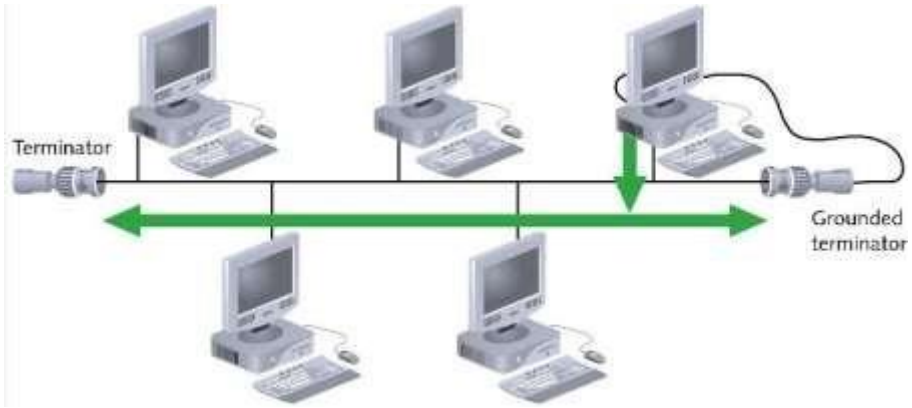
Bus Topology

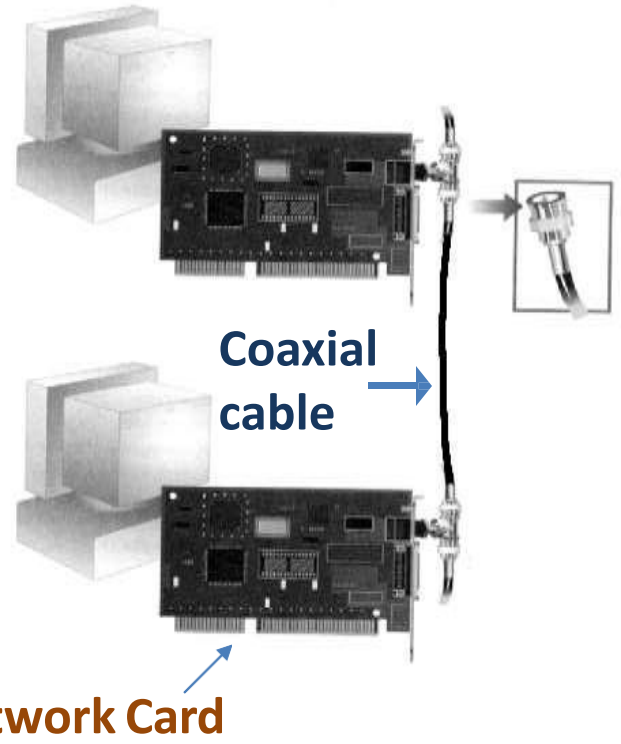
- A **Bus topology** consists of a single cable—called a **bus**— connecting all nodes on a network without intervening connectivity devices.



Advantages of Bus Topology

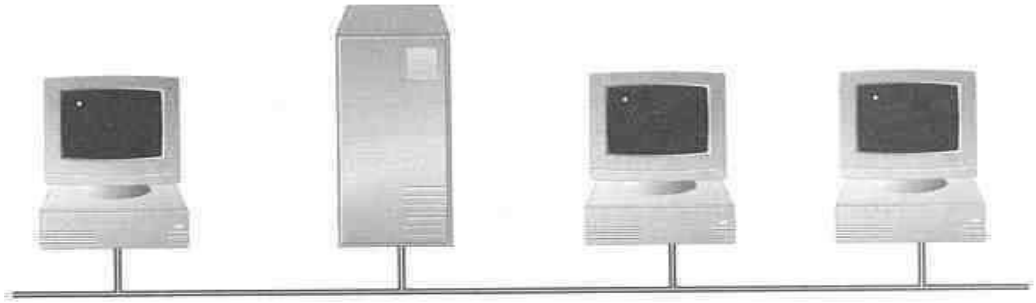
- Works well for small networks.
- Relatively inexpensive to implement.
- Easy to expand joining two cables together.
- Used in small network.





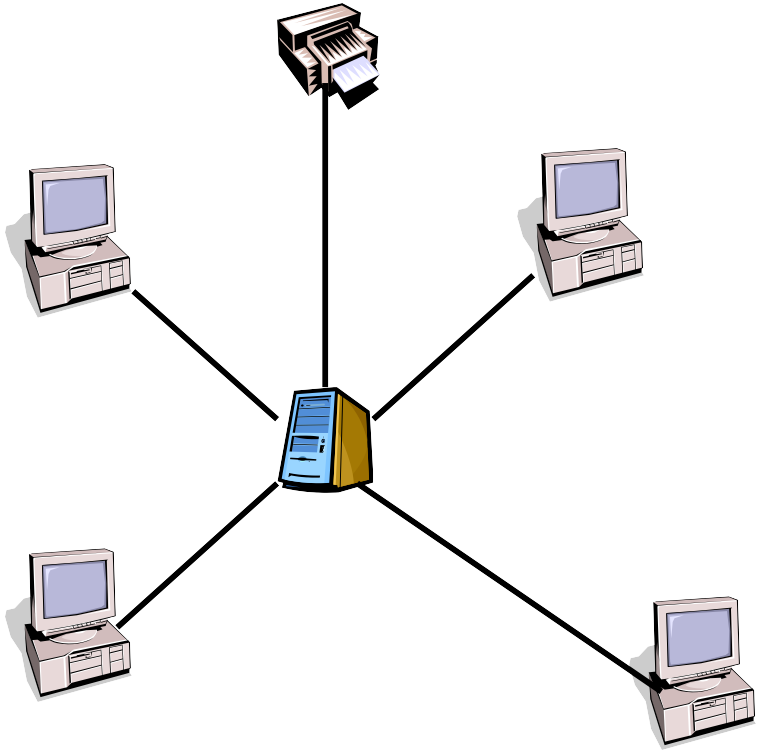
Disadvantages of Bus Topology

- Management costs can be high
- Cables fails then whole network fails.
- Cables has a limited length.



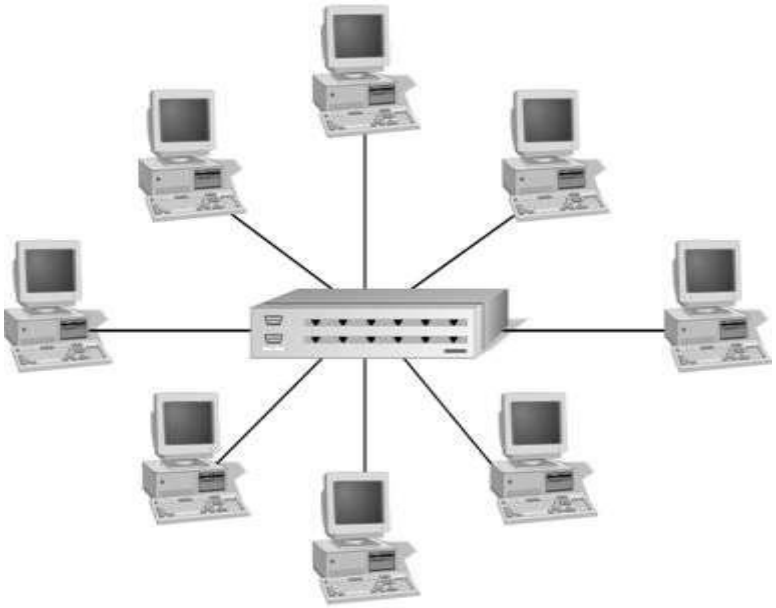
Star Topology

- A star network is designed with each node (file server, workstation, peripheral) connected directly to a central network hub or server.



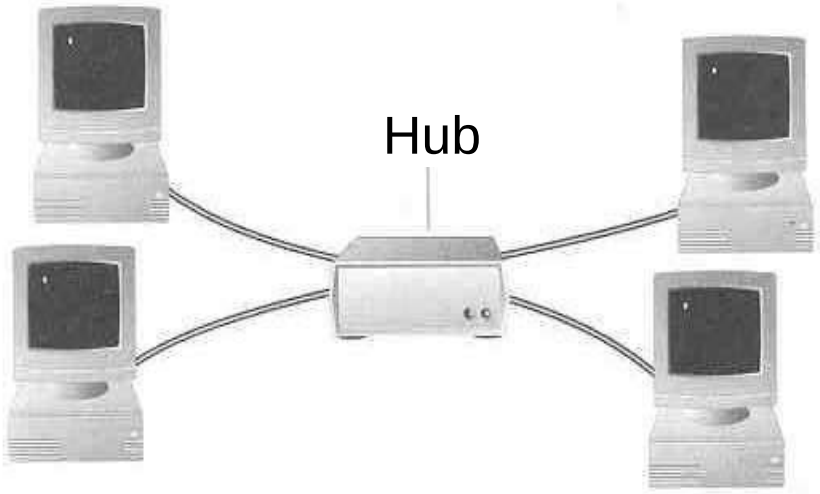
Advantages of Star Topology

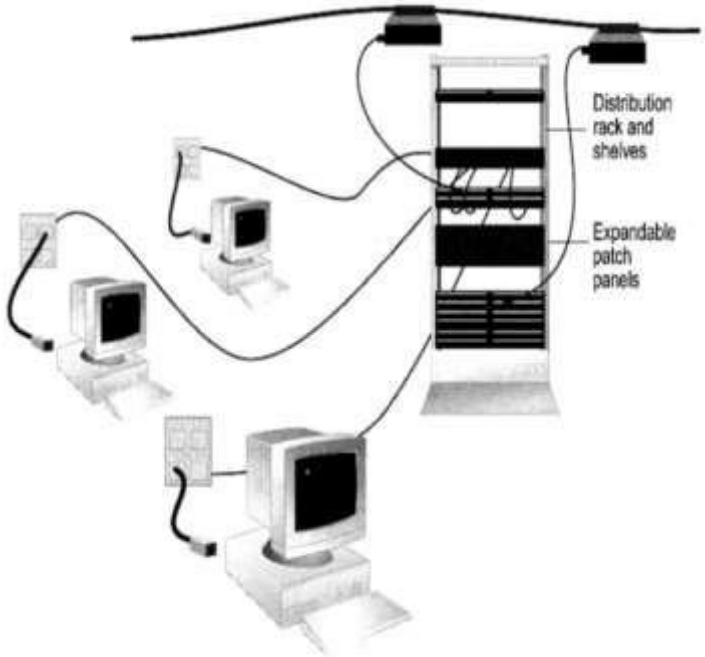
- Good option for modern networks
- Low startup costs
- Easy to manage
- Offers opportunities for expansion
- Most popular topology in use wide variety of equipment available



Disadvantages of Star Topology

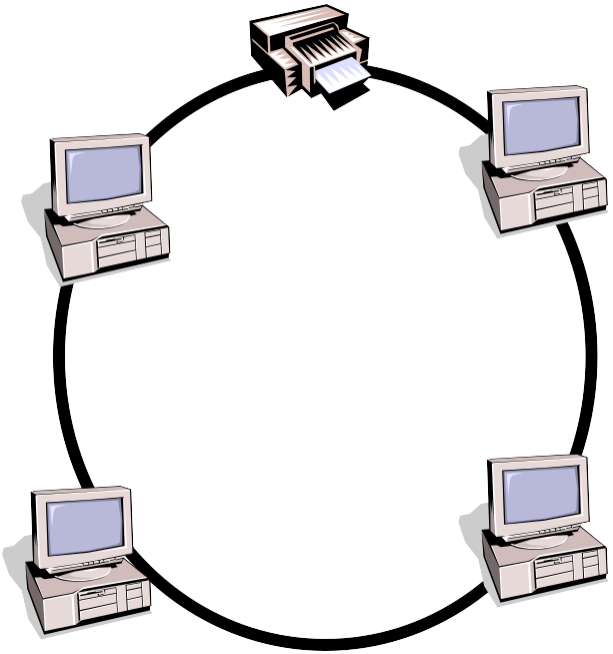
- Hub is a single point of failure
- Requires more cable than the bus
- Cost of installation is high.





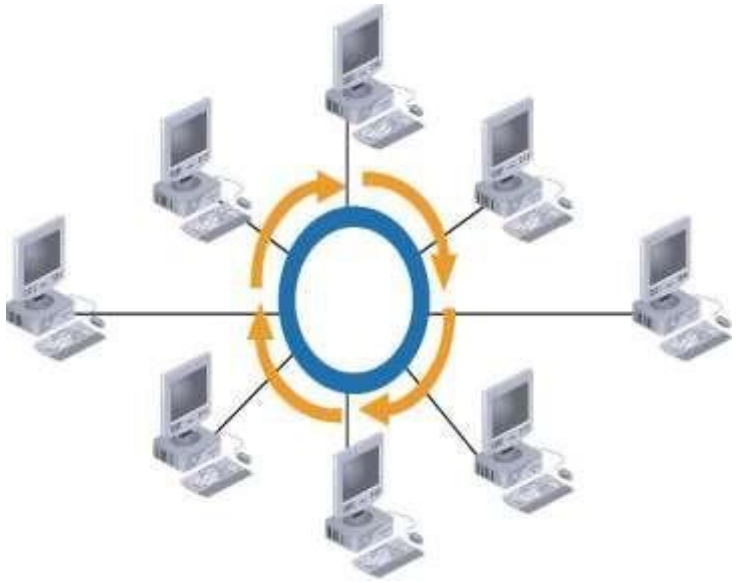
Ring Topology

- A ring network is one where all workstations and other devices are connected in a continuous loop. There is no central server.



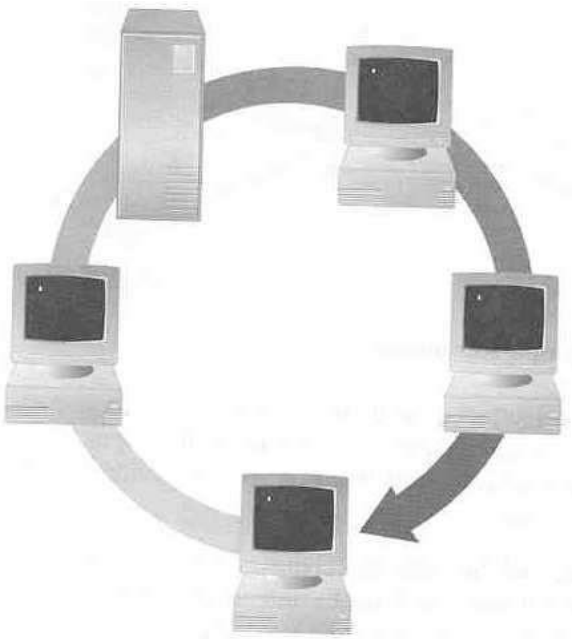
Advantages of Ring Topology

- Easier to manage; easier to locate a defective node or cable problem
- Well-suited for transmitting signals over long distances on a LAN
- Handles high-volume network traffic



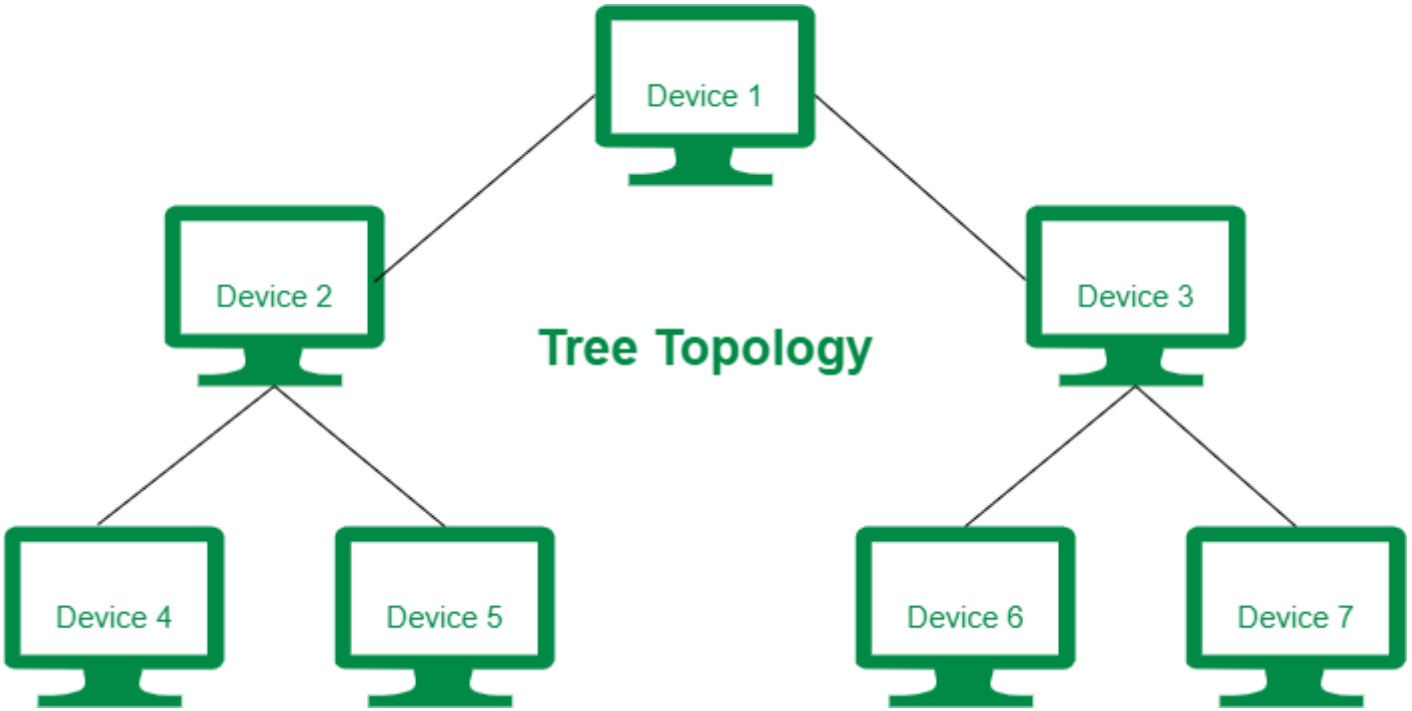
Disadvantages of Ring Topology

- Expensive
- Requires more cable and network equipment at the start
- Not used as widely as bus topology



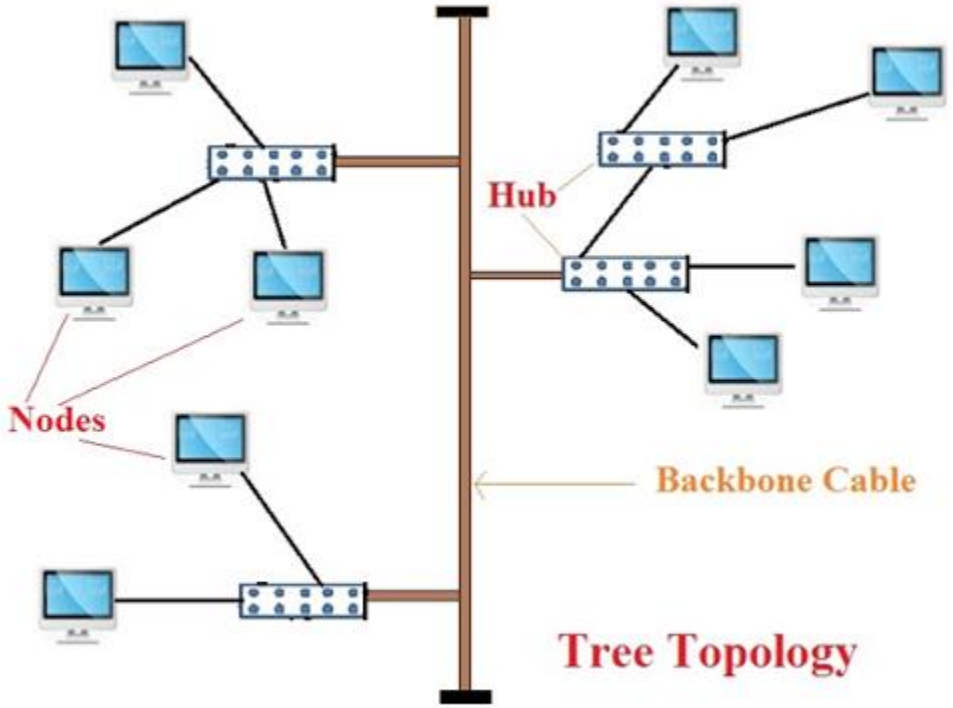
Tree Topology

- It has a root node and all other nodes are connected to it forming a hierarchy. It is also called Hierarchical Topology.



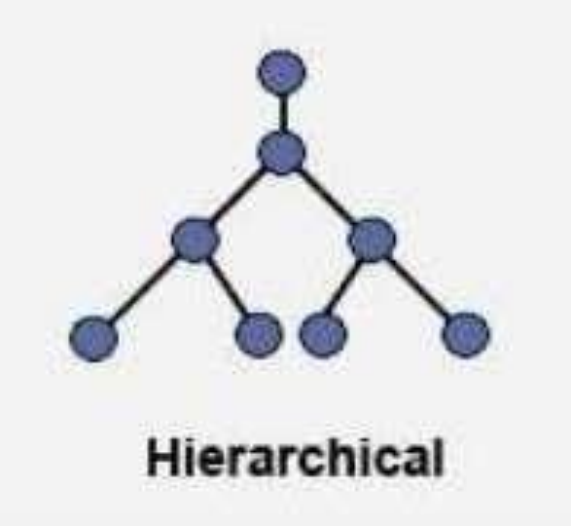
Advantages Of Tree Topology

- Extension of Bus and Star Topology.
- Expansion of nodes is possible and easy.
- Easily managed and maintained.



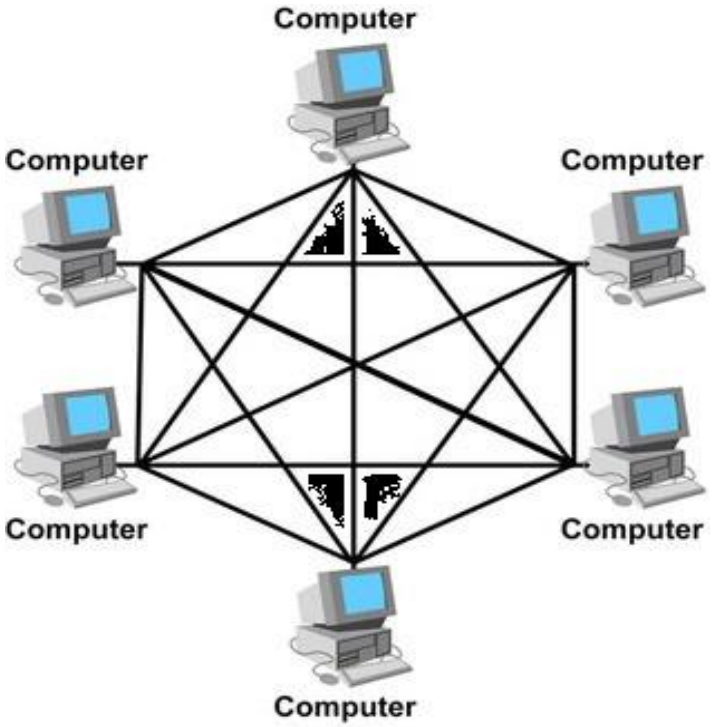
Disadvantages Of Tree Topology

- Heavily cabled.
- Costly.
- If more nodes are added maintenance is difficult.
- Central hub fails, network fails.



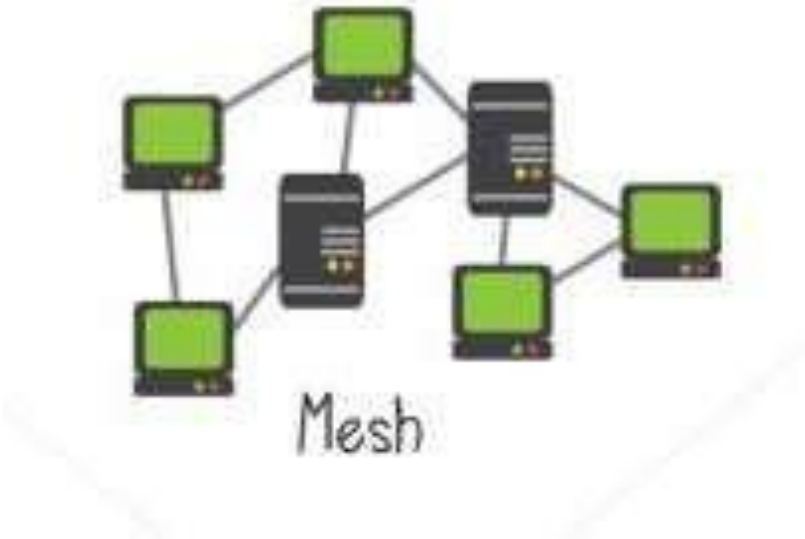
Mesh Topology

- It is a point-to-point connection to other nodes or devices.
- Traffic is carried only between two devices or nodes to which it is connected.



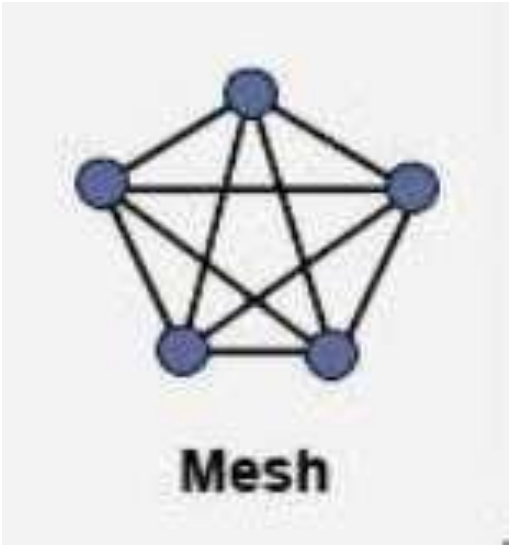
Advantages Of Mesh Topology

- Each connection can carry its own data load.
- Fault is diagnosed easily.
- Provide security and privacy.



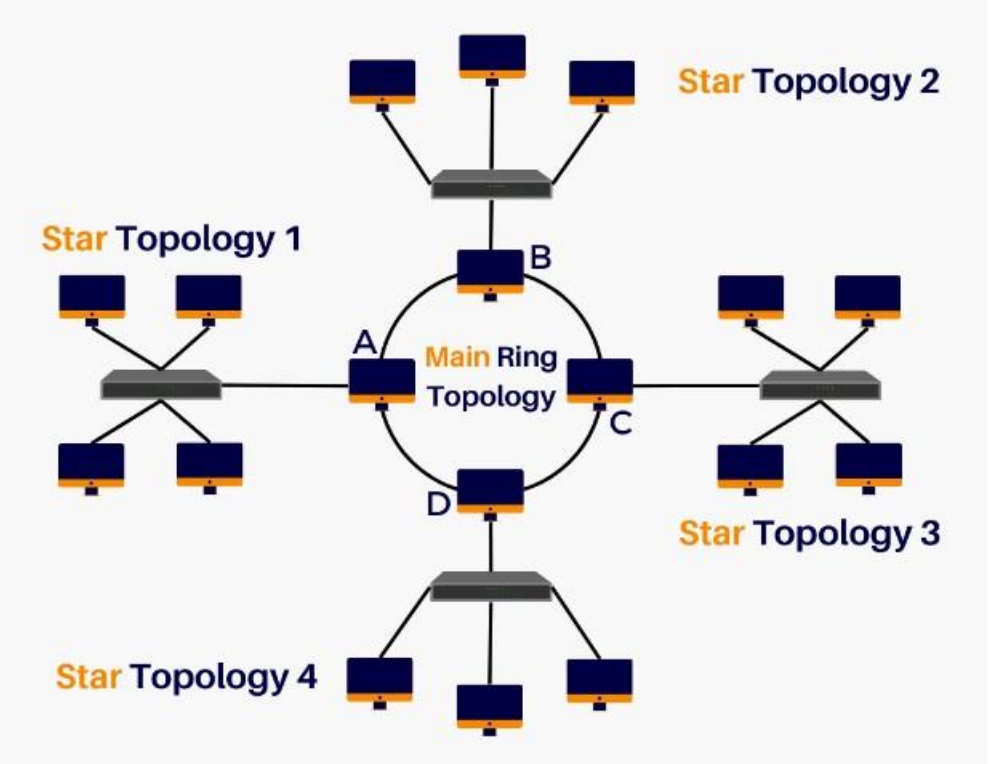
Disadvantage of Mesh Topology

- Installation and configuration is difficult.
- Cabling cost is more.
- Bulk wiring is required.



Hybrid Topology

- It is the mixture of two or more topologies. Therefore it is called Hybrid topology. A hybrid topology combines characteristics of linear bus and star and/or ring topologies.

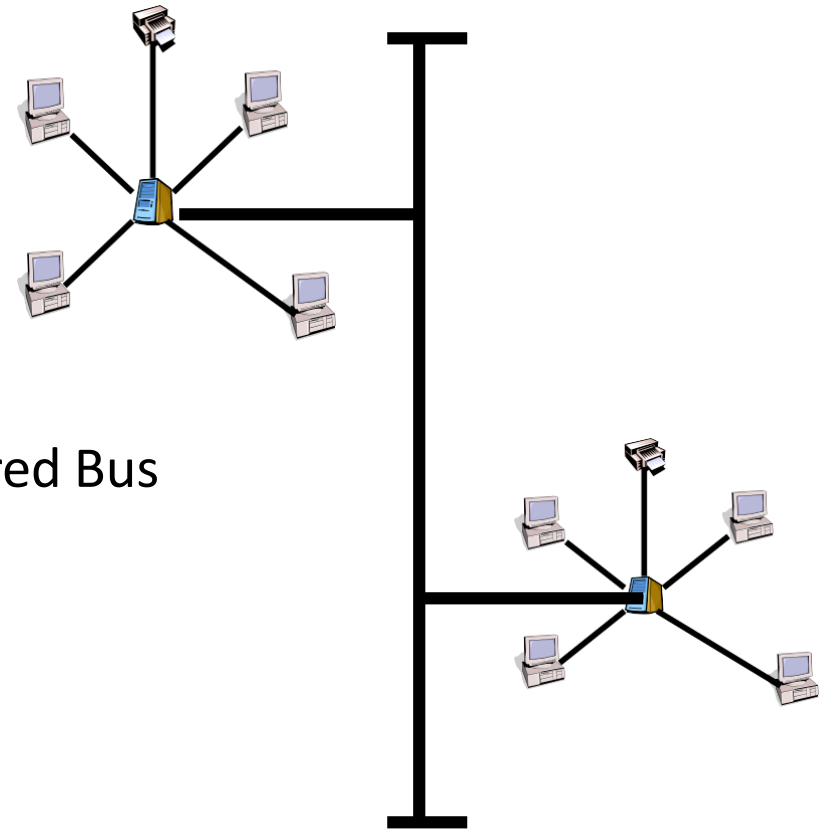


Advantages of Hybrid Topology

- Reliable as error detecting and trouble shooting is easy.
- Effective.
- Scalable as size can be increased easily.
- Flexible.

Disadvantages Of Hybrid Topology

- Complex in design.
- Costly.

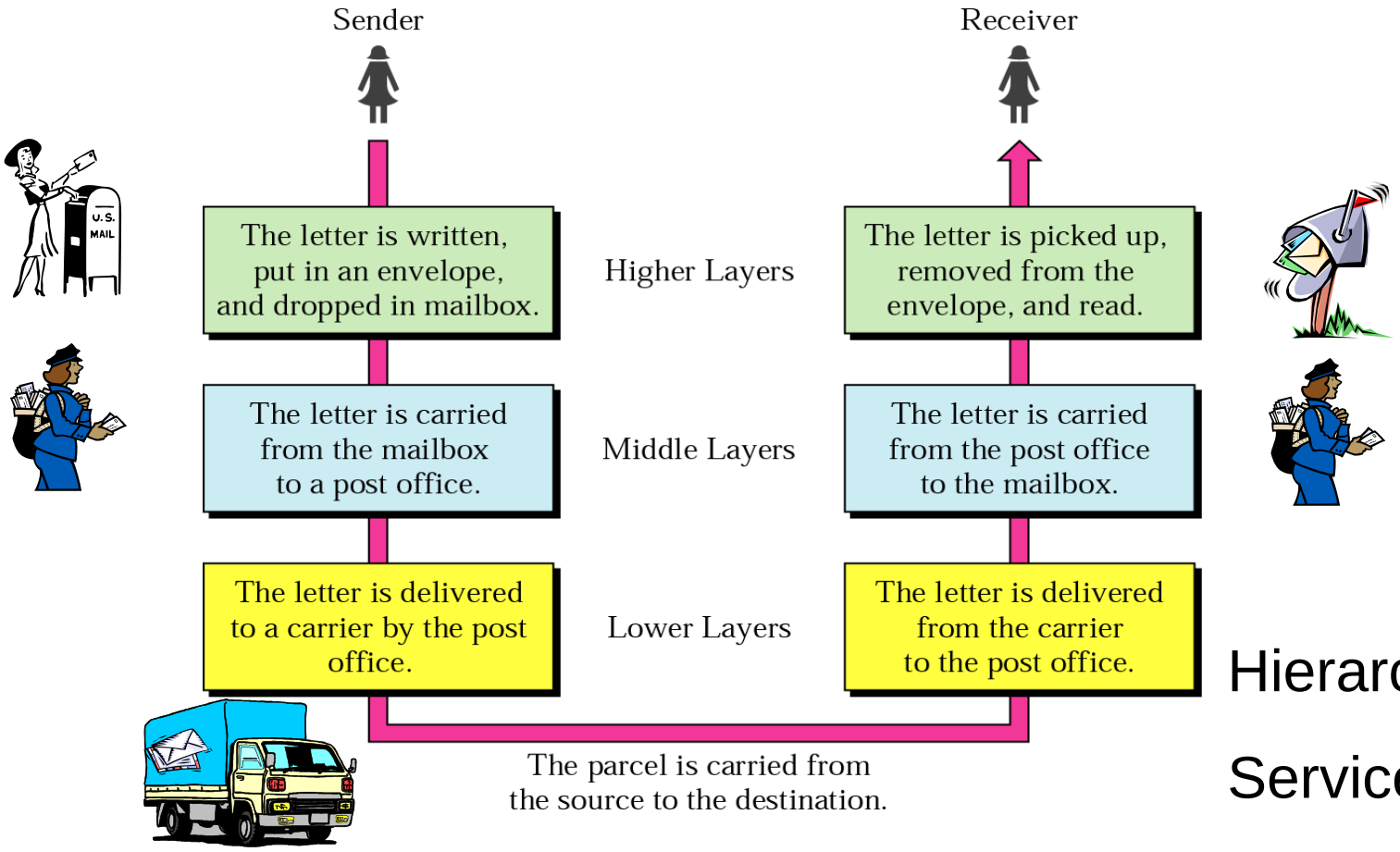


Star-Wired Bus

Layering (OSI & TCP) Stacks

Layered Tasks

An example from the everyday life



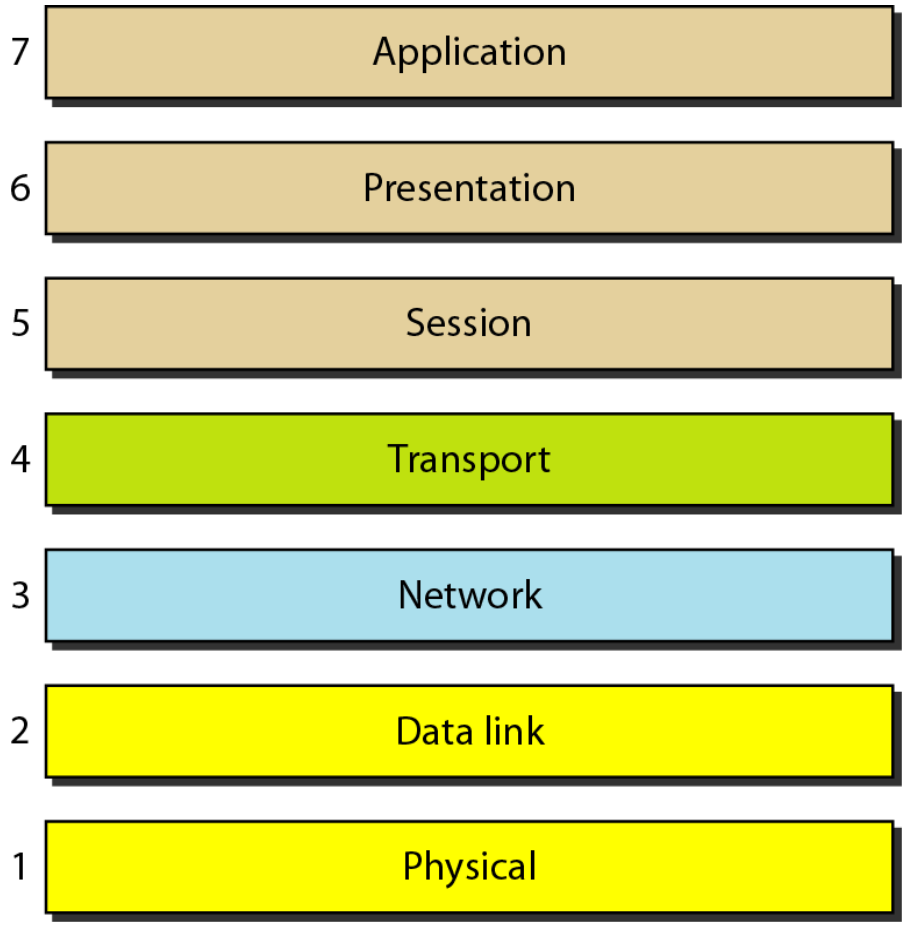
Hierarchy?

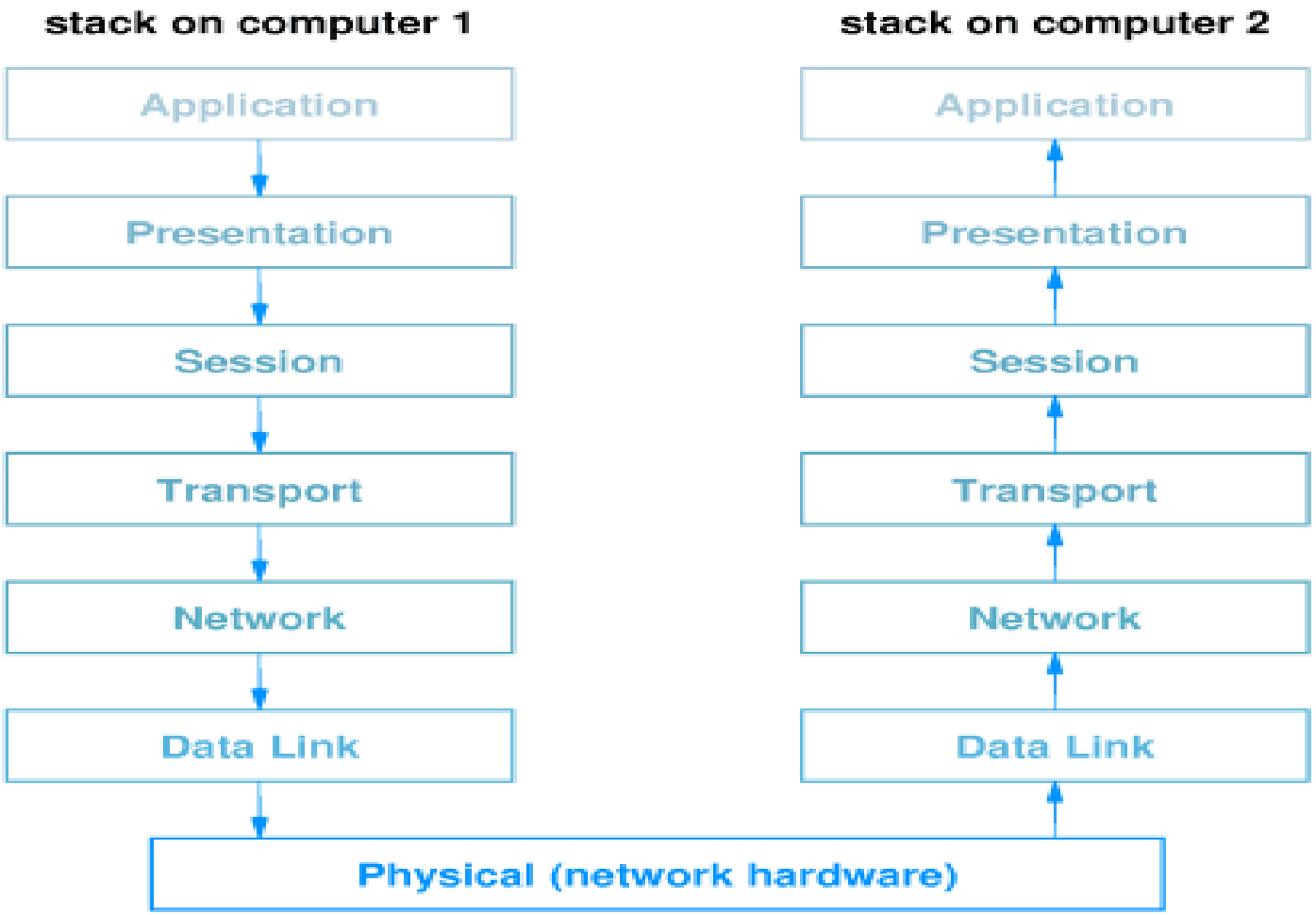
Services

Open System Interconnection (OSI) Model

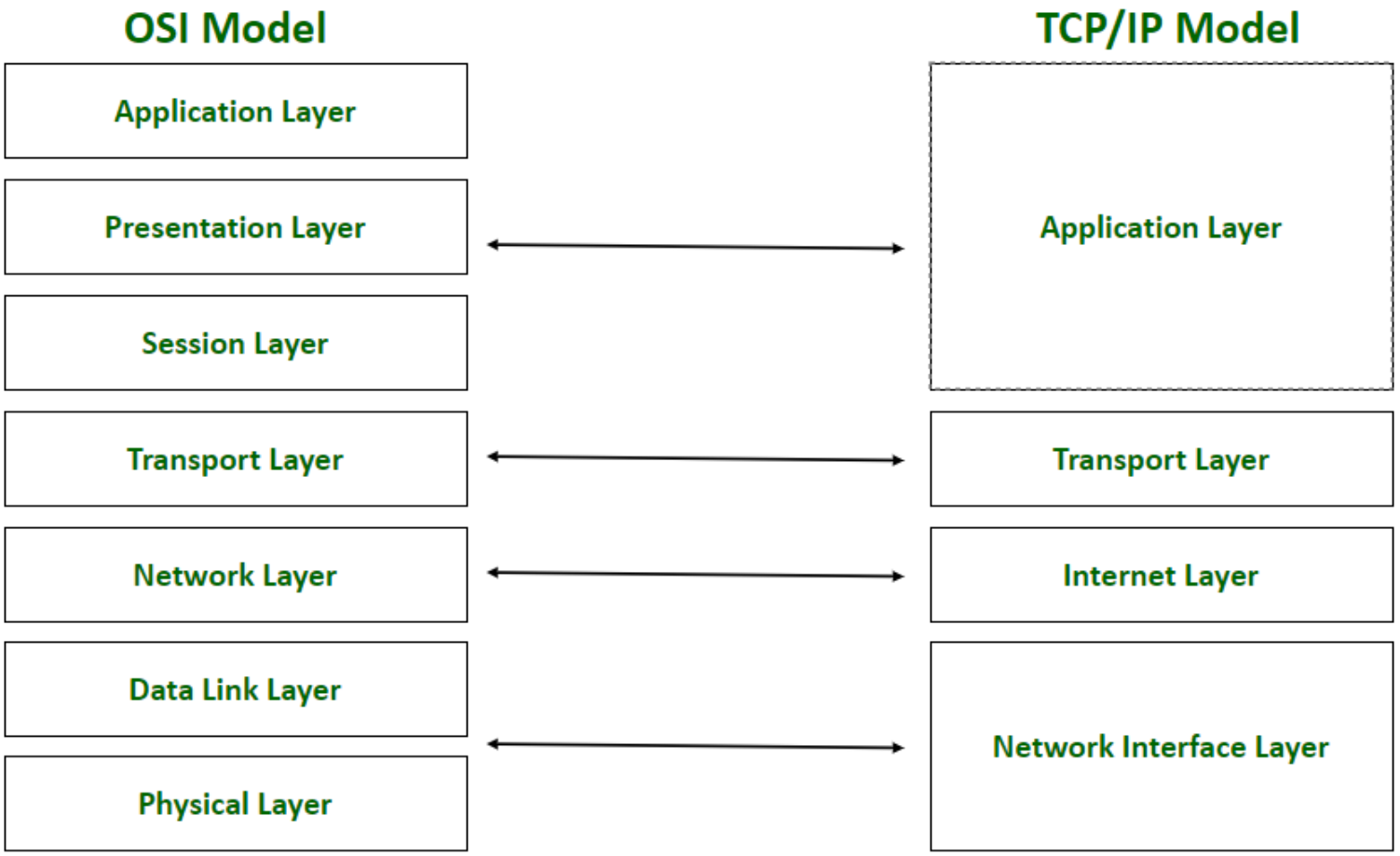
- The open systems interconnection (OSI) model refers to a standard model used to describe the flow of information from one computing device to another operating in a networking environment.
- The model defines a set of rules and requirements for data communication and interoperability between different devices, products, and software in a network infrastructure.
- The OSI model is split into seven fundamental layers (bottom to top): Physical, Data Link, Network, Transport, Session, Presentation, and Application.

Seven Layers of the OSI Model




stack on computer 1
stack on computer 2
Application
Presentation
Session
Transport
Network
Data Link
Application
Presentation
Session
Transport
Network
Data Link
Physical (network hardware)

OSI VS TCP/IP Model



OSI VS TCP/IP Model

- OSI is a conceptual framework, while TCP/IP is a connection-oriented protocol.
- TCP/IP has 4 layers, while OSI has 7 layers.
- OSI uses the session layer, presentation layer, and application layer to demarcate the upper layers, while TCP/IP uses only the application layer.
- Layers 1 and 2 are separate in the OSI model, but in TCP/IP they are combined.
- The layers in the OSI model are highly interdependent. So, if the lower layer fails, there is a probability that the upper layers will also not work well either. In contrast, TCP/IP offers a more flexible architecture.

The Networking Devices(Nodes)

- NIC Card
- Repeater
- Hub
- Switch
- Bridge
- Router
- Gateway
- Firewall

Network Interface Card

- NIC is used to physically connect host devices to the network media.
- A NIC is a printed circuit board that fits into the expansion slot of a bus on a computer motherboard.
- It can also be a peripheral device. NICs are sometimes called network adapters.
- Each NIC is identified by a unique code called a Media Access Control (MAC) address.
- This address is used to control data communication for the host on the network.

Repeaters

- A repeater is a network device used to regenerate a signal.
- Repeaters regenerate analog or digital signals that are distorted by transmission loss due to attenuation.
- A repeater does not make an intelligent decision concerning forwarding packets.

Hubs

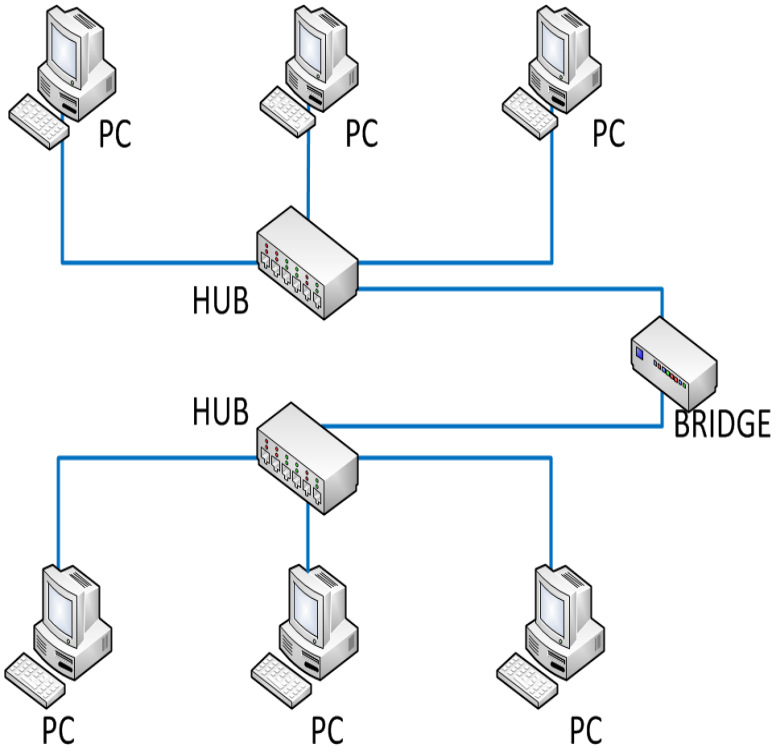
- Hubs concentrate on connections.
- In other words, they take a group of hosts and allow the network to see them as a single unit. This is done passively, without any other effect on the data transmission.
- Active hubs concentrate hosts and also regenerate signals.

100BaseT Hub

10BaseT Hub

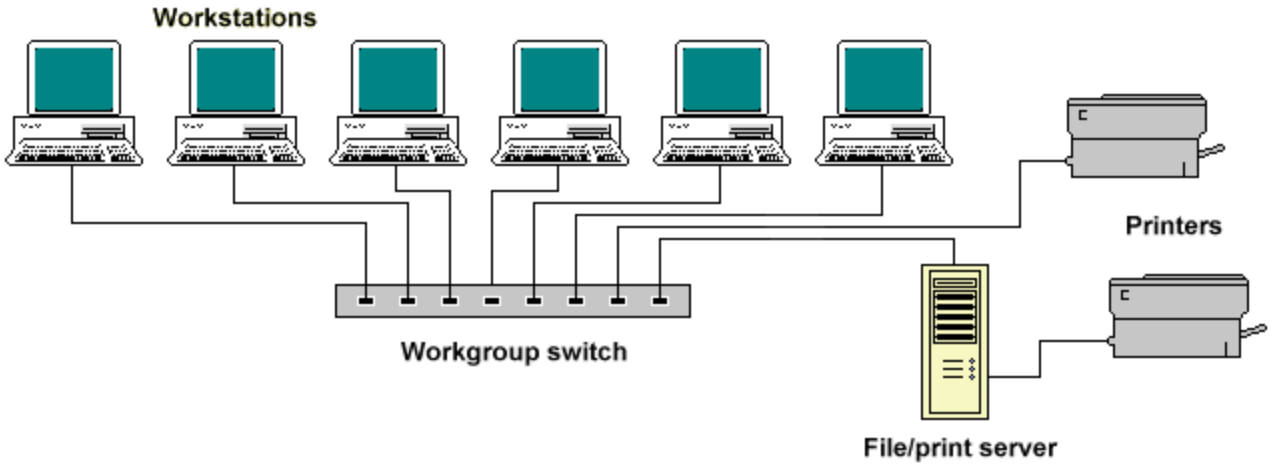
Bridges

- Bridges convert network data formats and perform basic data transmission management.
- Bridges provide connections between LANs.
- They also check data to determine if it should cross the bridge. This makes each part of the network more efficient.



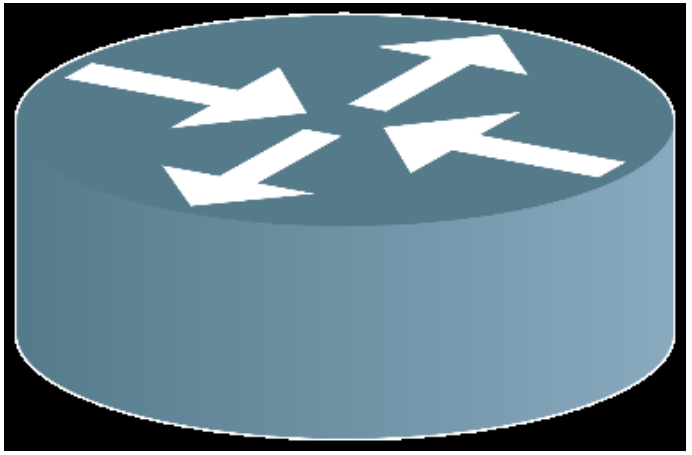
Switches

- Switches add more intelligence to data transfer management.
- They can determine if data should remain on a LAN and transfer data only to the connection that needs it.
- Another difference between a bridge and switch is that a switch does not convert data transmission formats.



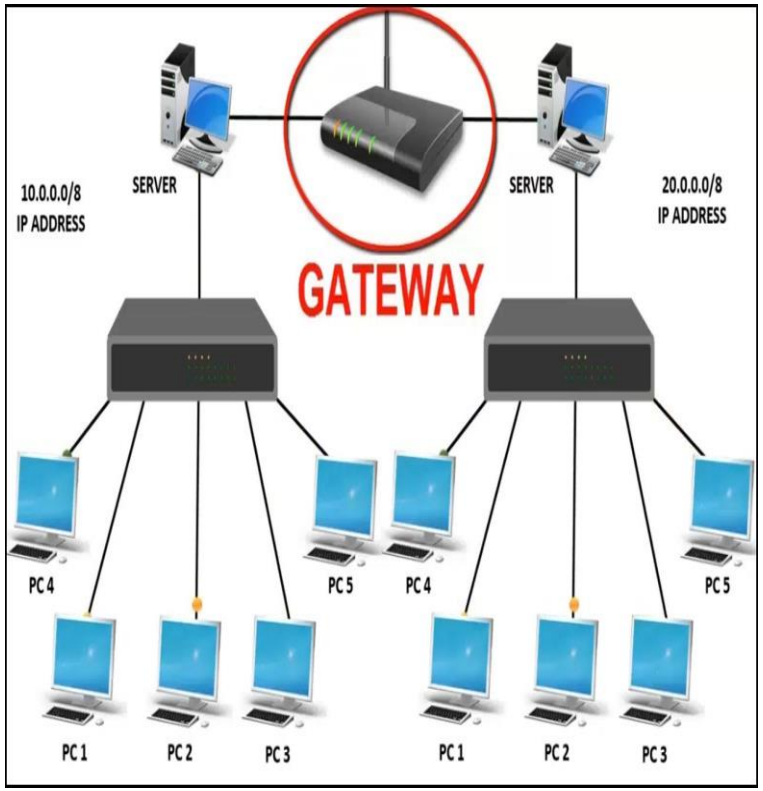
Routers

- Routers have all the capabilities listed above.
- Routers can regenerate signals, concentrate multiple connections, convert data transmission formats, and manage data transfers.
- They can also connect to a WAN, which allows them to connect LANs that are separated by great distances.



Gateway

- A **gateway** is a piece of networking hardware used in telecommunications for telecommunications networks that allows data to flow from one discrete network to another.
- Gateways are distinct from routers or switches in that they communicate using more than one protocol to connect a bunch of networks.



Firewall

- A firewall is a network device or software for controlling network security and access rules.
- Firewalls are inserted in connections between secure internal networks and potentially insecure external networks such as the Internet.
- Firewalls are typically configured to reject access requests from unrecognized sources while allowing actions from recognized ones.
- The vital role firewalls play in network security grows in parallel with the constant increase in cyber attacks.