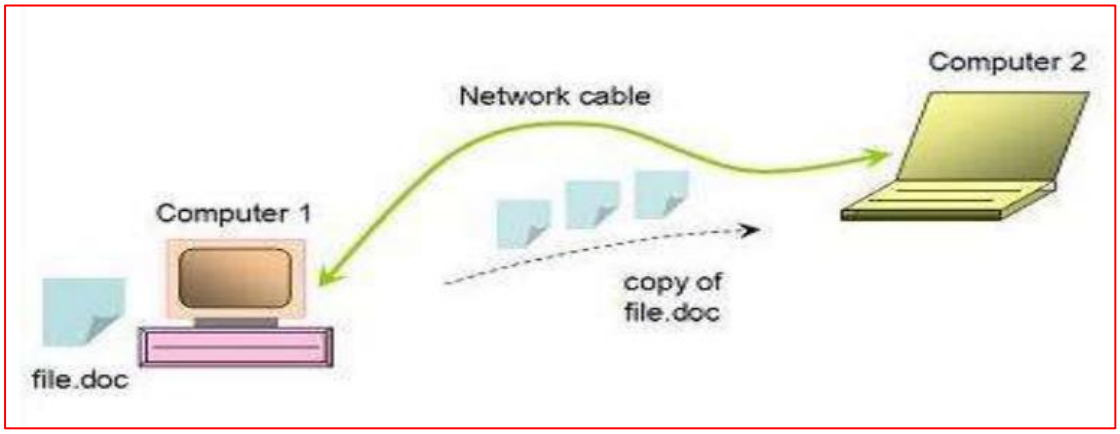
UNIT I: DATA COMMUNICATIONS

DATA COMMUNICATIONS:

- Data Communications are the **exchange of data between two devices** via some form of **transmission medium** such as wired or wireless.
- The **communication devices** must be part of a communication system made up of a **combination of hardware and software**.



The **effectiveness of a data communications** system depends on **four fundamental characteristics**:

1.Delivery

2.Accuracy

3.Timeliness

4.Jitter

Delivery:

- The system must **deliver data to the correct destination**.
- Data must be received by the intended device or user and only by that device or user.

Accuracy:

- The system must **deliver the data accurately**.
- Data that have been altered in transmission and left uncorrected are unusable.

Timeliness:

- The system must **deliver data in a timely manner**.
- Data delivered late are useless.
- In case of audio and video, timely delivery means delivering data as they are produced, in the same order without significant delay. This kind of delivery is called real time transmission.

Jitter:

- Jitter refers to the **variation in the packet arrival time**.
- For example, let us assume that video packets are sent every 30ms.If some of the packets arrive with 30ms delay and others with 40-ms delay, an uneven quality in the video is the result.

Data Communication Components:

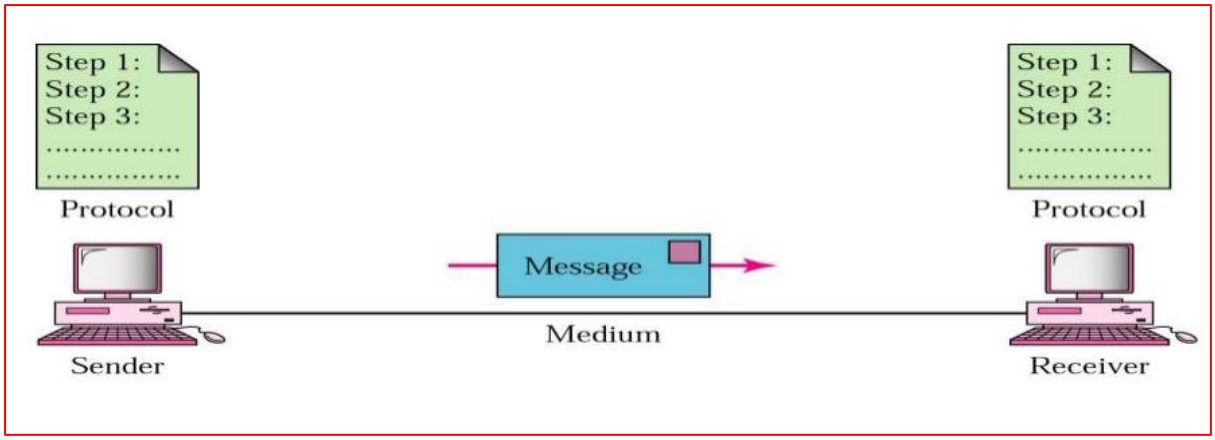
1.Message

2.Sender

3.Receiver

4.Transmission medium

5.Protocol



Message

- The message is the **information (data) to be communicated**.
- Popular forms of information include text, numbers, pictures, audio, and video.

Sender

- The sender is the **device that sends the data message**.
- It can be a computer, workstation, telephone handset, video camera, and so on.

Receiver

- The receiver is the **device that receives the message**.
- It can be a computer, workstation, telephone handset, television, and so on.

Transmission medium

- The transmission medium is the **physical path by which a message travels from sender to receiver**.
- Some examples of **transmission media** include **twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves**.

Protocol

- A protocol is a **set of rules that govern data communications**.
- It represents an **agreement between the communicating devices**.
- Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

DATA REPRESENTATION

Information today comes in different forms.

1.Text

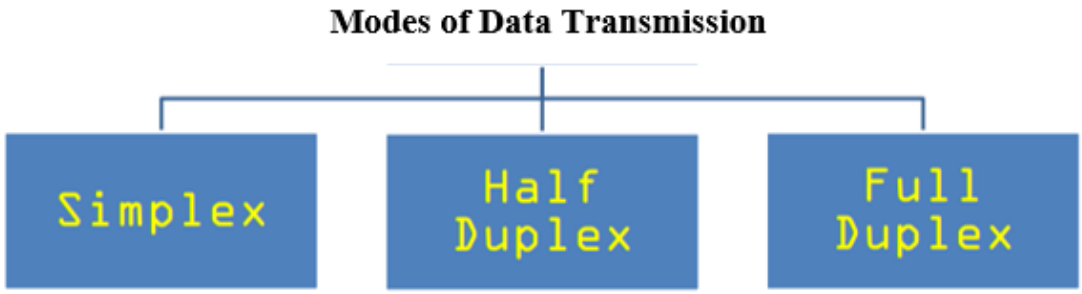
2.Numbers

3.Image

4.Audio

5.Video

DATA FLOW(Modes of Data Transmission):

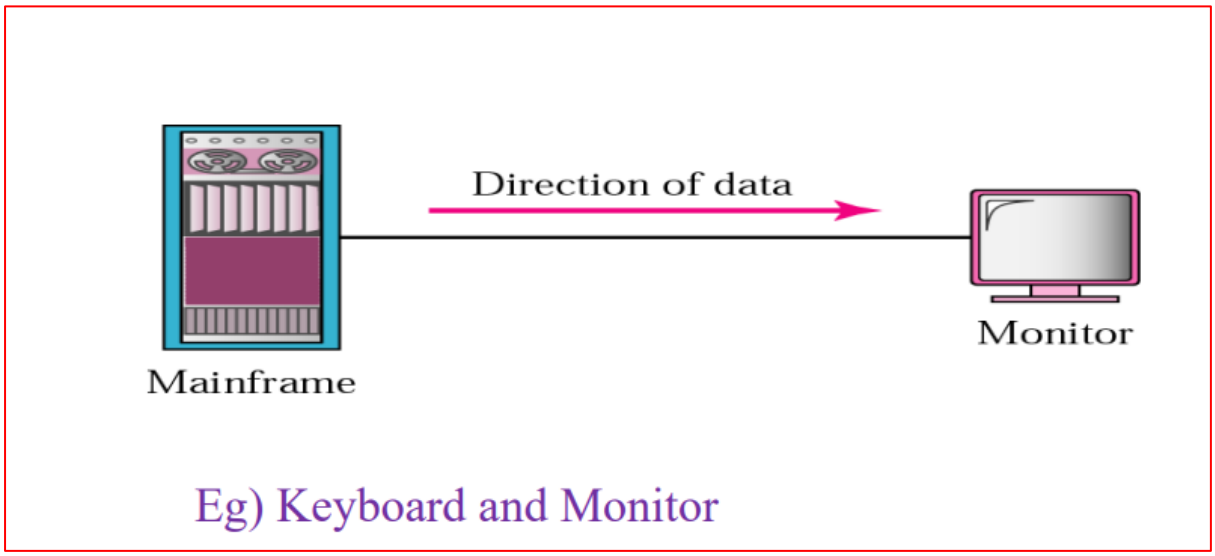


Simplex:

- In simplex mode, the communication is **unidirectional**, as on a one-way street.
- **Only one** of the two devices on a link can **transmit**; the **other** can **only receive**.
- The simplex mode can **use the entire capacity of the channel** to **send data in one direction**.

Example:

- **Keyboards and traditional monitors** are examples of simplex devices.
- The **keyboard** can only introduce **input**.
- The **monitor** can only accept **output**.



Eg) Keyboard and Monitor

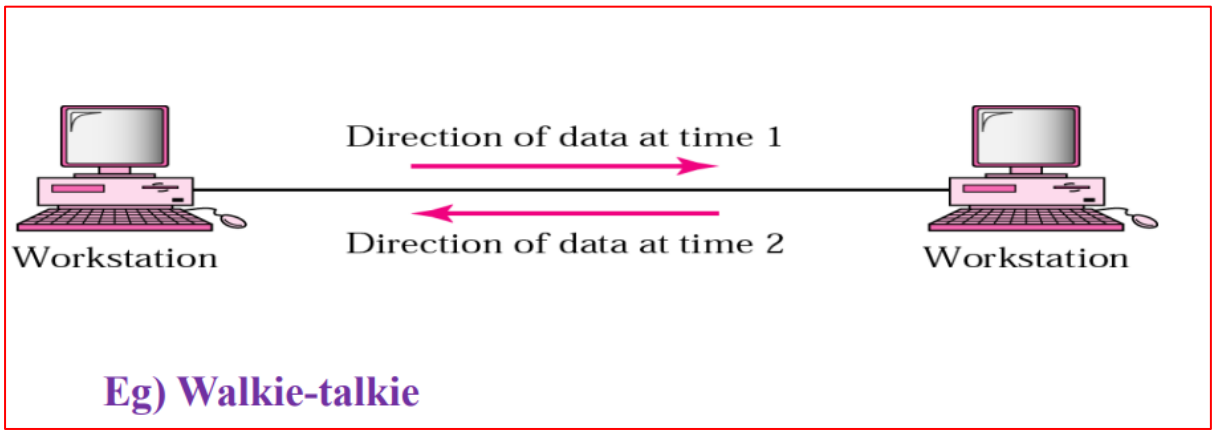
Half-Duplex:

- In half-duplex mode, **each station can both transmit and receive**, but **not at the same time.**
- When **one device is sending**, the **other can only receive**, and vice versa.
- In a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time.

- The **entire capacity of the channel can be utilized for each direction**.
- The half-duplex mode is **used** in cases where **there is no need for communication in both directions at the same time**.

Example:

- The half-duplex mode is like a **one-lane road with traffic allowed in both directions.**
- When **cars are traveling in one direction**, **cars going the other way must wait**.
- **Walkie-talkies** is half-duplex systems.



Eg) Walkie-talkie

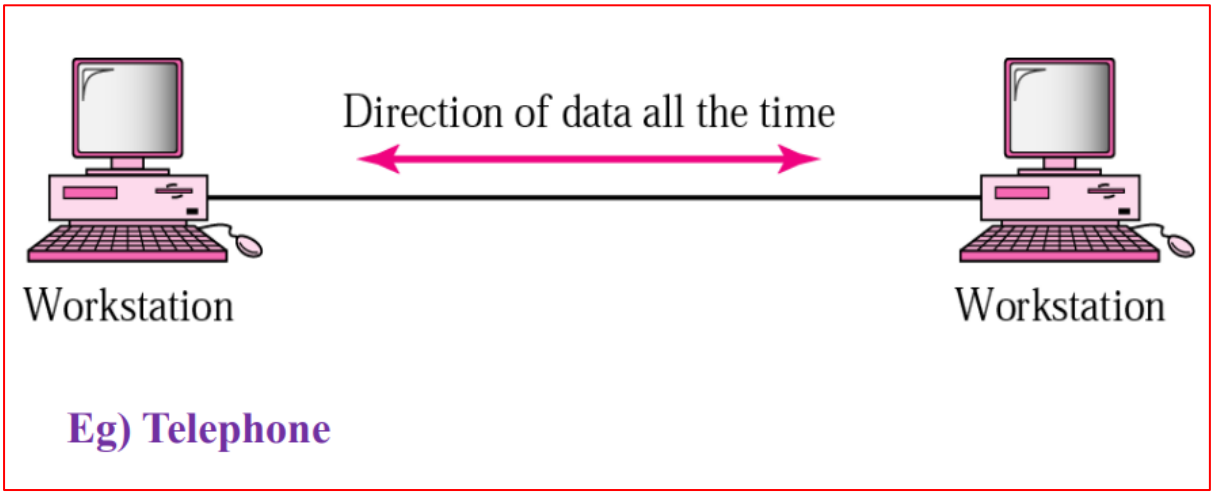
Full-Duplex:

- In full-duplex **both stations can transmit and receive simultaneously**.
- The full-duplex mode is **used** when **communication in both directions is required all the time**.
- The **capacity of the channel**, however, must be **divided between the two directions.**
- In full-duplex mode, signals going in one direction share the capacity of the link with signals going in the other direction.

- This sharing can occur in two ways:
- Either the link must contain two physically **separate transmission paths, one for sending and the other for receiving**; (or)
- The **capacity of the channel is divided between signals traveling in both directions**.

Example:

- The full-duplex mode is like a **two-way street with traffic flowing in both directions at the same time**.
- One **common example** of full-duplex communication is the **telephone network**.
- When **two people are communicating** by a **telephone** line, **both can talk and listen at the same time**.



NETWORKS

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

Distributed Processing

- Most **networks use distributed processing**, in which a **task is divided among multiple computers**.
- Instead of one single large machine being responsible for all aspects of a process, separate computers (usually a personal computer or workstation) handle a subset.

Network Criteria

- Performance
- Reliability
- Security

Performance:

- **Performance** can be **measured** in many ways, including **transit time and response time**.
- **Transit time** is the **amount of time required for a message to travel from one device to another**.
- **Response time** is the **elapsed time between an inquiry and a response**.
- The **performance** of a network depends on a number of **factors**, including the **number of users, the type of transmission medium, the capabilities of the connected hardware, and the efficiency of the software**.
- **Performance** is often evaluated by **two networking metrics**: **throughput and delay**.

- If we try to **send more data to the network**, we may **increase throughput** but we **increase the delay** because of traffic congestion in the network.

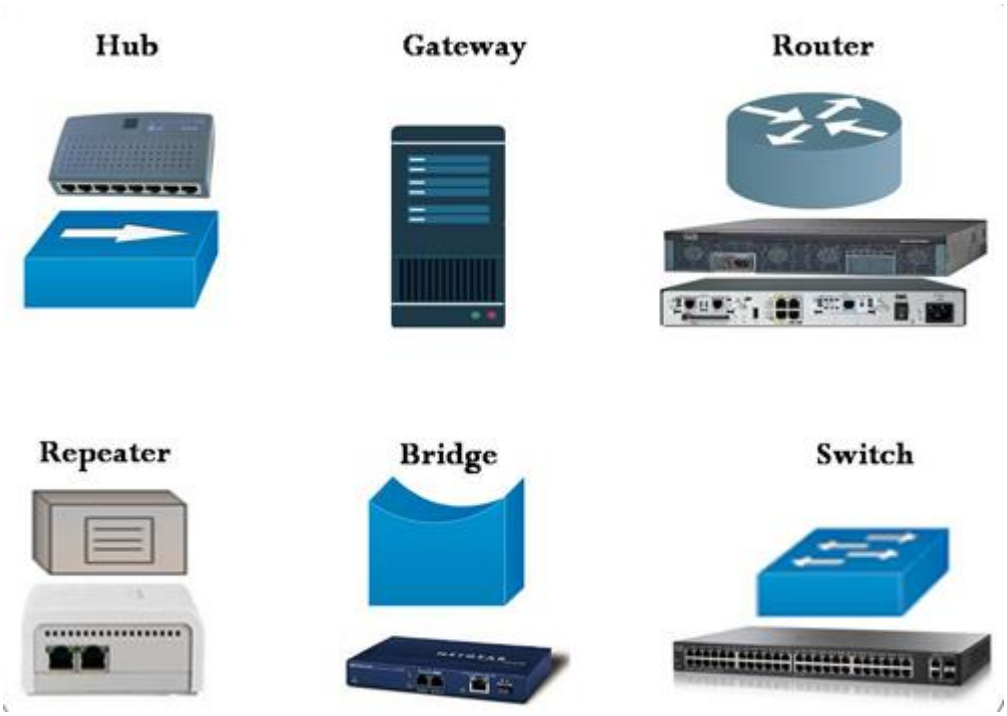
Reliability:

- Network reliability is measured by the **frequency of failure, the time it takes a link to recover from a failure,** and the **network's robustness in a catastrophe**.

Security:

- Network security issues include **protecting data from unauthorized access, protecting data from damage** and development, and
- **Implementing policies and procedures for recovery from breaches and data losses**.

NETWORK COMPONENTS



HUB:

- ✓ A Hub is a hardware device that divides the network connection among multiple devices.
- ✓ When computer requests for some information from a network, it first sends the request to the Hub through cable.
- ✓ **Hub will broadcast this request** to the **entire network**.
- ✓ **All** the **devices will check whether the request belongs to them or not. If not, the request will be dropped.**
- ✓ **multiport repeater.**
- ✓ Present in **Physical layer.**

SWITCH:

- ✓ A switch is a hardware device that connects multiple devices on a computer network.
- ✓ The Switch contains the updated table that decides where the data is transmitted or not.
- ✓ **Switch delivers the message to the correct destination based on the physical address present in the incoming message.**
- ✓ A Switch does not broadcast the message to the entire network like the Hub.
- ✓ Present in **Data link layer**.

ROUTER:

- ✓ A router is a **device like a switch that routes data packets** based on their **IP addresses.**
- ✓ A router is a hardware device which is used to **connect a LAN with an internet connection.**
- ✓ It is used to receive, analyze and forward the incoming packets to another network.

- ✓ It determines the best path from the available paths for the transmission of the packet.
- ✓ Present in **Network layer**

MODEM:

- ✓ It stands for **Modulator/Demodulator**
- ✓ A modem is a hardware device that **allows the computer to connect** to the **internet over the existing telephone line**.
- ✓ It converts the digital data into an analog signal over the telephone lines.

REPEATER

- ✓ Its job is to **regenerate the signal over the same network before the signal becomes too weak** or **corrupted** so as to extend the length to which the signal can be transmitted over the same network.
- ✓ An important point to be noted about repeaters is that they **do not amplify the signal**.
- ✓ When the **signal becomes weak**, they copy the signal bit by bit and **regenerate it at the original strength**.
- ✓ A repeater operates at the **physical layer**.

BRIDGE:

- ✓ A bridge is a repeater, with add on the functionality of **filtering content by reading the MAC addresses of source and destination**.
- ✓ It is also used for interconnecting two LANs working on the same protocol.
- ✓ A bridge operates at the **data link layer**.

GATEWAY:

- ✓ A gateway, as the name suggests, is a **passage to connect two networks** together that may **work** upon **different networking models**.
- ✓ Gateways are also called protocol converters.
- ✓ A Gateway operates at the **network layer**.

NIC:

- ✓ NIC or **network interface card** is a **network adapter** that is used to **connect the computer to the network**.
- ✓ It is installed in the computer to establish a LAN.

Physical Structures

Type of Connection

- A **network** is **two or more devices connected through links**.
- A **link** is a **communications pathway that transfers data from one device** to **another**.
- For visualization purposes, imagine any **link as a line drawn between two points**.
- For **communication** to occur, **two devices** must be **connected** in some way to the **same link at the same time**.
- There are two **possible types of connections**:

✓ Point-to-Point

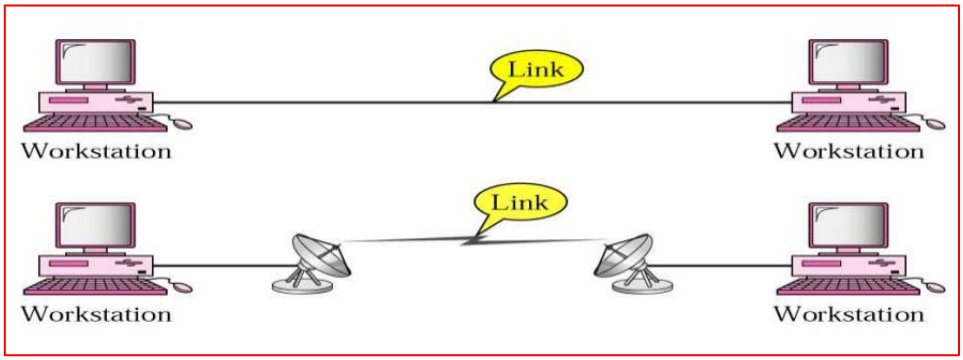
✓ Multipoint.

Point-to-Point

- A point-to-point connection provides a **dedicated link between two devices**.
- The **entire capacity** of the **link is reserved for transmission** between those two devices.
- Most point-to-point connections use an **actual length of wire or cable** to **connect the two ends**, but other options, such as **microwave or satellite links, are also possible**.

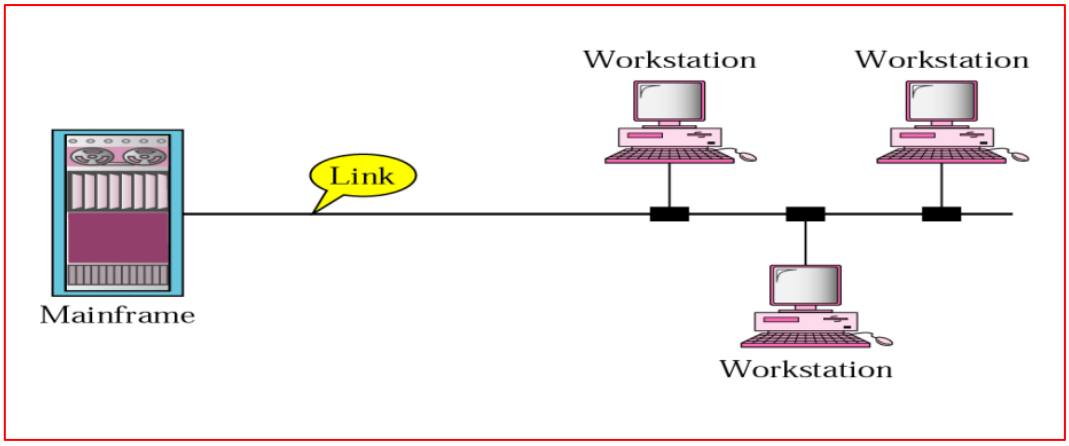
Example:

- When you change **television channels** by infrared **remote control**, you are **establishing a point-to-point connection** between the **remote control and the television's control system**.



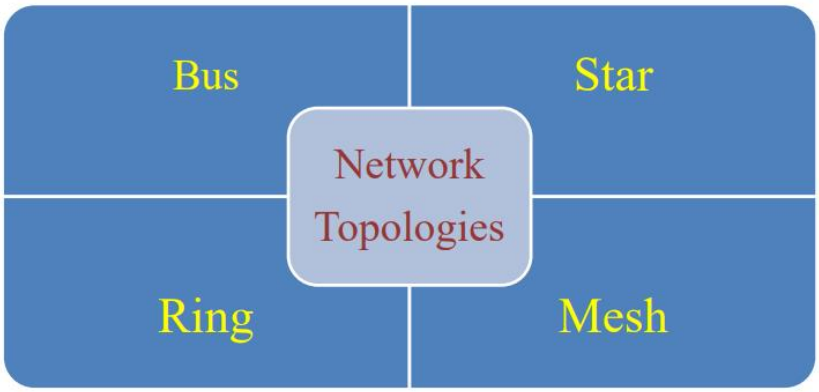
Multipoint:

- A multipoint (also called multidrop) **connection is one in which more than two specific devices share a single link.**
- In a multipoint environment, the **capacity of the channel is shared**, either spatially or temporally.
- If **several devices can use the link simultaneously**, it is a **spatially shared** connection.
- If **users must take turns**, it is a **timeshared connection**.



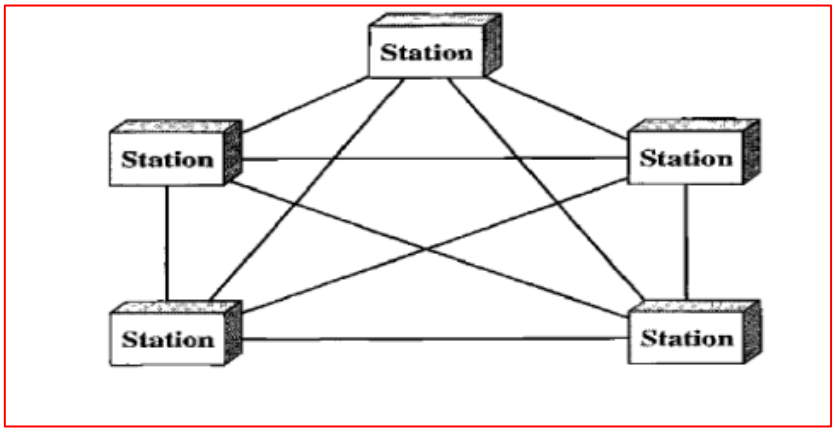
Network Topology

- Topology defines the **structure of the network of how all the components are interconnected to each other**.
- The topology of a network is the **geometric representation of the relationship of all the links and linking devices** (usually called nodes) to **one another**.
- There are two types of topologies: physical and logical topology.
- Physical Topology refers to the **way in which a network is laid out physically**.
- **One or more devices connect** to a **link**; **two or more links form a topology**.



Mesh Topology:

- In a mesh topology, **every device has a dedicated point-to-point link to every other device**.
- The term **dedicated** means that the **link carries traffic only between the two devices it connects**.
- To find the **number of physical links** in a fully connected mesh network with **n nodes**, we first consider that each node must be connected to every other node.
- **Node1** must be connected to **n -1 nodes**,
  node2 must be connected to n – 1 nodes, and **finally node n** must be connected to **n - 1 nodes**.
- We need **n(n - 1) physical links**.
- However, if **each physical link allows communication in both directions** (duplex mode), we can **divide the number of links by 2**.
- we need **n(n -1) /2 duplex-mode links**.



Advantages:

1. The use of **dedicated links** guarantees that **each connection** can **carry** its **own data load,** thus **eliminating the traffic problems** that can occur when **links must be shared by multiple devices**.

2. A mesh topology is **robust**. If **one link** becomes **unusable**, it **does not incapacitate the entire system**.

3. **Privacy or Security**. When **every message travels** along a **dedicated line**, only the **intended recipient sees** it. Physical boundaries **prevent other users** from **gaining access to messages**.

4.Finally, point-to-point links make **fault identification and fault isolation easy**. **Traffic can be routed to avoid links with suspected problems**.

This facility enables the network manager to discover the precise location of the fault and aids in finding its cause and solution.

Disadvantages:

1. The **amount of cabling** because every device must be connected to every other device, installation and reconnection are difficult.

2. The sheer **bulk of the wiring can be greater than the available space** (in walls, ceilings, or floors) can accommodate.

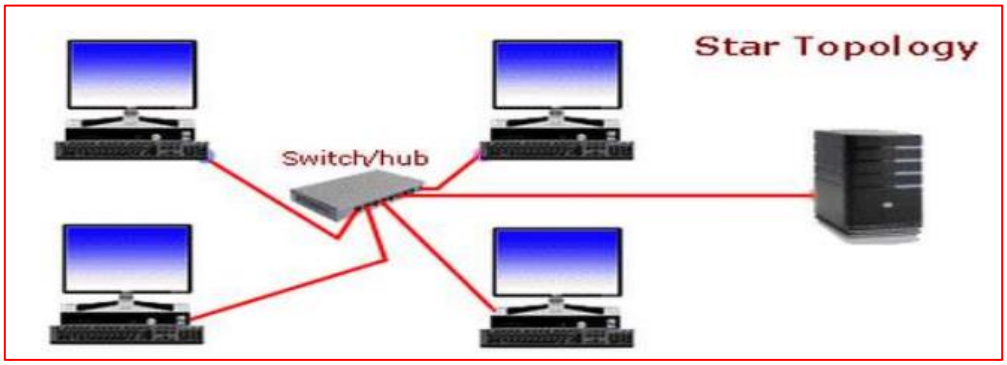
3. Finally, the **hardware required to connect each link** (I/O ports and cable) can be prohibitively **expensive**.

Example:

- **Connection of telephone regional offices** in which each regional office needs to be connected to every other regional office.

Star Topology:

- In this type of topology **all the computers are connected to a single hub through a cable**. This **hub** is the **central node** and all **others nodes are connected to the central node**.
- In a star topology, **each device has a dedicated point-to-point link only to a central controller, usually called a hub**.
- The **devices are not directly linked to one another**.
- Unlike a mesh topology, a star topology **does not allow direct traffic between devices**.
- The **controller** acts as an **exchange**: If **one device wants to send data to another**, it **sends the data to the controller**, which then **relays the data to the other connected device**.



Advantages:

- A **star topology is less expensive** than a mesh topology.
- In a star, **each device needs only one link and one I/O port** to **connect** it to **any number of others.** This factor also makes it **easy to install and reconfigure.**
- Far **less cabling** needs to be housed, and additions, moves, and deletions involve only one connection: between that device and the hub.
- **Robustness**. [If one link fails, only that link is affected. All other links remain active. This factor also lends itself to easy fault identification and fault isolation.]

Disadvantages:

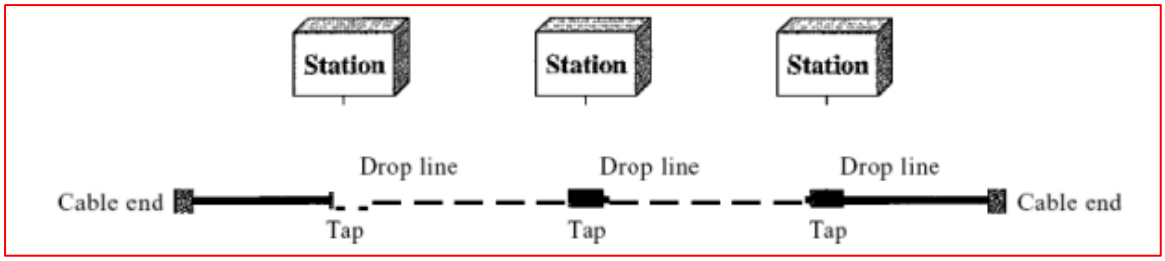
- **Whole topology on one single point**, the hub. If the **hub goes down, the whole system is dead**.
- Although a **star requires far less cable than a mesh**, **each node must be linked to a central hub**. For this reason, **often more cabling is required in a star than in some other topologies (such as ring or bus)**

Example:

Local Area Network [LAN].

BUS TOPOLOGY

- A bus topology, on the other hand, is **multipoint**.
- **One long cable act as a backbone** to link all the devices in a network.



- **Nodes** are **connected** to the bus **cable by drop lines and taps**.
- A **drop line** is a **connection running between the device and the main cable**.
- A **tap** is a **connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core**.
- As a **signal travels along the backbone**, some of its **energy is transformed into heat.**
- Therefore, it **becomes weaker** and weaker as it travels farther and farther.
- For this reason there is a **limit on the number of taps a bus** can **support** and on the distance between those taps.

Advantages

- **Ease of installation.**
- Backbone cable can be laid along the most efficient path, then connected to the nodes by drop lines of various lengths. In this way, a bus **uses less cabling** than mesh or star topologies.
- In a star, for example, four network devices in the same room require four lengths of cable reaching all the way to the hub.
- In a bus, this **redundancy is eliminated**. Only the **backbone cable stretches** through the entire facility.
- Each **drop line has to reach only as far as the nearest point** on the backbone.

Disadvantages

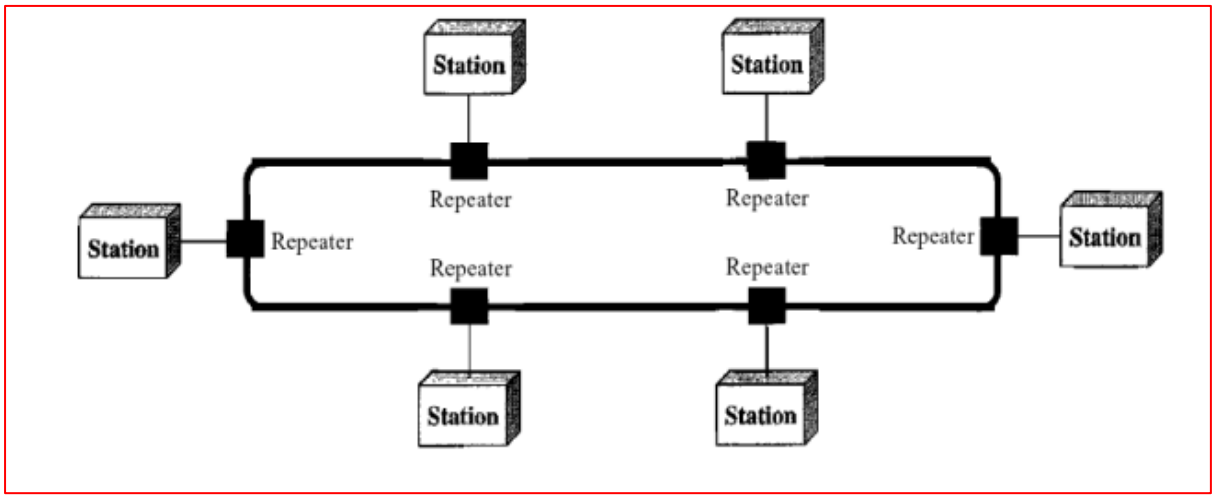
- **Difficult reconnection and fault isolation**.
- It can therefore be difficult to add new devices.
- **Signal reflection at the taps** can cause **degradation in quality**. This **degradation** can be **controlled** by **limiting the number and spacing of devices connected** to a given length of **cable**.
- **Adding new devices** may therefore **require modification or replacement of the backbone.**
- In addition, a **fault or break in the bus cable stops all transmission**, even between devices on the same side of the problem.
- The **damaged area reflects signals back in the direction** of **origin**, creating **noise in both directions.**

Example:

Ethernet LANs can use a bus topology, but they are less popular.

Ring Topology

- It is called ring topology because it forms a **ring as each computer is connected to another computer, with the last one connected to the first**.
- **Exactly two neighbours for each device.**
- A **signal** is passed along the **ring in one direction**, from device to device, **until it reaches its destination**.
- **Each device in the ring incorporates a repeater**.
- When a **device receives a signal intended for another device**, its **repeater regenerates the bits and passes them along.**



Advantages:

- **Easy to install and reconfigure**.
- **Each device** is **linked** to only its **immediate neighbors** (either physically or logically). To **add or delete a device requires changing only two connections**.
- **Fault isolation is simplified.**
- Generally, in a ring, a signal is circulating at all times. If **one device does not receive a signal within a specified period, it can issue an alarm**.
- The **alarm alerts the network operator to the problem and its location**.

Disadvantages:

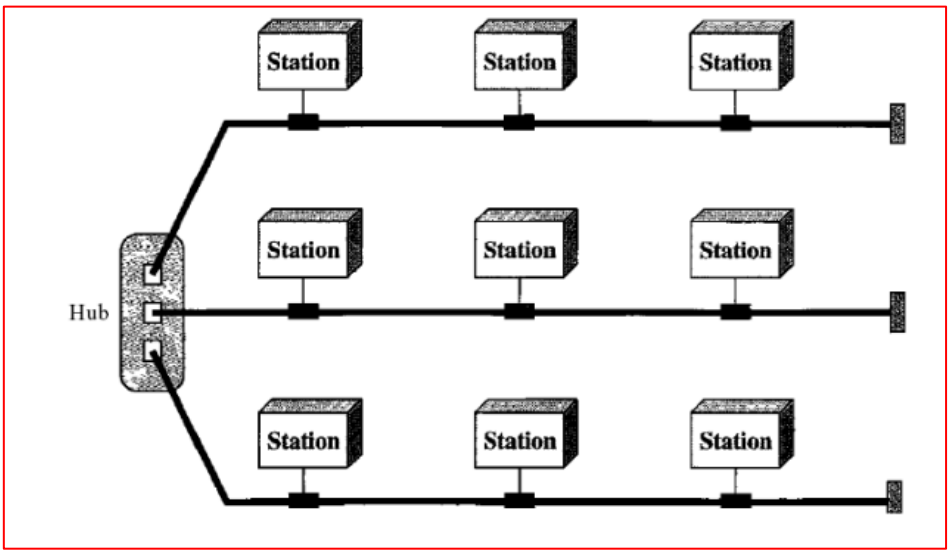
- **Unidirectional** traffic.
- In a simple ring, a **break in the ring** (such as a disabled station) can **disable** the **entire network**.
- This **weakness** can be **solved** by using a **dual ring** or a **switch** capable of closing off the break.

Example:

- Ring topology was prevalent when IBM introduced its local-area network Token Ring.
- Today, the need for higher-speed LANs has made this topology less popular.

Hybrid Topology

- A network can be hybrid.
- For example, we can have a **main star topology with each branch connecting several stations in a bus topology**.

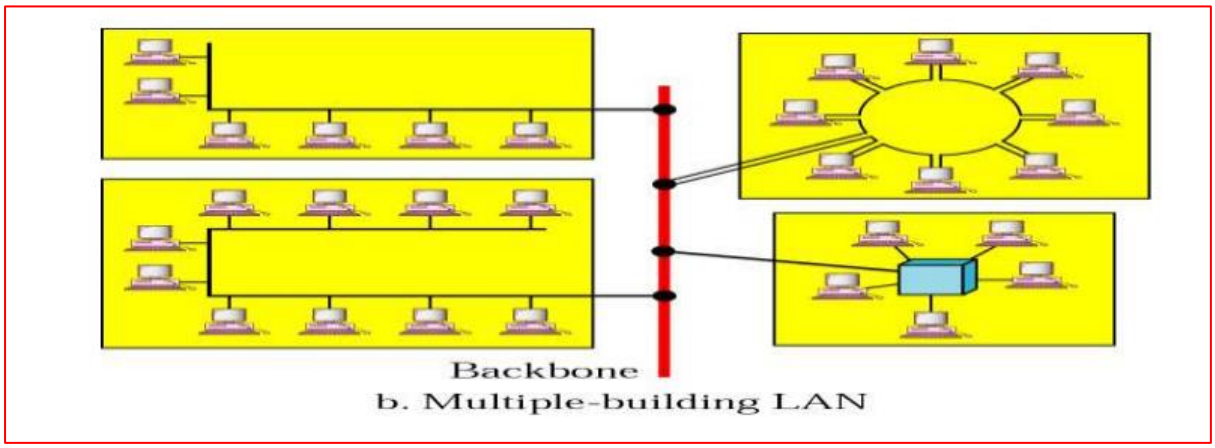


Categories of Networks:

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

Local Area Network (LAN)

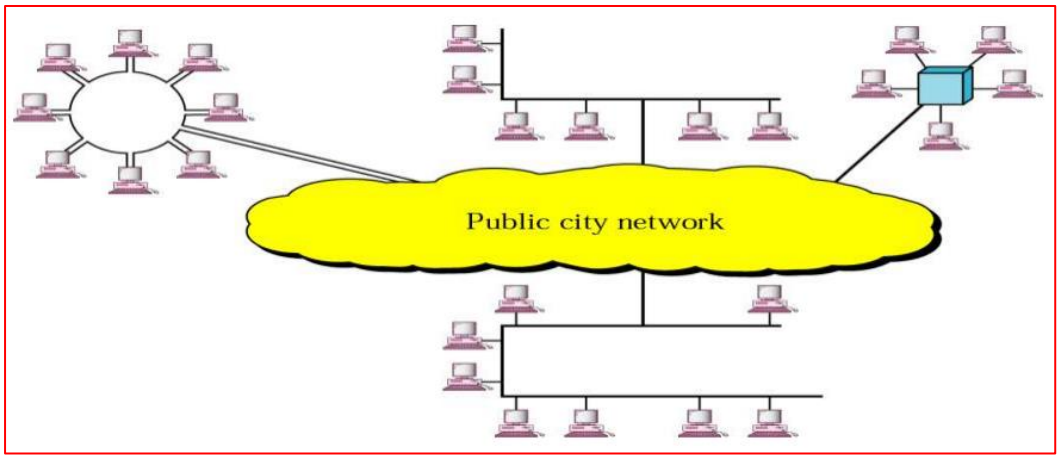
- A local area network is a **communication network that interconnects** a variety of data **communicating devices within a small geographic area**.
- Depending on the organization need, LAN **can be simple as two PCs and a printer or it can extend to whole office**.
- The resources to be shared can include printer, software, data,..
- LAN distinguished from other networks by transmission media and topology.
- LAN will use only **one type of transmission media**.
- Common LAN topologies are **bus, ring, star**.
- Wireless LAN is the newest evolution.



b. Multiple-building LAN

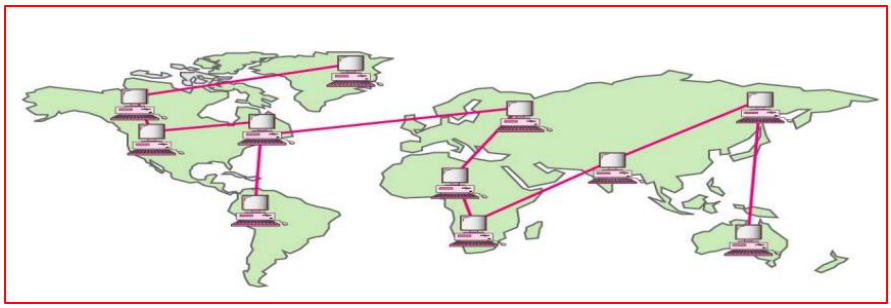
MAN (Metropolitan Area Network)

- MAN is a larger version of LAN which **covers an area that is larger than the covered by LAN but smaller than the area covered by WAN.**
- A MAN **covers a city, connects two or more LANs.**
- Example: Telephone company network provide high speed DSL line to the customer.
- Cable TV network



Wide Area Network (WAN)

- WAN spans a **large geographical area, often a country or region**.
- A WAN connects **different smaller networks**, including local area networks (**LANs**) and metro area networks (**MANs**).



Personal Area Network(PAN)

- Personal Area Network is a **network arranged within an individual person**, typically within a range of 10 meters.
- Personal Area Network is used for connecting the computer devices of personal use is known as Personal Area Network.

INTERCONNECTION OF NETWORKS(INTERNETWORK)

Intranet:

- Intranet **belongs to an organization** which is **only accessible by the** organization's employee **or members**.

Internet:

- The Internet is **a vast network that connects computers all over the world**.
- Global system of interconnected computer networks.

PROTOCOLS AND STANDARDS

Protocols:

- ✓ A protocol is a **set of rules that govern data communications.**
- ✓ A protocol defines **what is communicated, how it is communicated, and when it is communicated.**
- ✓ The **key elements of a protocol are syntax, semantics, and timing.**

Syntax

The term syntax refers to the **structure or format of the data**, meaning the **order** in which they are presented.

Example: a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message itself.

Semantics

The word semantics refers to the **meaning of each section of bits**. How is a particular pattern to be interpreted, and what action is to be taken based on that interpretation?

Example: does an address identify the route to be taken or the final destination of the message?

Timing

The term timing refers to two characteristics: **when data should be sent and how fast they can be sent**.

Example:

If a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

Standards

- Standards provide **guidelines** to manufacturers, vendors, government agencies, and other service providers to **ensure the kind of interconnectivity** necessary in today's marketplace and in international communications.
- Data communication standards fall into two categories:

✓ de facto (meaning "by fact" or "by convention") and

✓ de jure (meaning "by law" or "by regulation").

De facto

- Standards that have **not been approved by an organized body** but have been adopted as standards through widespread use are de facto standards.
- De facto standards are often **established originally by manufacturers** who seek to define the functionality of a new product or technology.

Example:

Apple and Google are two companies which established their own rules on their products which are different.

De jure

The standards that have been **approved by officially recognized body** like ANSI, ISO, IEEE etc

Example:

All the data communication standard protocols like SMTP, TCP, IP, UDP etc. are important to follow the same when we needed them.