# Data Communication

## Objective of Lesson 1:

On Completion of this lesson, the students will be able to:
Define Computer Networks and its architecture and components.
Explain effectiveness of data communications.
Categorize different types of Computer Networks
Specify some of the application of Computer Networks.
Determine the network criteria.
Categorize different types of topologies of network.

## INTRODUCTION

**Computer network and Telecommunication:** Computer network is a group of computers that are connected together to communicate and share resources such as files, printers, and email. Each Computer on a network is called **node**. In other hand, **Telecommunication**: it includes telephony, telegraphy, and television, means communication at a distance (tele is Greek for "far").

**Uses of Computer Networks:**

Before starting to study the technical issues of the computer network in detail, it is better to mention why people are interested in computer networks and what they can be used for. The benefits of computer network ranges between the traditional uses at companies and for individuals and the recent developments regarding mobile users and home networking.

### Business Applications

The companies have many and many distributed resources (softcopy and hardcopy) that should be utilized in efficient manner by the employee and costumers of these companies such as public and privet banks. To ease use and keep the data up-to-date, the companies should use networks (LAN, MAN, WAN). Some companies accomplish most of their operations electronically.

### Home Applications:

# Data Communication

There are some of popular uses of the computer network and internet for home users are as follows:

Access to remote information (arts, business, cooking, government, health, history, hobbies, recreation, science, sports, travel, and many others.)

Person-to-person communication.

Interactive entertainment (video on demand, live TV, electronic exam)

Electronic commerce (Home shopping, e-commerce).

**Mobile Users:**

The mobile devices are one of the fastest-growing segments of the computer industry such as: sensor, embedded controllers, Mobile phones, Personal digital assistant (PDAs), Pocket computer, Notebook/laptop and other. These devices can be used during the movement of the users such as: vehicles, ambulance car, walking, Aircraft. The wireless network is used as an access media in these usages.

**Social Issues:**

The widespread introduction of networking has introduced new social, ethical, and political problems.

**Effectiveness of Data Communications:**

Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable. The effectiveness of a data communications system depends on four fundamental characteristics: delivery, accuracy, timeliness, and jitter.

**Delivery**: The system must deliver data to the correct destination. Data must be received by the intended device(s) or user(s).

**Accuracy**. The system must deliver the data accurately (without errors or unnecessary changing).

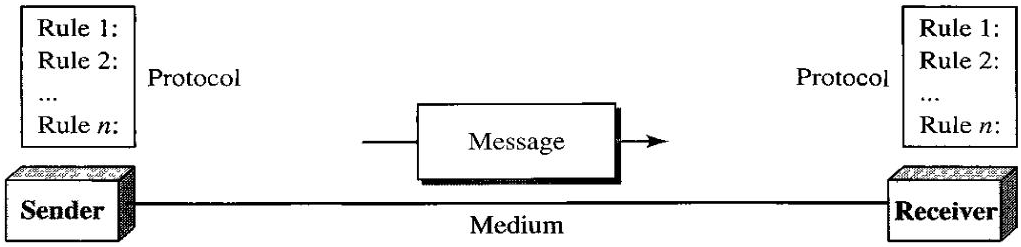
**Timeliness**: The system must deliver data in a timely manner. Data delivered late are

useless.

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

**Components:**

A data communications system has five main components and without one of them no connection is existing see the following figure:




Message: The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video. These data can be represented by using popular code such as UNI-CODE, The American Standard Code for Information Interchange (ASCII).

Sender: The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on. Some devices can be sender only such as keyboard.

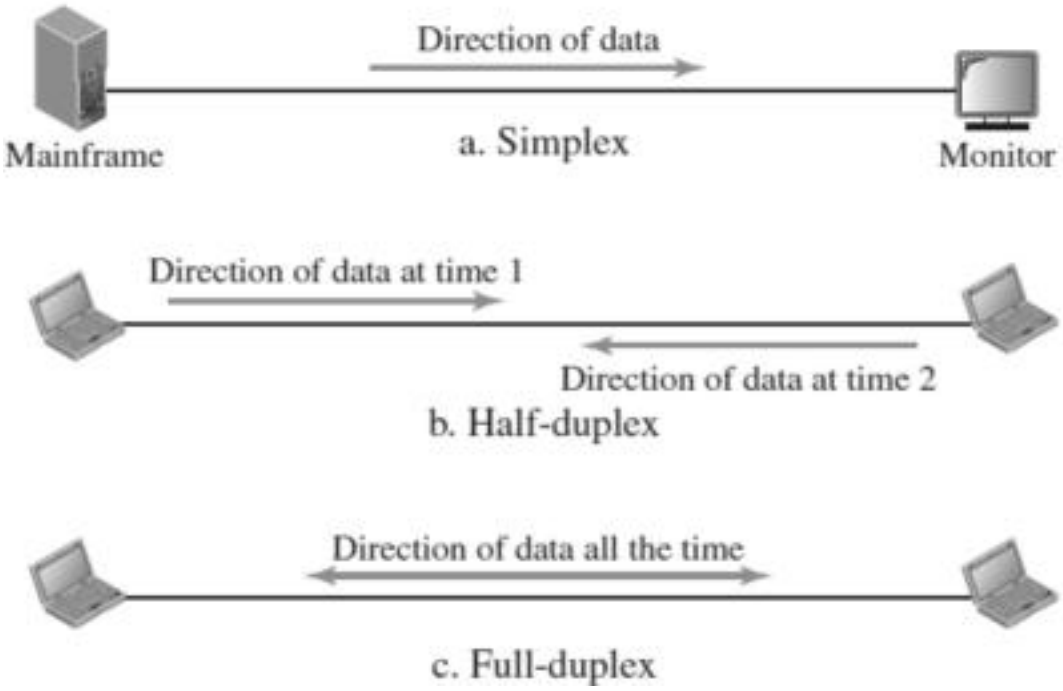
Receiver: The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on. Some devices can be receiver only such as printer.

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.

Protocols: it is a standardized set of rules for formatting, processing and sending data.

## 5. Data Flow:

Communication between two devices can be simplex, half-duplex, or full-duplex as shown in the following figure:




### a. Simplex:

In simplex mode, the communication is unidirectional. Only one of the two devices on a link can transmit; the other can only receive. Keyboards and traditional monitors are examples of simplex devices. The simplex mode can use the entire capacity of the channel to send data in one direction.

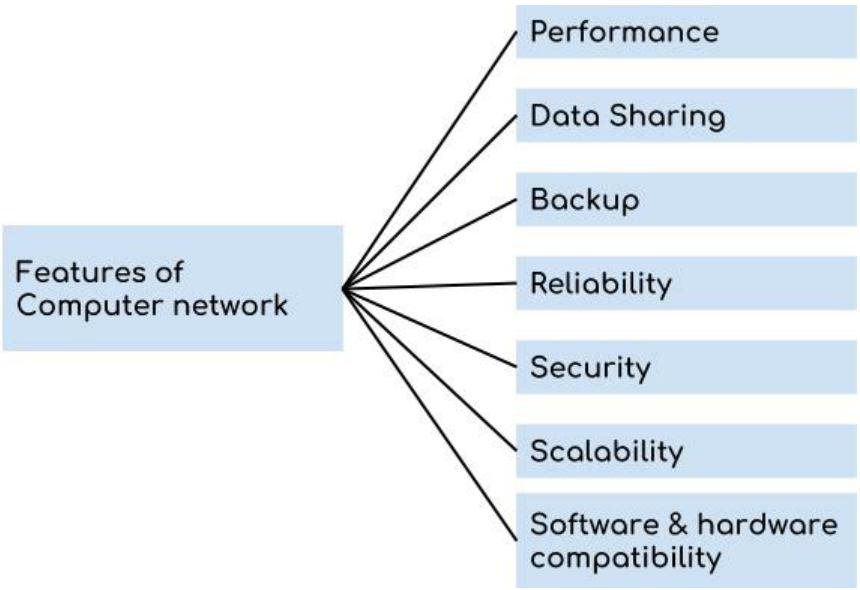
**Half-Duplex:** each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa. In half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time.

**Full-Duplex:** In mode, both stations can transmit and receive simultaneously. 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.

## 6. Network Criteria

A network must be able to meet a certain number of criteria. The most important of them are as the following.




**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. . We often need more throughput and less delay. However, these two criteria are often contradictory. 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.

**Data Sharing**: One of the reason why we use a computer network is to share the data between different systems connected with each other through a transmission media.

**Backup**: A computer network must have a central server that keeps the backup of all the data that is to be shared over a network so that in case of a failure it should be

able to recover the data faster.

**Software and hardware compatibility**: A computer network must not limit all the computers in a computer network to use same software and hardware, instead it should allow the better compatibility between the different software and hardware configuration.

**Reliability**: the 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 disaster.

**Security**: Network security issues include protecting data from unauthorized access, protecting data from damage, and implementing policies and procedures for recovery from data losses.

**Scalability**: A computer network should be scalable which means it should always allow to add new computers (or nodes) to the already existing computer network.

## 7. Computer Network Architecture

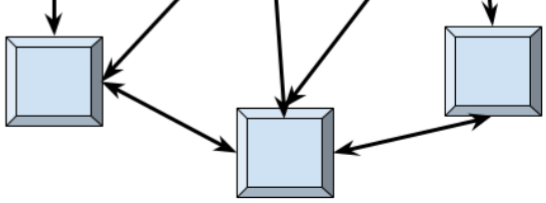
It is a design in which all computers in a computer network are organized. A architecture defines how the computers should get connected to get the maximum advantages of a computer network such as better response time, security, scalability etc. The two most popular computer architectures are **P2P (Peer to Peer)** and **Client-Server architecture**.

7.1. Peer to Peer Architecture: In peer to peer architecture all the computers in a network are connected with every computer in the network. Every computer in the network uses the same resources as other computers. There is no central computer that acts as a server rather all computers acts as a server for the data that is stored in them.

### Advantages of a Peer to Peer Architecture

Less costly as there is no central server that has to take the backup.

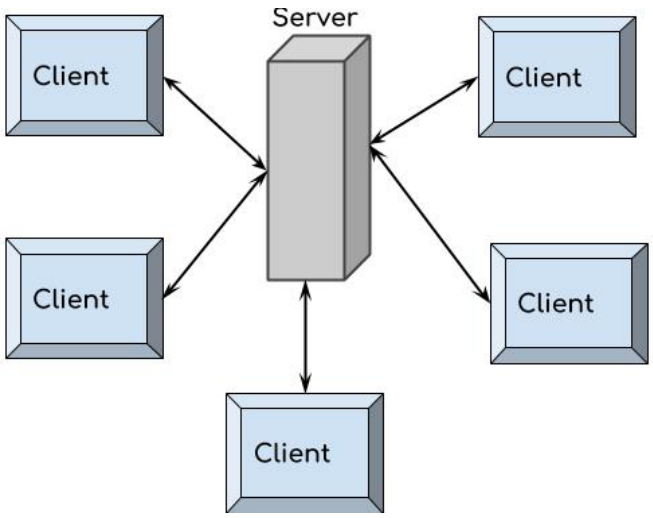
In case of a computer failure all other computers in the network are not affected and they will continue to work as same as before the failure.



3. Installation of peer to peer architecture is quite easy as each computer manages itself. **Disadvantages of a Peer to Peer Architecture**

- Each computer has to take the backup rather than a central computer and the security measures are to be taken by all the computers separately.
- Scalability is an issue in a peer to Peer Architecture as connecting each computer to every computer is a problem on a very large network.

## 7.2. Client Server Architecture




In Client Server architecture a central computer acts as a hub and serves all the requests from client computers. All the shared data is stored in the server computer which is shared with the client computer when a request is made by the client computer.

All the communication takes place through the server computer, for example if a client computer wants to share the data with other client computer then it has to send the data to server first and then the server will send the data to other client.

### Advantages of Client Server Architecture

- Data backup is easy and cost effective as there is no need to manage the backup on each computer.
- Performance is better as the response time is greatly improves because the server is more powerful computer than the other computers in the network.
- Security is better as unauthorized access is denied by server computer and all the data goes through the server.

Scalability is not an issue in this Architecture as large number of computers can be connected with server.

**Disadvantages of Client Server Architecture**

In case of server failure entire network is down.

Server maintenance cost is high as the server is the main component in this Architecture.

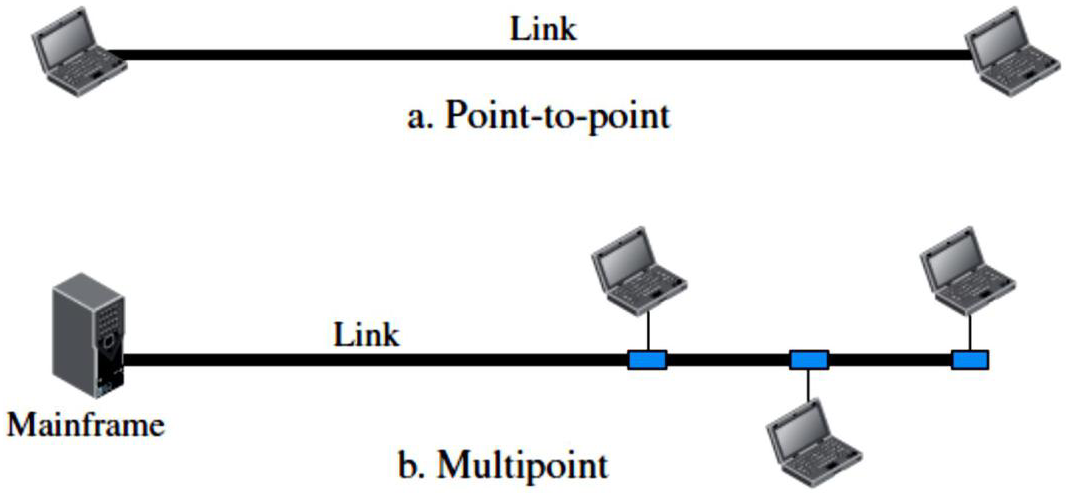
Cost is high as the server needs more resources to handle that many client requests and to be able to hold large amount of data.

## 8. Physical Structures

It is useful to define some physical attributes of the network.

### 8.1. Type of Connection

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 and multipoint.




8.2. A **node** (station) is any network device that can connect to the network and can generate, process, or transfer network data. Every node has at least one unique network address.

8.3. A **server:** it shares resources with and responds to requests from other network computers, including other servers. Servers provide centralized access and storage for resources that can include applications, files, printers or other hardware, and specialized services such as email. A server can be optimized and dedicated to one specific function, or it can serve general needs. Multiple servers of various types can exist on a single network.

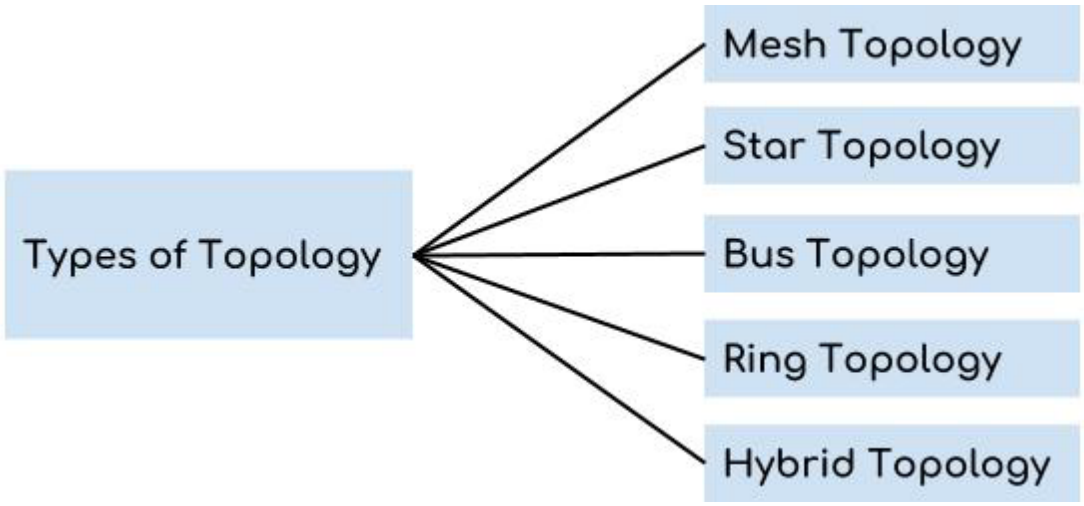
8.4. A **client** is a network computer that utilizes the resources of other network computers, including other clients. The client computer has its own processor, memory, and storage, and can maintain some of its own resources and perform its own tasks and processing. Any type of computer on a network can function as a client of another computer from time to time.

8.5. **Broadcasting**: it is a transmission method in which data goes from a source node to all other nodes on a network. Each one receives the data and acts on it.

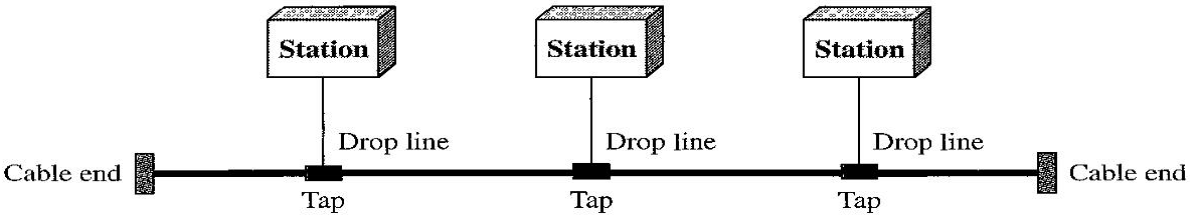
8.6. **Multicast transmission**: it is a transmission method in which data is sent from a client or server to specific nodes that are defined as members of a multicast group. Network nodes not in the group ignore the data.

## 9. Topology

It specifies the layout of the networks and it can be physical or logical topology.
There are five basic topologies possible: mesh, star, bus, ring and hybrid.




9.1. **Bus Topology**: Bus topology is a network type in which every computer and network device is connected to single cable. When it has exactly two endpoints, then it is called **Linear Bus topology**.




**Advantages of bus topology**

1. Easy installation, each cable needs to be connected with backbone cable. Less cables required than Mesh and star topology

**Disadvantages of bus topology**

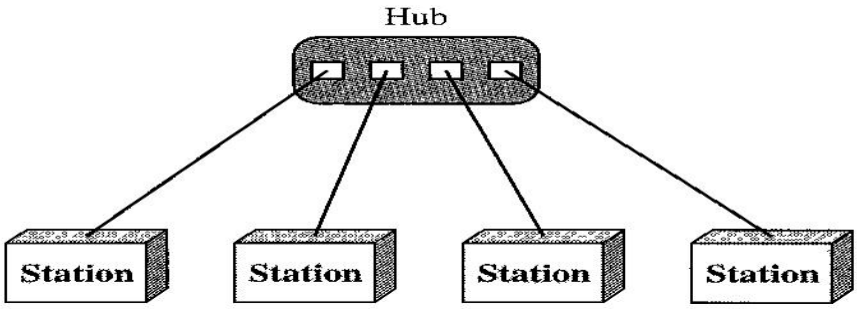
Difficultly in fault detection.

Not scalable as there is a limit of how many nodes you can connect with backbone

cable.

9.2. **Star Topology:** In a star topology, each device has a dedicated point-to-point link only to a central controller, usually called a hub (**no usual**). The devices are not directly linked to one another as a result 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 as shown in the following Figure:




### Advantages of Star topology

Less expensive because each device only need one I/O port and needs to be connected with hub with one link.

Easier to install.

Less amount of cables required because each device needs to be connected with the hub only.

Robust, if one link fails, other links will work just fine.

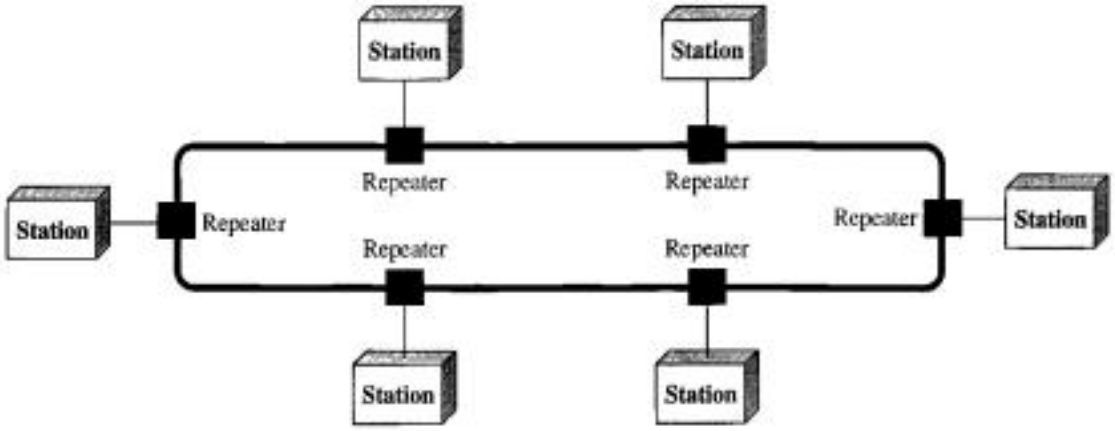
Easy fault detection because the link can be easily identified.

### Disadvantages of Star topology

If hub goes down everything goes down, none of the devices can work without hub.

Hub requires more resources and regular maintenance because it is the central system of star topology.

9.3. **Ring Topology:** In this topology, each device has a dedicated point-to-point connection with only the two devices on either side of it. 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 as shown in the following figure:




## Advantages of Ring Topology

Easy to install.

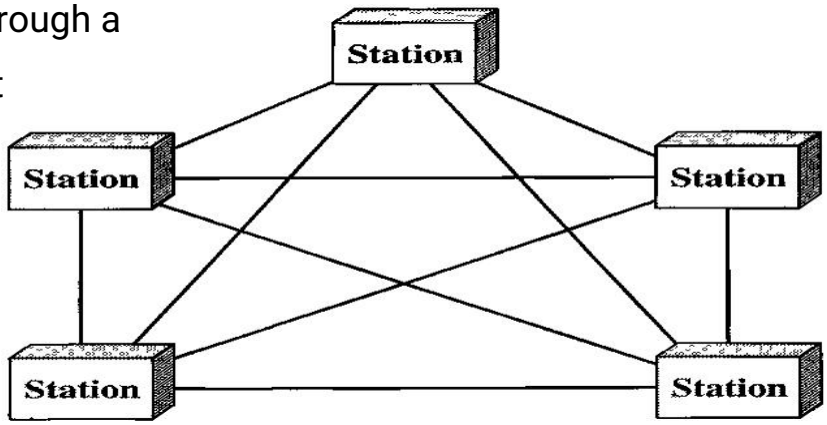
Managing is easier as to add or remove a device from the topology only two links are required to be changed.

## Disadvantages of Ring Topology

A link failure can fail the entire network as the signal will not travel forward due to failure.

Data traffic issues, since all the data is circulating in a ring.

9.4. **Mesh Topology:** In mesh topology each device is connected to every other device on the network through a dedicated point-to-point link. When we say dedicated it means that the link only carries data for the two connected devices only. Let's say we have n devices in the network then each device must be connected with (n-1) devices of the network. Number of links in a mesh topology of n devices would be



## Advantages of Mesh topology

No data traffic issues as there is a dedicated link between two devices which means the link is only available for those two devices.

Mesh topology is reliable and robust as failure of one link doesn't affect other links and the communication between other devices on the network.

Mesh topology is secure because there is a point to point link thus unauthorized access is not possible.

Fault detection is easy.

## Disadvantages of Mesh topology

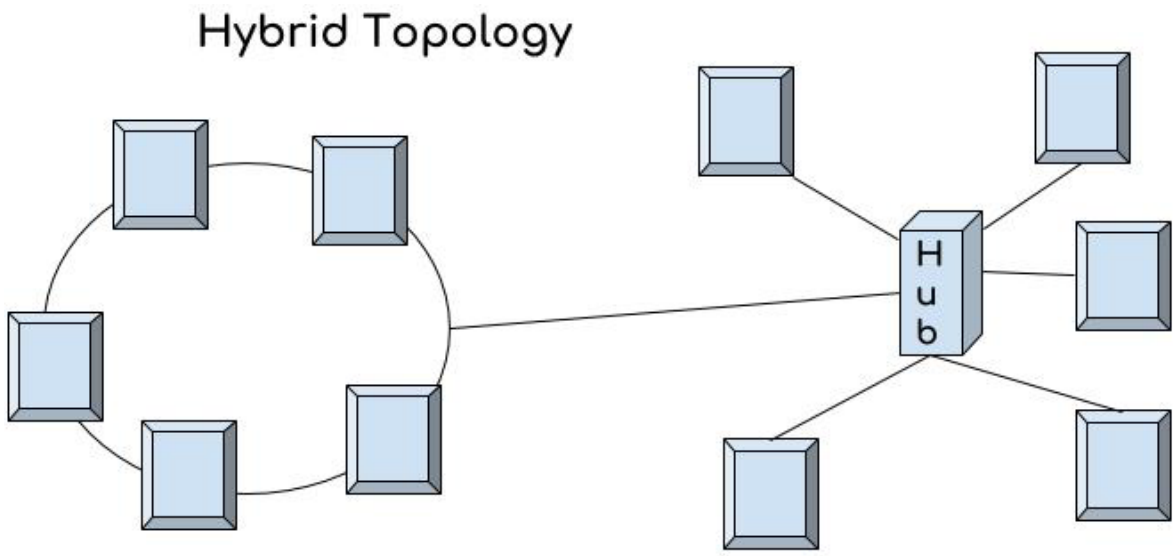
Amount of wires required to connected each system is tedious and headache.

Since each device needs to be connected with other devices, number of I/O ports required must be huge.

Scalability issues because a device cannot be connected with large number of devices with a dedicated point to point link.

## 9.5. Hybrid topology

A combination of two or more topology is known as hybrid topology. For example a combination of star and mesh topology is known as hybrid topology.




## Advantages of Hybrid topology

1. We can choose the topology based on the requirement for example, scalability is our concern then we can use star topology instead of bus technology. Scalable as we can further connect other computer networks with the existing networks with different topologies.

## Disadvantages of Hybrid topology

Fault detection is difficult.

Installation is difficult.

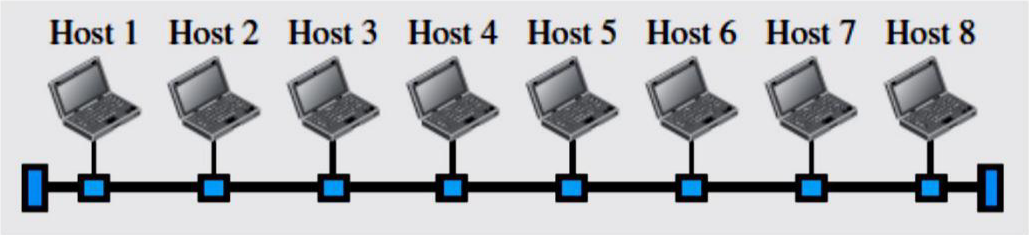
Design is complex so maintenance is high thus expensive.

## 10. Network Categories:

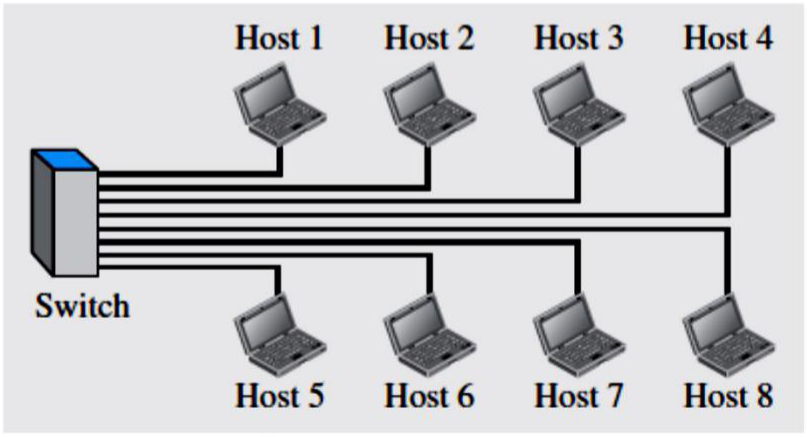
Networks can be categorized according to size into three types:

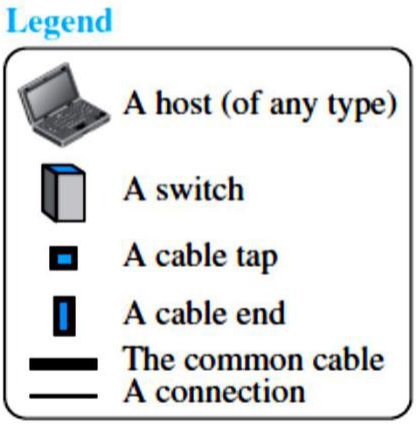
Local area network (LAN): it is usually privately owned and links the devices in a single office, building or campus of up to few kilometers in size. LANs are distinguished from other kinds of networks by three categories: their size, transmission technology and topology. LANs are restricted in size, which means that their worst-case transmission time is bounded and known in advance. Hence this is **more reliable** as

compared to MAN and WAN. It also **simplifies** network management. LAN typically used **transmission technology** consisting of single cable or internetworking device to which all machines are connected. Early LANs had data rates in the 4 to 16 megabits per second (Mbps) range. Today, however, speeds are normally 100 or 1000 Mbps. The most common LAN topologies are bus, ring and star. Wireless LANs are the newest evolution in LAN technology.



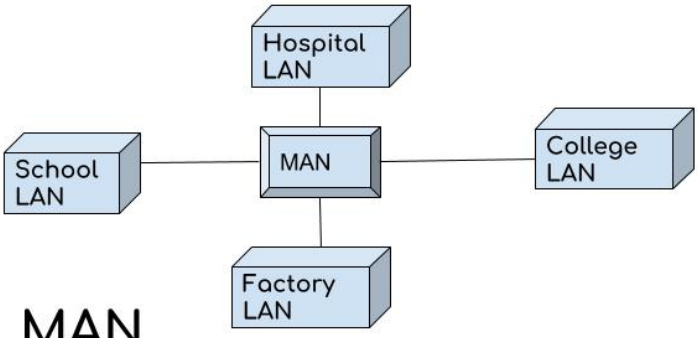

a. LAN with a common cable (past)




b. LAN with a switch (today)

Metropolitan area network (MAN): it is designed to extend over the entire city. It may be a single network as a cable TV network or it may be means of connecting a number of LANs into a larger network so that resources may be shared as shown in the next figure. For example, a company can use a MAN to connect the LANs in all its




MAN

offices in a city. MAN is wholly owned and operated by a private company or may be a service provided by a public company.

Wide area network (WAN): WAN provides long-distance transmission of data, voice, image and information over large geographical areas that may comprise a country, continent or even the whole world. In contrast to LANs, WANs may utilize public, leased or private communication devices, usually in combinations, and can therefore span an unlimited number of miles as shown in the following figure.


11. **Media access**:

In telecommunication systems, transmission media can be divided into two broad categories:

Guided media: include twisted-pair cable, coaxial cable, and fiber-optic cable. A signal traveling along any of these media is directed and contained by the physical links such as TP, Coax cable and optical fiber.

Unguided media: it is free space. It is often referred to as wireless communication. The signals are normally broadcast through free space such as radio waves and laser waves.