Chapter One

Introduction to Networking

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

1.1- Data Communication:

When we communicate, we are sharing information. This sharing can be **local** or **remote**. ***Local communication*** usually occurs face to face, while ***remote communication*** takes place over distance.

The term ***Telecommunication,*** which includes telephony and television, means *communication at a distance*.

Data communication is the exchange of *data* (in the form of 0's and 1's) between two *devices* via some form of *transmission medium* (such as a wire cable).

1.2- Components:

A data communication system is made up of five components (see Figure 1).

1. ***Message***: The message is the information (data) to be communicated. It can consist of text, numbers, pictures, sound, or video—or any combination of these.
2. ***Sender***: The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
3. ***Receiver***: The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
4. ***Medium:*** The transmission medium is the physical path by which a message travels from-sender to receiver. It can consist of twisted pair wire, coaxial able, fiber- optic cable, laser, or radio waves.

5. **Protocol**: A protocol is a set of rules that govern data communication. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating; just as a person who speaks, only Japanese cannot understand a person speaking French.

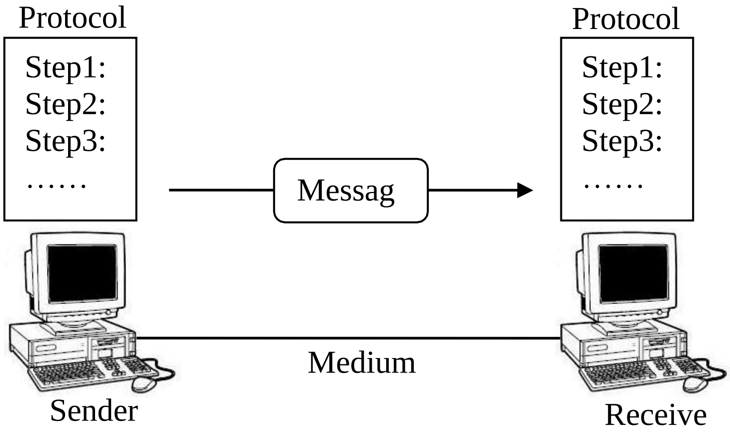


Figure (1) Components of a Data Communication System

1.3 Network Criteria:

To be considered effective and efficient, a network must meet a number of criteria. The most important of these are ***performance***, ***reliability***, and ***security***.

(A) 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:

 Number of users:

Having a large number of concurrent users can slow response time in a network not designed to coordinate heavy traffic loads. The design of a given network is based on an assessment of the average number of users that will be communicating at any one time. How a network responds to loading is a measure of its performance.

- ***Type of transmission medium***:

The medium defines the speed at which data can travel through a connection (the data rate). Today’s networks are moving to faster and faster transmission media, such as fiber optic cabling. A medium that can carry data at 100 megabits per second is ten times more powerful than a medium that can carry data at only 10 megabits per second.

- ***Hardware***:

The types of hardware included in a network affect both the speed and capacity of transmission. A higher speed computer with greater storage capacity provides better performance.

- ***Software***:

The software used to process data at the sender, receiver, and intermediate nodes also affects network performance. Moving a message from node to node through a network requires processing to transform the raw data into transmittable signals, to route these signals to the proper destination, and to recast the signals into a form the receiver can use. The software that provides these services affects both the speed and the reliability of a network link. Well-designed software can speed the process and make transmission more effective and efficient.

(B) <u>Reliability:</u>

In addition to accuracy of delivery, network reliability is measured by frequency of failure, the time it takes a link to recover from a failure, and the network’s robustness.

- ***Frequency of failure***:

All networks fail occasionally. A network that fails often, however, is of little value to a user.

- ***Recovery time of a network after a failure***:

How long does it take to restore service? A network that recovers quickly is more useful than one that does not.

- ***Catastrophe*:**

Networks must be protected from catastrophic events such as fire or theft. One protection against unforeseen damage is a reliable system to back up network software.

(C) Security:

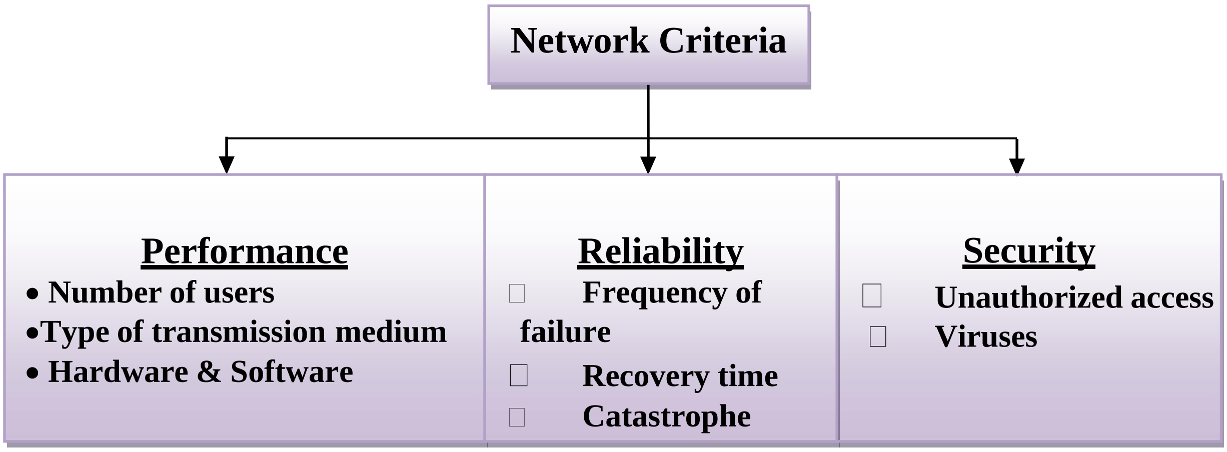
Network security issues include protecting data from unauthorized access and viruses.

- ***Unauthorized access***:

For a network to be useful, sensitive data must be protected from unauthorized access. Protection can be accomplished at a number of levels. At the lowest level are user identification codes and passwords. At a higher level are encryption techniques.

- ***Viruses***:

Because a network is accessible from many points, it can be susceptible to computer viruses. A virus is an illicitly introduced code that damages the system. A good network is protected from viruses by hardware and software designed specifically for that purpose.



Network Criteria

Performance
- **Number of users**
- **Type of transmission medium**
- **Hardware & Software**

Reliability
□ **Frequency of failure**
□ **Recovery time**
□ **Catastrophe**

Security
□ **Unauthorized access**
□ **Viruses**

1.4- Applications

Some of the network applications in different fields are the following:

- Marketing and sales.
- Financial services.
- Manufacturing.
- Electronic messaging.
- Information services.
- Cellular telephone.
- Cable television.

1.5- Protocols and Standards

- ***Protocols***

In computer networks, communication occurs between entities in different systems. An entity is anything capable of sending or receiving information. Examples include application programs, file transfer packages, browser, and database management systems and electronic mail software. A system is physical object that contains one or more entities. Examples include computers and terminals. However, two entities cannot just send bit streams to each other and expect to be understood. For communication to occur, the entities must agree on a protocol. *A protocol is a set of rules that govern data communication. A protocol defines what is communicated, how it's communicated, and when its communicated.*

- ***Standards***

A standard provides a model for development that makes it possible for a product to work regardless of the individual manufacturer. Standards are essential in creating and maintaining an open and competitive market for equipmentmanufacturer and in guaranteeing national and international interoperability of data and telecommunications technology and processes.

Standards are developed by cooperation among a standards creation committees, forums, and government regulatory agencies such as:

- The **I**nternational **S**tandards **O**rganization **(ISO)**
- The **I**nternational **T**elecommunications **U**nion **(ITU)**
- The **A**merican **N**ational **S**tandards **I**nstitute **(ANSI)**
- The **I**nstitute of **E**lectrical and **E**lectronics **E**ngineers **(IEEE)**

1.6- Basic Concepts of Networking

Before examining the specifics of how data are transmitted from one device to another it is important to understand the relationship between the communicating devices. Five general concepts provide the basis for this relationship.

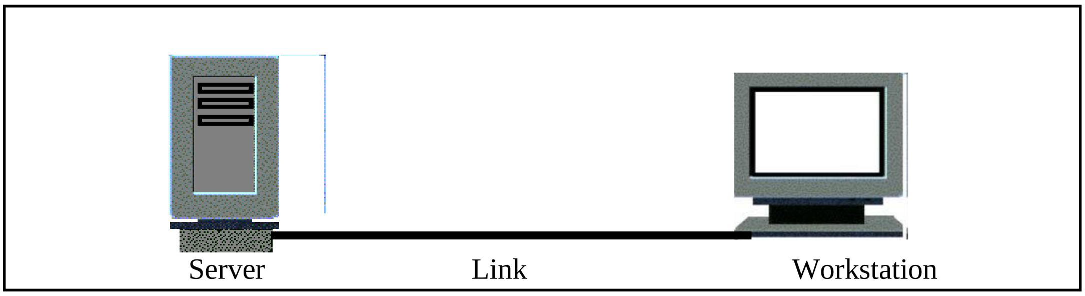
- Line configuration.
- Topology.
- Transmission mode.
- Categories of networks.
- Internetworks.

1.6.1- Line Configuration

Line configuration refers to the way two or more communication devices attach to a link. A link is the physical communication pathway that transfers data from one device to another. Line configuration defines the attachment of communication devices to a link. There are two possible line configurations:

Point-to-Point

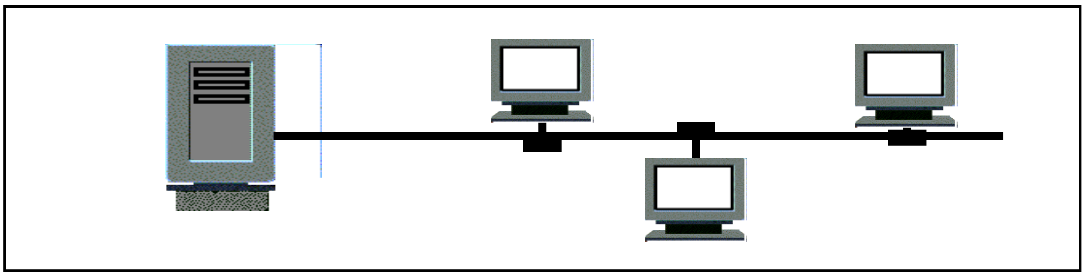
A point-to point line configuration provides a dedicated link between two devices. The entire capacity of the channel is reserved for transmission between those two devices. Most point-to-point line configurations use an actual length of wire or cable to connect the two ends but other options, such as microwave or satellitelinks are also possible (see Figure below)



Multipoint

A multipoint (also called multidrop) line configuration is one in which more than two specific devices share a single link (see Figure below).

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 line configuration. If users must take turns, it is a time shared line configuration.



1.6.2- Topology

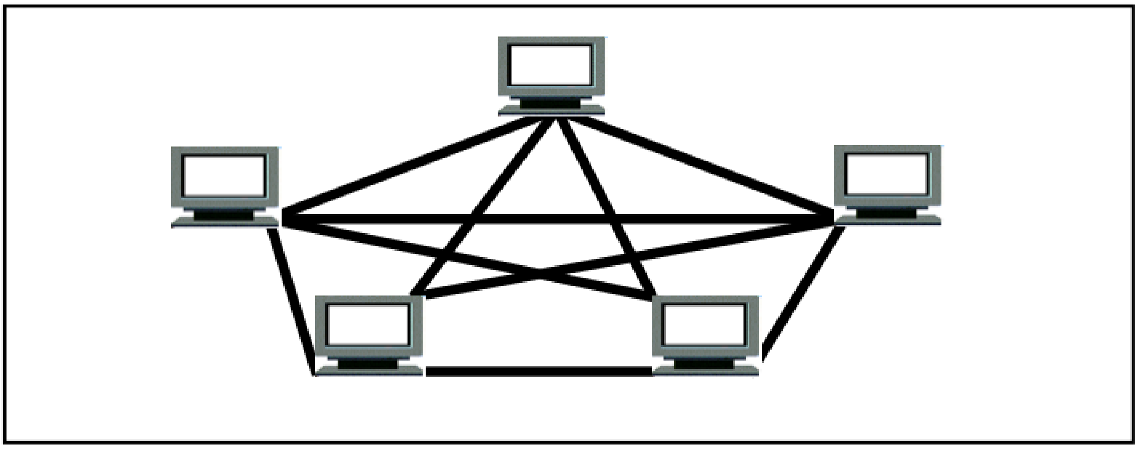
The term topology refers to the way a network is laid out, either physically or logically. Two or more devices connect to a link; two or more links form a topology. ***The topology of a network is the geometric representation of the relationship of all the links and linking devices (nodes) to each other***.

There are five basic topologies possible. These five labels describe how the devices in a network are interconnected rather than their physical arrangement.

Two relationships are possible: ***peer-to-peer***, where the devices, share the link equally, and ***client-server***, where one device controls traffic and the others must transmit through it. Ring and mesh topologies are more convenient for peer-to- peer transmission, while star and tree are more convenient for client-server. A bus topology is equally convenient for either,

- ***Mesh***

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.
A fully connected mesh network therefore has **[n (n-1) / 2]** physical channels to link it devices. (See Figure below).



A mesh offers ***several advantages*** over other network topologies:

1. The use of dedicated links guarantees that each connection can carry its 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 affect the entire system.
3. Security where every message sent travels along a dedicated line, only the intended recipient see it.
4. Point-to-point links make fault identification and fault isolation easy.

The main ***disadvantages*** of a mesh topology are:

1. Difficult installation and reconfiguration because every device must be connected to every other device.
2. The bulk of the wiring can be greater than the available space can accommodate.
3. The hardware required to connect each link can be expensive.

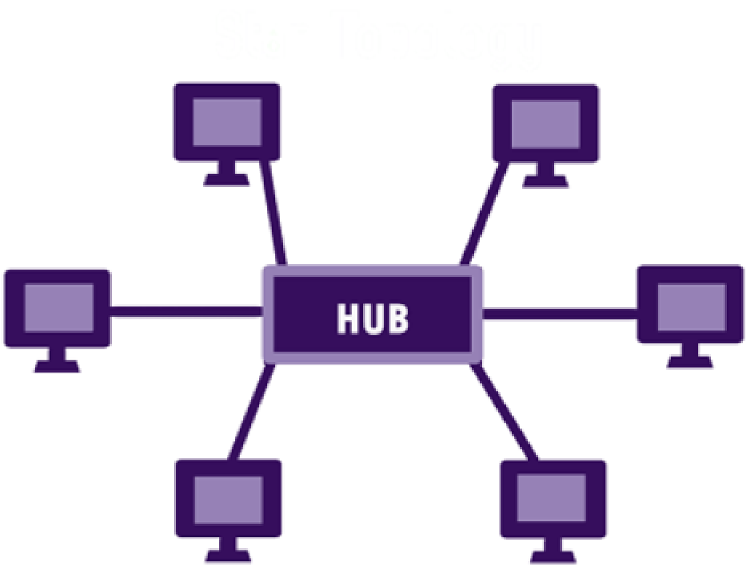
Due to these reasons, a mesh topology is usually of limited use

□ ***Star***

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 linked to each other. 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 to the controller, which then relays the data to the other connected devices (see Figure below).

The ***advantages*** of star topology are:

1. Less expensive than a mesh topology.
2. Easy to install.
3. Robustness. If one link fails, only that link is affected.
4. Easy fault identification and fault isolation. As long as the hub is working, it can be used to monitor link problems and bypass defective links.

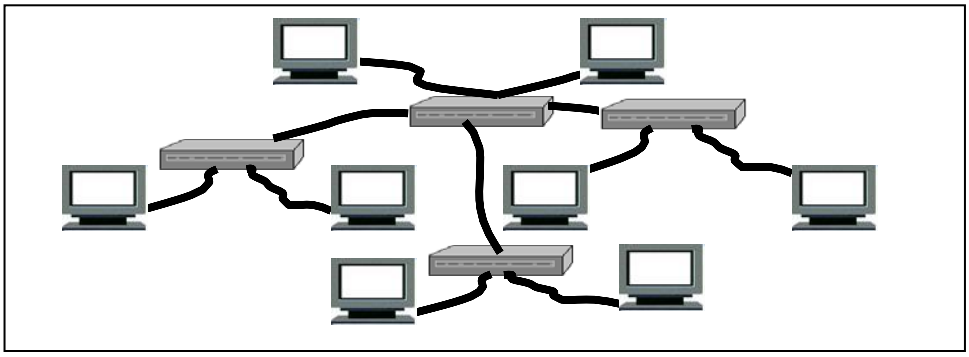


The ***disadvantages*** of the star topology are:

1. Any fault occur to the central controller will drop down the entire network.
2. Although the star needs less cabling than mesh, it still needs more cables than ring and tree topology.

- ***Tree***

A tree topology is a variation of a star. However, not every device plugs directly into the central hub. The majority of devices connect to a secondary hub that in turn is connected to the central hub (see Figure below).



The central hub in the tree is an active hub. An ***active hub*** contains a repeater, which is a hardware device that regenerates the received bit patterns before sending them out. Repeating strengthens transmissions and increases the distance a signal can travel between sender and receiver.

The secondary hubs may be active or ***passive hubs***. A passive hub provides a simple physical connection between the attached devices. Internally, each passive hub contains a set of resistors to balance the circuit linking the connected devices.

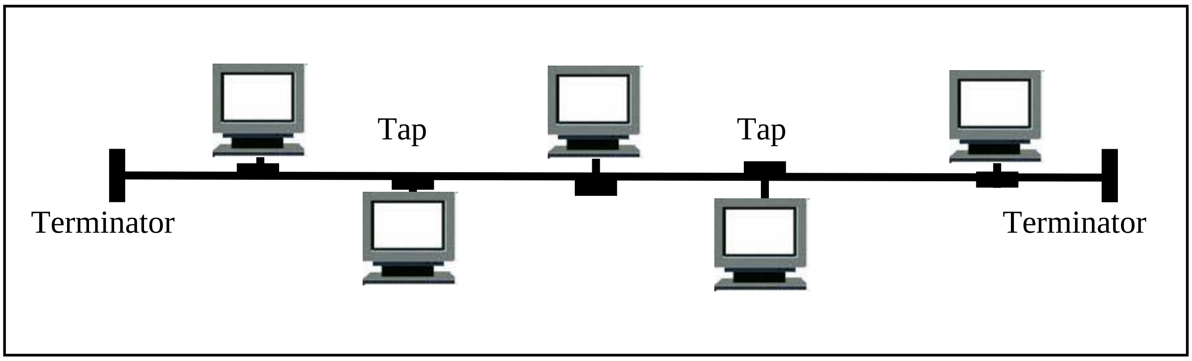
The advantages and disadvantages of a tree topology are generally the same as those of a star. The addition of secondary hubs however, brings two ***further advantages.***

First, it allows more devices to be attached to a single central hub and can therefore increase the distance a signal can travel between devices.

Second, it allows the network to isolate and prioritize communications from different computers.

 Bus

The preceding examples all describe point-to-point configurations A bus topology on the other hand, is multipoint. One long cable acts as a backbone to link all the devices in the network (see Figure below).



Nodes are connected to the bus cable by drop lines and taps. A drop line is a connection that running between the device and the main cable, a tap is a connector that splices into the main. As a signal travels along the backbone, some of its energy is transformed into heat. Therefore, it becomes weaker and weaker the farther it has to travel. For this reason, there is a limit on the number of taps a bus can support and on the distance between those taps.

The ***advantages*** of a bus topology are:

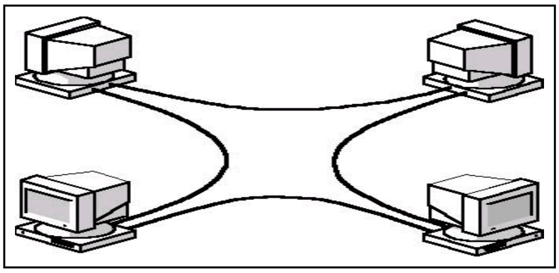
1. Ease of installation.
2. Backbone cable can be laid along the most efficient path, then connected to the nodes by drop lines of various lengths.
3. Use less cabling than mesh, star, and tree topologies.

While the ***disadvantages*** are:

1. Difficult reconfiguration and fault isolation.
2. 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.

- ***Ring***

In a ring topology, each device has a dedicated point-to-point line configuration only with 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 (see, Figure below).



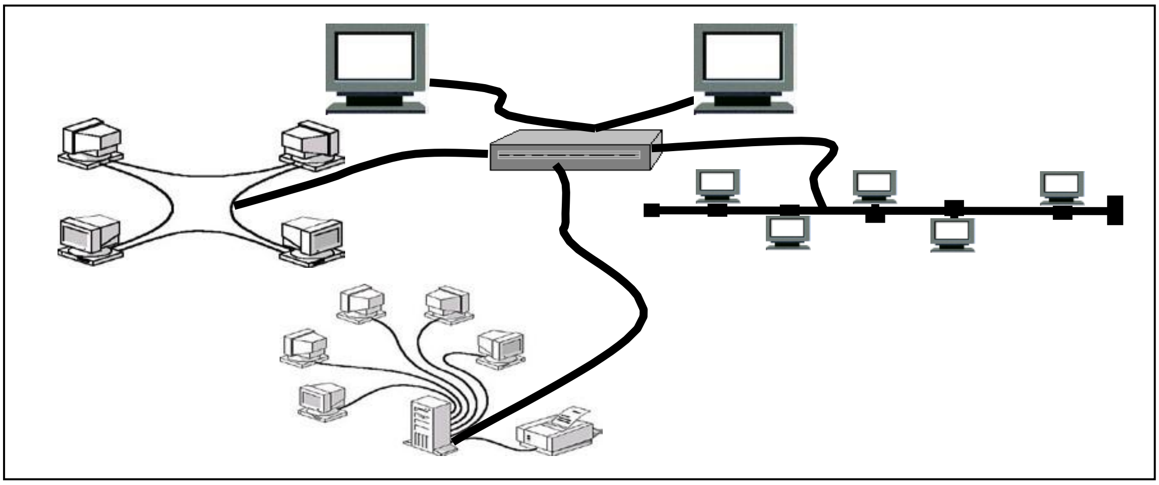
The ***advantages*** of ring topology are:

1. Relatively easy to install and reconfigure.
2. Addition or deletion of a device requires moving only two connections.
3. Fault isolation is simplified.

The ***disadvantage*** of the ring topology is that a break in the ring (such as a disabled station) can disable the entire network.

- ***Hybrid Topologies***

Often a network combines several topologies as sub-networks linked together in a larger topology. For instance, one department of a business may have decided to use a bus topology while another department has a ring. The two can be connected to each other via a central controller in a star topology (see Figure below).



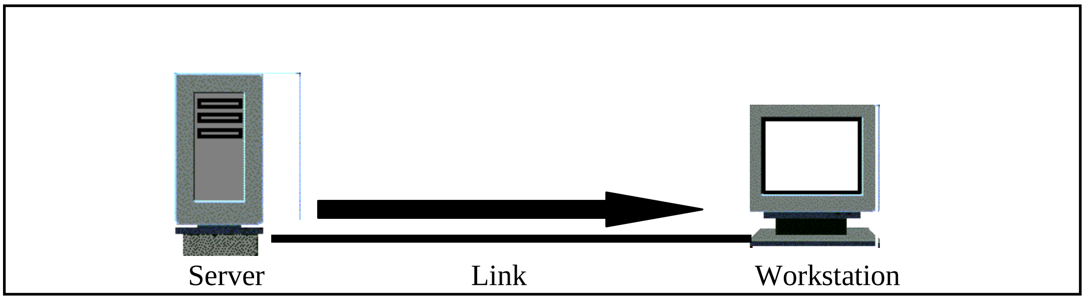
1.6.3- Transmission Modes

The term transmission mode is used to define the direction of signal flow between two linked devices. There are *three* types of transmission modes:

□ ***Simplex.***
□ ***Half duplex.***
□ ***Full duplex***

Simplex

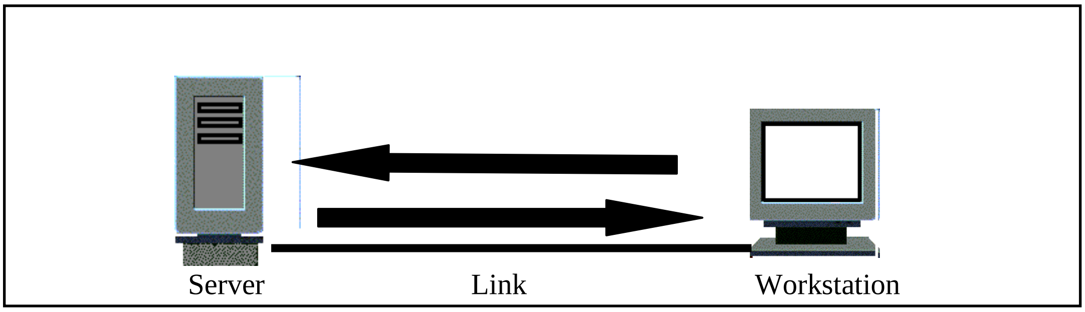
In, simplex mode, the communication is unidirectional, as on a one-way street. Only one of the two stations on a link can transmit the other can only receive (see Figure below).



Keyboards and traditional monitors are both examples of simplex devices. The keyboard can only introduce input; the monitor can only accept output.

Half-Duplex

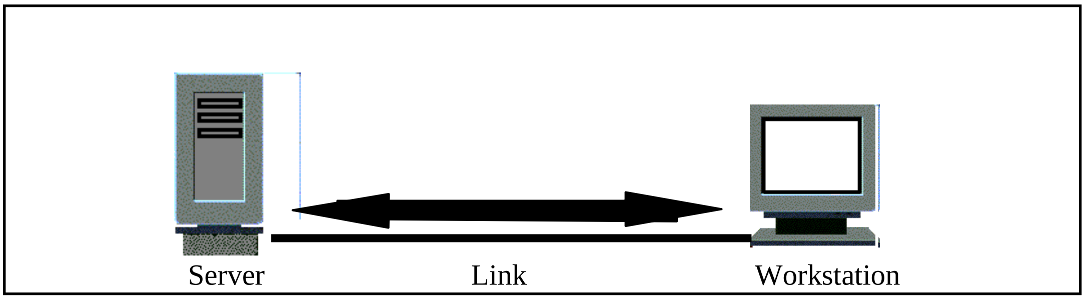
In half-duplex mode, each station can both transmit and receive, but not at the same time When one device is sending, the other can only receive, and vice versa (see Figure below).



The half-duplex mode is like a one-lane road with two-directional traffic. 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. Walkie-talkies are half-duplex systems.

Full-Duplex

In full-duplex mode (also called duplex), both stations can transmit and receive simultaneously (see Figure below).



The full-duplex mode is like a two-way street with traffic flow in both directions at the same time. In full-duplex mode, signals going in either direction share the capacity of the link.

This sharing can occur in two ways: either the link must contain two physically separate transmission paths, one for sending or the other for receiving; or, the capacity of the channel is divided between signals traveling in opposite directions.

1.6.4- Categories of Networks

The category of a network can be determined

- According to its size.
- According to its physical architecture (center of control).
- According to transmission technology.
- According to its ownership.
- According to service providing.

(A) According to the size:

We are generally referring to three primary categories:

- ***Local area networks (LANs).***
- ***Metropolitan area networks (MANs).***
- ***Wide area networks (WANs).***

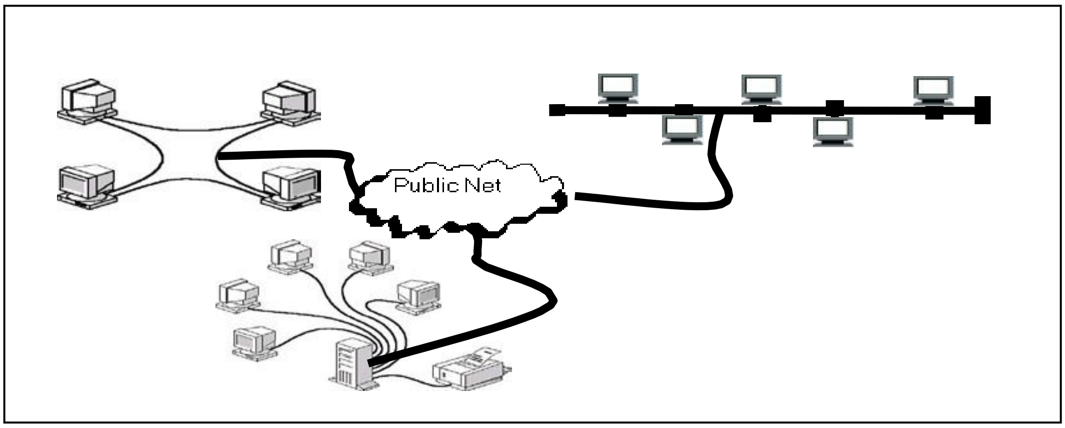
Local Area Network (LAN)

- ✓ A local area network is usually privately owned and links the devices in a single office building, or campus. Depending on the needs of anorganization and the type of technology used. A LAN can be as simple as two PCs and a printer in someone's home office or it can extend throughouta company and include voice, sound, and video peripherals. Currently, LANsize ***is limited to a few Kilometers.***
- ✓ LANs are designed to ***allow resources to be shared between personal computers or workstations***. The resources to be shared can include hardware (e.g., a printer), software (e.g., an application program), or data. Acommon example of a LAN, found in many business environments, links a work group of task-related computers, for example, engineering workstations or accounting PCs. One of the computers may be given a large-capacity disk drive and become a server to the other clients. Software can be stored on this central server and used as needed by the whole groupIn this example the size of the LAN may be determined by licensing restrictions on the number of users per copy of software, or by restrictionson the number of users licensed to access the operating system.
- ✓ In addition to size, LANs are distinguished from other types of networks by their ***transmission media and topology***. In general, a given LAN will use only one type of transmission medium. The most common LAN topologies are bus, ring, and star.
- ✓ Traditionally, LANs have data rates in the 4 to 16 Mbps range. Today, however, speeds are increasing and can reach 1Gbp***s*** or even ten's of Gigabits per seconds.

Metropolitan Area Network (MAN)

A metropolitan area network is designed to ***extend over*** an entire city. It may be a single network such as a cable television network or it may be a means of connecting a number of LANs into a larger network so that resources may be shared LAN-to-LAN as well as device-to-device. For example, a company can use a MAN to connect the LANs in all of its offices throughout a city (see Figure below).

A MAN may be wholly owned and operated by a private company, or it may be a service provided by a public company, such as a local telephone company. Many telephone companies provide a popular MAN service called Switched Multi-megabit Data Services (SMDS)



- **Wide Area Network (WAN)**

A wide area network provides ***long-distance*** transmission of data; voice, image, and video information over large geographical areas that may comprise a country,a continent, or even the whole world. In contrast to LANs (which depend on their own hardware for transmission), WANs may utilize public, leased, or private communication devices, usually in combinations, and can therefore span an unlimited number of miles. A WAN that is wholly owned and used by a single company is often referred to as an *enterprise network*.

(B) According to the physical architecture (center of control)

- **Centralized Networks**

  A central computer "Mini computer or Mainframe" that manages all communication and requests in the network.
- **Distributed Network**

  A group of Personal Computers (PC's) works together and share the same input / output devices.
- **Hybrid Network**

  A combination of centralized and distributed networks

(C) According to the ownership

- **Public Network**

  On a network that is owned, managed, and operated by a public company.
- **Private Network**

  Owned and managed by a private organization

(D) ***<u>According to transmission technology</u>***

- **Broadcasting Network**

  It does not restrict or determine a specified destination.

- **Point to Point Network**

  Data or packets are sent to a specify destination which is able to reflect an each of the receiving.

(E) ***<u>According to service providing</u>***

- **Peer to Peer Network**

  Any PC connected to this network can provide services to any other PC and request for services from any.

- **Client/Server Network**

  The most popular network. The net depends on a PC acts as a service provider called the SERVER. The server restricts the same policy to control the determination of the client how will get the service and type of service.

1.6.5- <u>Internetworks</u>

When two or more networks are connected they become an *Internetwork*, or***Internet***. Individual networks are joined into internetwork by the use of internetworking devices. These devices include *routers* and *gateways*.