

7

COMPUTER NETWORKS

7.1 COMPUTER NETWORK

A collection of computers and other devices connected together via communication devices and communication channels for sharing information and resources is called a *computer network*. The resources may include printers, scanners, and storage devices (such as hard disks). In a computer network, computers or devices are connected together via communication devices and transmission media. Examples of transmission media are cables and wirelessly or WiFi. The connected computers/devices in the network can be in the same room, building, or at different locations.

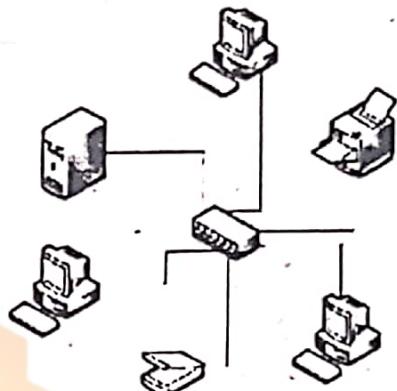


Figure: Computer Network

A computer network can be simple or very large. In a large computer network, usually many computer networks are connected together. This type of network is called a *network of networks*. The Internet is the most well-known example of a network of networks.

7.1.1 Uses of Computer Network

People around the world use computer networks every day in business, at offices, and homes, etc. Following are some important uses or benefits of a computer network:

1. Communication

People can communicate with each other around the world through computer networks. They can talk and share information with each other using different network services such as email, social networking, video conferencing, groupware, blogs, wikis, and SMS service.

2. Data Sharing

Different users connected to the computer network can share data among them. For example, on the Internet, a large number of users can access the same database.

3. Software Sharing

In a computer network, usually, application software and other software are installed on the central computer (i.e. server computer). These software can be shared over a network instead of purchasing a separate copy of the software for each user.

4- Hardware Sharing

In a computer network, hardware devices such as printers, scanners, CD-ROM drives, and hard disks can be shared among different users. For example, many users can share a single printer connected to a network. An organization can save a lot of money by sharing different devices over a network. Without the facility of the network, these devices have to be arranged separately for each user. It becomes very costly for an organization.

5- Internet Sharing

In a computer network (i.e. LAN), many users can access the Internet through a single Internet connection and can use its different services.

6- Centralized Software Management

All of the software are installed or updated on one computer (server computer). This saves the time for installing/updating on individual computers in the network. Users connected to a network can access these software/programs.

7- Data Security and Management

The computer network provides centralized data storage. It means that all data is stored on the central computer. In a business environment, an administrator manages the company's critical data in a better way. Everyone can find the data easily. The administrator has full control and he/she can read or change critical information. He/she can take the backup of data very easily. Similarly, security features can also be implemented on the data very easily.

8- Saving Disk Space

In a computer network, all computers use the same copy of application programs and data files. These are only stored on the hard disk(s) of the server computer. There is no need to store application programs and data files on individual computers on the network. In this way, disk space on each computer is saved.

9- Performance Enhancement

A network can be used to improve (enhance) the performance of different applications by using distributed computing. In distributed computing, a computation task is divided on various computers on the network. In this way, the performance of the application is increased.

10- Entertainment

The computer network provides many sources of entertainment to the people. For example, we can play different types of games, see movies, and listen to music. We can also make new friends on the Internet.

11- Remote Access

A network also provides the facility to access data remotely. A user can access and update data by connecting to the network from anywhere in the world.

7.2 TYPES OF NETWORK

The computer networks are divided into the following types based on the size and physical area or distance covered by the network:

- i) Local Area Network
- ii) Wide Area Network
- iii) Metropolitan Area Network
- iv) Personal Area Network (PAN)

7.2.1 Local Area Network (LAN)

Local Area Network (LAN) is a type of computer network that covers a small area. It is generally limited to a building or group of adjacent buildings. It consists of a limited number of computers. LAN is designed to share different resources (such as printers, scanners, storage devices, and application programs) between computers. The network of computers in the computer laboratory of a college and network of computers in an office building are examples of LANs.

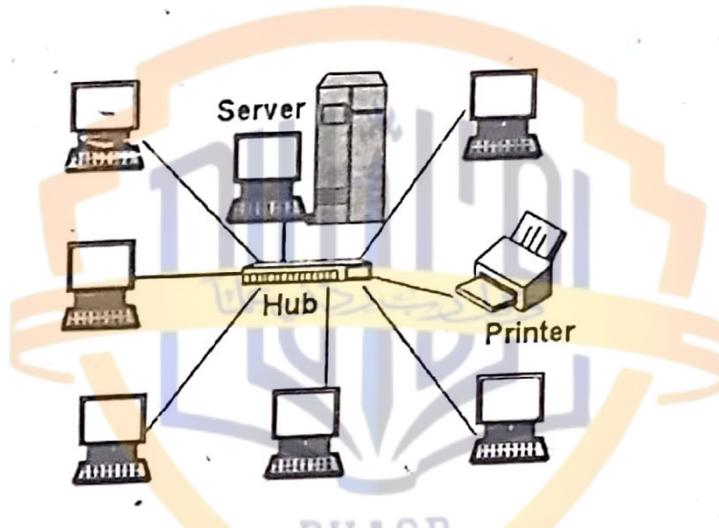


Figure: Local Area Network

In LAN, the nodes (computers and other devices such as printers and scanners) are connected to each other using cables or wireless transmission medium. Network Interface Card (NIC) is used in each computer to connect it to a LAN. The network card enables the computer to share information with other computers connected to the LAN. The data transmission rate through LAN is very fast. It is from 10 Mbps to 1 Gbps.

Advantages of LAN

Following are some advantages of LAN:

- i) **Resource Sharing:** The resources can be shared among different users. For example, many users on the network can use a single printer. Similarly, storage media and software located in the central server can be shared between all users on the network.

- ii) **Inexpensive:** It is inexpensive to install. The small businesses, firms, and educational institutes can afford and easily install the LAN.
- iii) **Communication:** The users can easily communicate with each other. They can also share data among them.
- iv) **Centralized Data:** All the data is stored and updated on the central server through nodes. So it becomes very easy to take a backup of the database at regular intervals.
- v) **Internet Access Sharing:** Multiple users can access the Internet using a single Internet connection. The Internet connection is established at the central server. In this way, all users can access the Internet.
- vi) **Data Security:** Data security can be implemented very easily because users are granted data access rights. The authorized users can connect to the server and can access a specific portion of the data.
- vii) **Speed:** Data transmission in a LAN is very fast.
- viii) **Reliability:** It is a very reliable network. Communication errors are very rare.

Disadvantages of LAN

Following are some disadvantages of LAN:

- ★ If the central server is infected by a virus, then the important data and software stored on the server may be corrupted and the entire network may also be affected.
- ★ All nodes depend on the central computer or device (i.e. Hub), if it fails, then the entire network will stop working.
- ★ A trained and competent network manager is required to run the LAN, so a handsome salary has to be paid to him. Therefore, it becomes very expensive to run the LAN.
- ★ Mostly in a LAN, one or two printers are shared among several users. In this situation, lengthy print queues are created. So the users have to wait for a long period of time to take print on the printer.

7.2.2 Wide Area Network (WAN)

A Wide Area Network (WAN) is a type of computer network that covers a large area such as different cities of the country or different countries and continents of the world. Typically, a WAN consists of many LANs connected together across a wide geographical area. Suppose an organization has a LAN at each site. The LANs of all sites are connected together to form a WAN. The Internet is the world's largest WAN. It connects many thousands of computers and LANs around the world and making it a web. WAN is expensive than LAN but its transmission rate is slower than LAN.

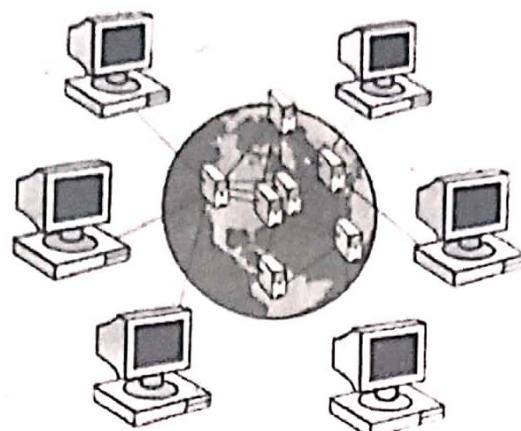


Figure: Wide Area Network

In WAN, computers and other devices are often connected through telephone lines. However, they can also be connected through leased lines, microwave, or satellite systems. A modem is used in computers to establish communication between computers over a long distance.

WANs are used in large organizations. For example, in Pakistan, large organizations like PIA, WAPDA, ARMY, NADRA, and BANKS use the WAN.

Advantages of WAN

Some important advantages of WAN are as follows:

Covers Large Area

WAN covers a large geographical area so long-distance businesses can connect on the network. Users can access the network from any location of the country or world.

Sharing and Communicating Messages

Messages can be shared and communicated all over the world. These messages can have text, pictures, and sounds. For example, users can communicate and share messages through video conference.

Centralized Data

The data of an organization is stored in a single location even if the organization is spread all over the world (or different cities of the country). Everyone on the network can use the same data. This avoids problems where some users may have older information than others.

Entertainment

WAN provides many sources of entertainment to users. For example, users can play different types of games, see movies, and listen to music over the Internet.

Disadvantages of WAN

Although WAN has many advantages, it also has some disadvantages. The main disadvantages are as follows:

i) **Hardware and Software Costs**

WAN becomes expensive to install. The devices and software that are required for installing WAN are very costly.

ii) **Management and Staff Training Costs**

Once WAN is setup, maintaining a network is a full-time job. Managing WAN is complicated. Trained and competent network managers/supervisors and technicians are required to run the WAN. So handsome salaries have to be paid to them. Therefore, it becomes very expensive to run the WAN.

The training for users to use the WAN is also required. Training is required at all levels, including network managers/administrators. The organization has to pay a lot of amount on the training of staff to run the network.

iii) **Slow for Data Transmission**

WAN is very slow for data transmission. Its data transmission rate is from 56 Kbps to 50 Mbps. Usually, the database applications perform their functions very slowly over WAN.

iv) **Security Issue**

Security is a real issue when many different people have the ability to use information from other computers. Protection against hackers and viruses adds more complexity. It needs a good firewall* to restrict outsiders from entering and disrupting the network. Viruses can also spread very quickly and easily through WAN.

v) **Failure of Server and Communication Line**

If a server fails, the entire network is affected. Similarly, a failure in the communication line may also stop the working of WAN.

7.2.3 Metropolitan Area Network (MAN)

A Metropolitan Area Network (MAN) is a network system that covers the area of a city or town. Usually, MAN consists of two or more LANs in a city or town which are connected together. For example, a company may design a MAN by connecting all the LANs in all its offices throughout the city. The cable television companies, telephone companies, and Internet Service Providers use MAN. Mobile phones (cellular) systems often use a MAN. MAN is larger than LAN and smaller than WAN. It covers an area of between 5 to 50 km diameter.

* Firewall is a security system consisting of hardware and/or software to prevent unauthorized access of a network or computer.

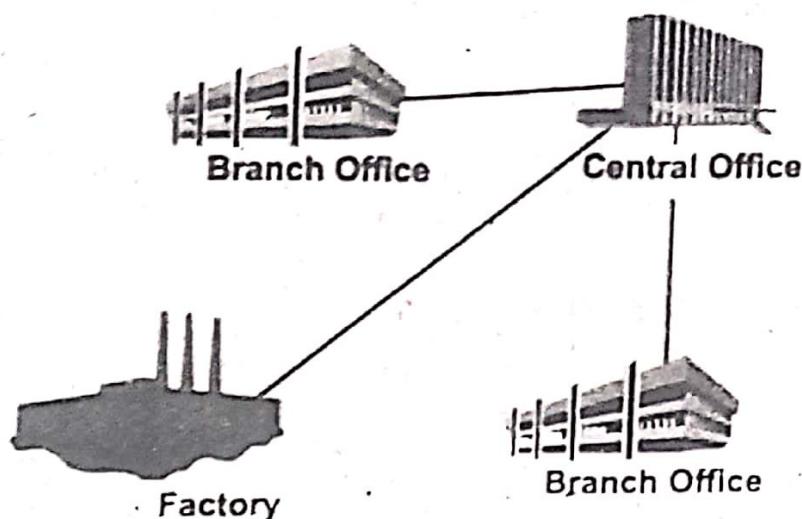


Image Public City Network (MAN)

A MAN uses different transmission media (wired or wireless) and devices for communication. In most of MANs, fiber optic cables are used as transmission media. So it is a very high-speed network.

Advantages of MAN

Following are some advantages of MAN:

- ★ It covers a larger area than LAN.
- ★ It requires fewer resources as compared to WAN. This saves the implementation cost.
- ★ It provides high-speed communication.
- ★ The resources can be shared among different users all over the city.
- ★ Its installation and maintenance is less expensive than WAN.
- ★ It provides higher security as compared to WAN.
- ★ Like LAN and MAN, it also provides centralized data management.

Disadvantages of MAN

Following are some disadvantages of MAN:

- ★ It is more expensive than LAN.
- ★ It becomes difficult to manage if the network becomes large.
- ★ It is difficult to make the system secure from hackers and industrial spying.
- ★ Network installation requires skilled technicians and network administrators. This increases the overall installation and management costs.

7.2.4 Personal Area Network (PAN)

A personal area network (PAN) is a network that connects personal computers and devices using wired and wireless technology. The computers/devices are typically located within a range of about 30 feet. The devices may include smartphones, digital cameras, printers, telephones, tablets, and PDAs. A PAN may connect devices through a router using network cables or directly using special USB cables. PANs also may use Bluetooth or Wi-Fi technology.

7.2.5 Difference between LAN & WAN

Following table shows the main differences between LAN and WAN:

LAN	WAN
1. It covers a small geographical area.	1. It covers a large geographical area.
2. Computers are directly connected through the physical cable or wireless connection.	2. Computers are connected through a telephone line or microwave system.
3. In LAN, the connection is permanent using cables.	3. In WAN, the connection is not permanent.
4. A network card is used in each computer for data transmission between computers.	4. Modem or router is used in each computer for data transmission between computers.
5. Its data transmission speed is faster than WAN.	5. Its data transmission speed is slower than LAN.
6. Its installation and configuration cost is less than WAN.	6. Its installation and configuration cost is greater than LAN.
7. It has less possibility of data transmission errors.	7. It has a higher possibility of data transmission errors.
8. In LAN, normally problems occur due to cable disturbance.	8. In WAN, normally problems occur due to telephone lines, or other wireless media.
9. In LAN, computers can be connected in a limited area.	9. In WAN, computers can be connected anywhere in the world.

7.3 NETWORK ARCHITECTURES

Network architecture is the design or layout of computers, devices, and media in a computer network. The computer network can be designed using different ways. The most popular network architectures are client-server network, peer-to-peer (P2P) network, and hybrid network.

7.3.1 Client-Server Network

A network architecture in which one or more computers act as *servers* and other computers act as *clients* is called a *client-server network*. In this network, servers are not used as clients and clients never act as servers. Both wired and wireless networks can be configured as a client-server network.

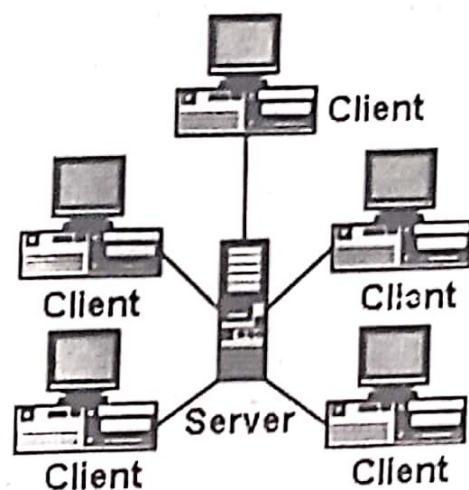


Figure: Client-Server Network

The server is a powerful computer. It is also called a *host computer*. It controls the whole network and provides services to the clients. It also provides a centralized storage area for data & software and centralized security to ensure that resources are not accessed by unauthorized users.

A client-server network may consist of two or more servers. Each server performs only one specific task. A server that performs only a specific task in the network is called a *dedicated server*. Some examples of dedicated servers are as follows:

- **File Server:** It stores and manages files.
- **Print Server:** It manages printers and print jobs.
- **Database Server:** It stores and manages databases. It also provides access to databases.
- **Application Server:** It stores and distributes application software on the network.
- **Network Server:** It manages network activity (or network traffic).
- **Web Server:** It stores web pages. It also receives requests from clients, processes the requests, and sends the results of requests to clients.
- **Email Server:** It stores and handles incoming and outgoing email messages.
- **Authentication Server:** It keeps track of the users who log on the network. It also keeps track of different services available to each user on the network.

All computers and mobile devices other than the server(s) in the client-server network are called *clients*. They can be PCs and laptops or other mobile computers or devices. The users run applications on the clients. For example, the users send requests to the server through clients. The server receives the requests from the clients and takes proper actions on these requests. The results of the requests are sent to the clients. The clients depend on the server for different resources like centralized storage, printing, and data processing, etc.

Advantages

The client-server or dedicated server network has the following advantages:

- ★ It reduces the volume of data traffic on the network.
- ★ It provides faster responses to the clients.
- ★ It allows using less expensive computers as clients because most of the work is done by the server.
- ★ It provides centralized security/management.
- ★ It provides the facility to easy backup of data.

Disadvantages

The main disadvantages of the client-server network are as follows:

- ★ More powerful computer is required to install as server. So it becomes very costly.
- ★ The entire network may be affected if there is any problem on the server.

7.3.2 Peer-to-Peer Network

A network architecture in which all computers on the network have equal status and no one has control over others is called a *peer-to-peer network* (or simply *P2P network*). In this network architecture, each computer or mobile device is called a *peer*. Each peer can act as both a server and client at the same time. Both wired and wireless networks can be configured as a peer-to-peer network.

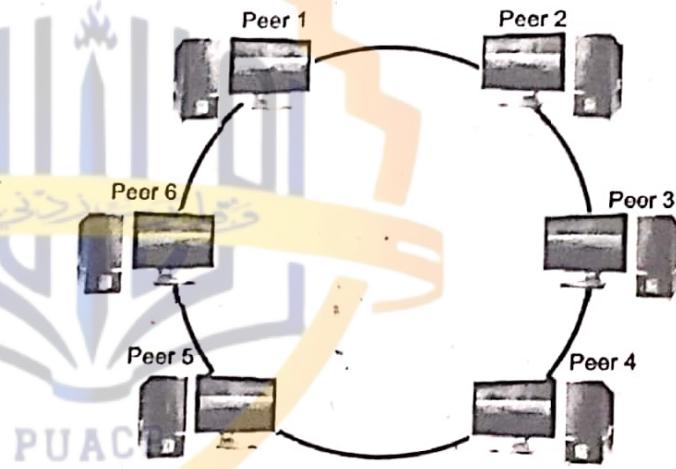


Figure: Peer-to-Peer Network

In peer-to-peer network architecture, there is no central computer to control other computers on the network. Each computer can share data and devices (or resources) of other computers in the network. For example, a printer attached to any computer can be used by all computers connected to the network. Each computer stores its data and program files because P2P does not have a common file server.

The peer-to-peer network is a simple and low-cost network. It normally consists of less than 10 computers. This type of network architecture is ideal for small businesses and home users. Some operating systems include a P2P networking tool that can be used to set up a peer-to-peer network.

Advantages

The main advantages of peer-to-peer network are as follows:

- ★ It is useful in small offices.
- ★ It is easy to design and to maintain.
- ★ It does not require any powerful computer.

Disadvantages

The main disadvantages of a peer-to-peer network are as follows:

- ★ It becomes slow under heavy use.
- ★ There is no central place for storing data and software.
- ★ In this network, data is not stored on a central computer. So it provides less security.

7.3.3 Hybrid Network

The hybrid network has combined features of both client-server and peer-to-peer networks. It also has one or more servers. Users can share data and software. Similarly, each node can store its own data files and programs and has its own peripheral devices. The users can also share each other's data and devices.

7.3.4 Distinguish between Client-Server & Peer-to-Peer Networks

The main differences between the client-server network and peer-to-peer network are as follows:

Client-Server Network	Peer-to-Peer Network
1. In this network, each computer is called either a <i>server</i> or a <i>client</i> .	1. In this network, each computer is called a <i>peer</i> .
2. In this network, one or more computers act as <i>servers</i> .	2. In this network, no computer act as a <i>server</i> .
3. In this network, there is one or more <i>dedicated servers</i> that control the other computers on the network.	3. In this network, there is no <i>dedicated server</i> or <i>central computer</i> to control other computers on the network.
4. It may consist of many computers.	4. It consists of less than ten computers.
5. Mostly data and program files are stored on the dedicated server.	5. Each computer stores its data and program files.
7. Data can be managed very easily because all data is stored on a dedicated server.	6. Data cannot be managed easily because data is stored on different computers.
7. It is used in large organizations.	7. It is useful in small offices/businesses.
8. In this network, data is stored on a central computer. So it provides the best security.	8. In this network, data is not stored on a central computer. So it does not provide proper data security.

7.4 NETWORK TOPOLOGIES

In networking, the term topology is the way of connecting computers or nodes on a network. There are many ways in which computers can be connected together in a computer network. The way in which computers or other devices are connected in a network is called *network topology*. Shortly the term network topology refers to the physical layout or shape of the network. The commonly used network topologies are as follows.

- | | |
|--------------------|--------------------|
| (i) Bus topology | (ii) Star topology |
| (ii) Ring topology | (iv) Tree topology |
| (v) Mesh topology | |

7.4.1 Bus Topology

In a Bus topology, all nodes are connected to a common communication medium. Usually, a central cable is used as a communication medium. This cable is called *Bus*. This cable is the backbone of the topology. The nodes are connected to the *Bus* through an interface connector. Both ends of the cable are closed with terminators. A terminator is a special small device that absorbs data signals (or prevents data signals). It is also known as *terminating resistance*. Bus topology is suitable for small networks.

Working of Bus Topology

When a sending computer wants to send a message, it has to determine whether the media is in use or free. If no other device is transmitting the data, it sends a message to the destination computer. The address of the destination computer is also attached to the message. This message moves from one computer to another through the bus. Each computer connected to the network receives the message, checks the attached address. If the attached message matches with the address of the computer, then it accepts the message. Otherwise, the message moves toward the next computer. When the message reaches the destination computer, it accepts the message. In this way, the message is received by the destination computer.

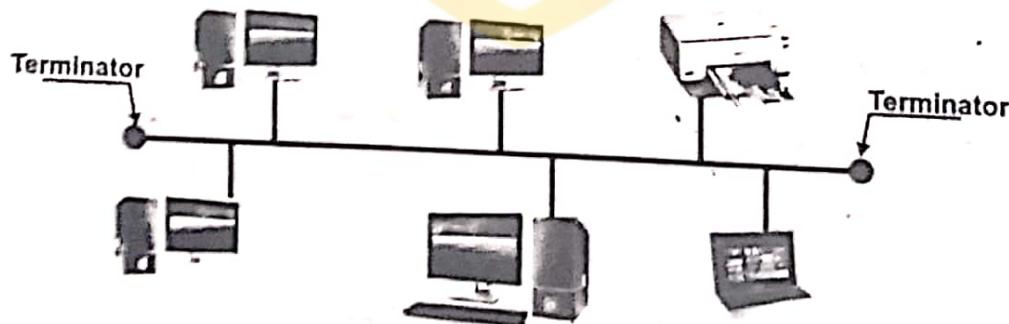


Figure: Bus Topology

Advantages

The main advantages of Bus topology are as follows;

- ★ It is a very simple network.
- ★ It is easy to install and to maintain.

- ★ It is less expensive because it requires a single cable to connect devices.
- ★ When nodes are added and removed in the network, the network is not affected.
- ★ If one node fails in the network, other nodes are not affected.

Disadvantages

The main disadvantages of Bus topology are as follows:

- ★ The entire network fails if there is any problem with the bus (central cable).
- ★ It supports only a small number of nodes. So it is not suitable for a large network.

7.4.2 Star Topology

In a star network, all nodes are directly connected to a central device, called *Hub* or *Switch*. This central device controls all the traffic. Usually, the nodes are connected to the Hub with unshielded twisted pair (UTP). The shape of the Star network looks like a star. Star topology is most commonly used in LAN.

Working of Star Topology

In the Star network, the computers communicate with each other through a central device i.e. hub. The sending computer sends data to the central device. The central device sends data to the receiving computer. In this way, data is transferred from one computer to another in the Star network.

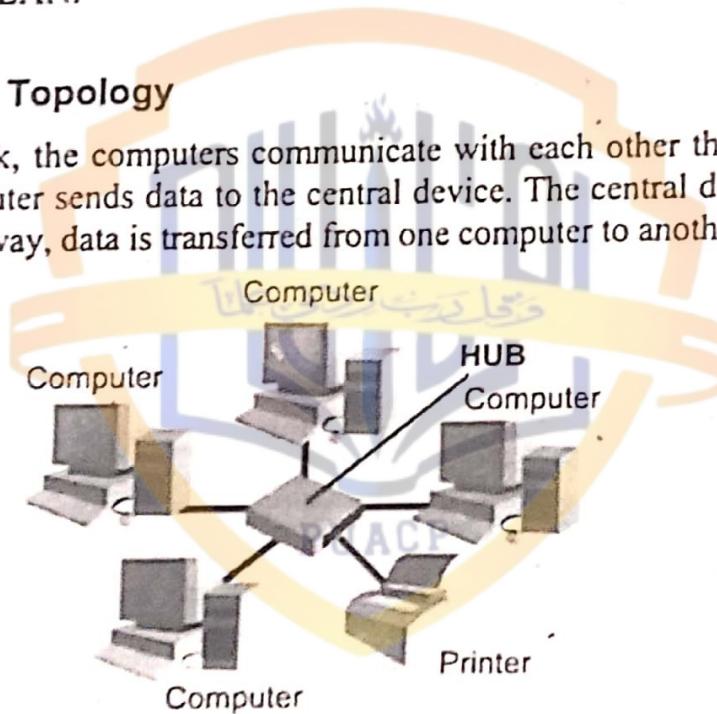


Figure: Star Topology

Advantages

The main advantages of star topology are as follows:

- ★ It is easy to install and to maintain.
- ★ The nodes can easily be added or removed without affecting the network.
- ★ If any node or cable fails then the rest of the network is not affected.
- ★ It is easy to detect and remove faults in the network.
- ★ It is suitable for small and large networks.

Disadvantages

The main disadvantages of star topology are as follows:

- ★ This type of network depends upon the central device. If this device fails, the whole network breaks down.
- ★ It requires more cables than any other networks. So it becomes more costly.

7.4.3 Ring Topology

In a ring topology, each node is connected to the next node and the last node is connected to the first. Thus, the shape of the network is formed just like a ring.

Working of Ring Topology

In the Ring topology, a token is passed around the network. The computer that has control of the token can transmit data/message. When a computer sends a message to another computer on the network, the message flows from one computer to the next computer. Every computer receives a message from the previous computer and retransmits it to the next computer until the destination computer receives the message. The destination computer sends an acknowledgment of receiving a message to the sender computer. The sender computer then releases the token back to the network. This method of controlling access to the shared network cable is called *token passing*.

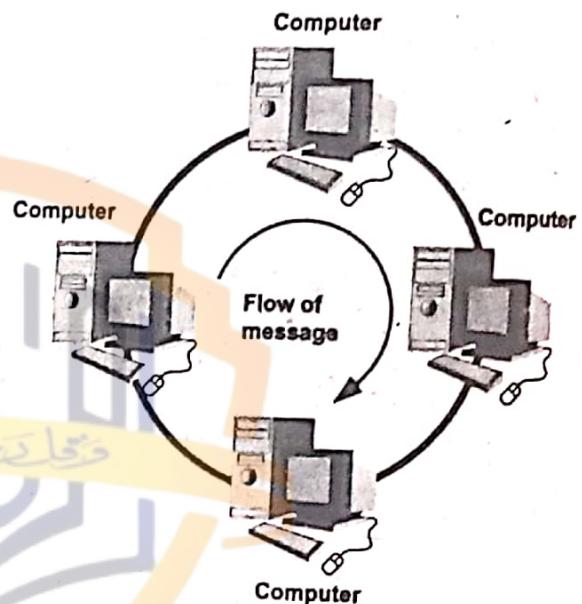


Figure: Ring Topology

Advantages

The main advantages of ring topology are as follows:

- ★ It is less expensive to implement.
- ★ It is easy to install and to maintain.
- ★ All computers have equal access to the network.
- ★ Every computer regenerates/refreshes the data signal that's why it can travel over a longer distance.

Disadvantages

The main disadvantages of ring topology are as follows:

- ★ If one node fails (or the ring is broken at any point), the entire network stops functioning.
- ★ Adding or removing a computer in the network affects the whole network.

7.4.4 Tree Topology

Tree topology has combined features of both bus and star topologies. The whole network is divided into segments. Each segment represents a Star topology. All the segments (i.e. Star topologies) are combined through central cable or bus. Thus, Bus topology works as the backbone of the Tree network. The tree network looks like a tree structure. In the figure of Tree topology, three Star networks are combined through a central cable (or bus):

In the Tree topology network, usually, multiple hubs are used. Each hub controls the nodes directly connected to it and exchanges data among them. It also exchanges data to other devices connected to the other hubs.

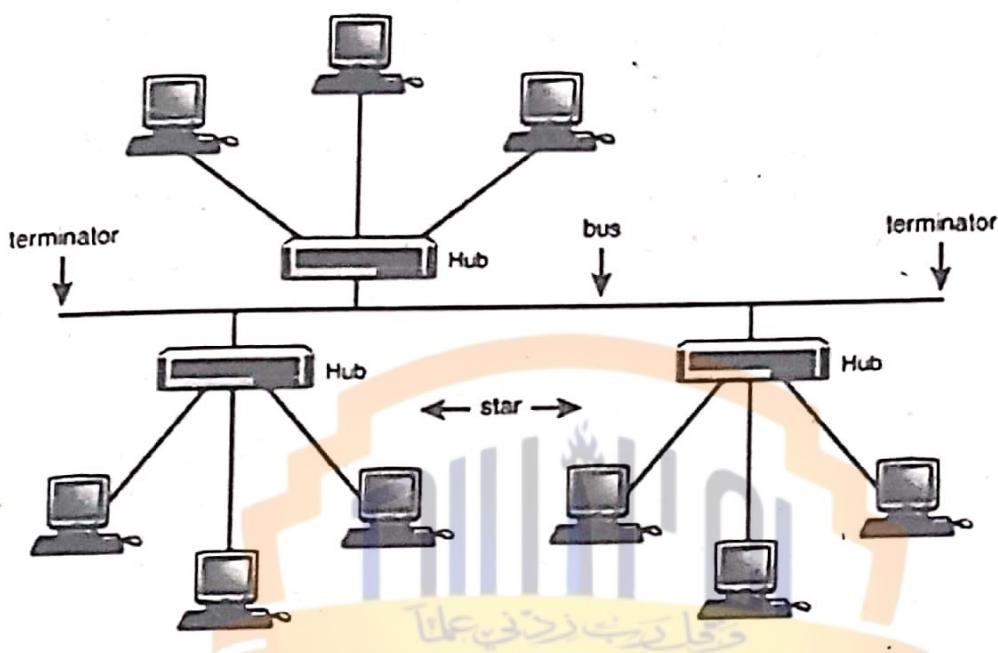


Figure: Tree Topology

The cable TV network is an example of tree topology. In this network, the main cable is divided into branches and each branch is further divided into smaller branches, and so on. The hub is used when a new branch is created.

Advantages

Following are the main advantages of tree topology:

- ★ Its existing network can be expanded very easily (i.e. easily scalable).
- ★ Each segment of the network can be easily managed and maintained.
- ★ If one segment fails, other segments are not affected.
- ★ Errors detection and correction is easy.

Disadvantages

Following are the main disadvantages of tree topology:

- ★ It is more expensive because more hubs are required to be installed in the network.
- ★ It relies on the central cable or bus. If it breaks, the whole network is affected.

7.4.5 Mesh Topology

In the Mesh topology, each node is directly connected to every other node on the network. This type of network involves the concept of routes. Mesh topology is rarely used in LAN. It is mostly used in WANs like the Internet use mesh topology.

Working of Mesh Topology

In the Mesh topology, each node can send a message to the destination through multiple paths. It means that each node of the Mesh network has several possible paths to send or to receive a message, but in Bus, Star, and Ring topologies each node has only one path. The data always travels through the best-suited path.

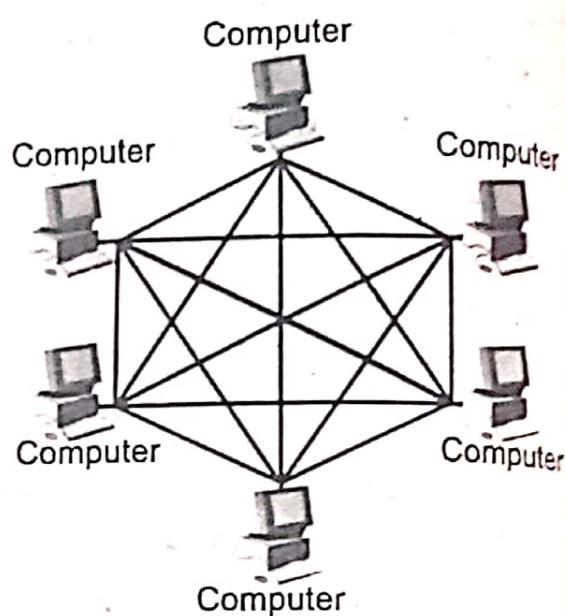


Figure: Mesh Topology

Advantages

Mesh topology has the following advantages:

- ★ It provides multiple routes. If one route is blocked, then another suitable route can be used for data communication.
- ★ Its performance is not affected by the heavy load of data transmission.
- ★ It ensures data privacy or security.
- ★ Troubleshooting of this topology is easy as compared with other networks.

Disadvantages

Mesh topology has the following disadvantages:

- ★ It becomes very expensive because a large number of cabling and I/O ports are required.
- ★ It is difficult to install and configure. Its maintenance is also difficult.

7.5 DATA COMMUNICATION

The process of transferring data from one location to another in a networking environment is called *data communication*. In this process, data is transmitted from one location to another by using transmission media and communication devices such as transmitter and receiver. Today, computer networks are commonly used for data communication.

7.5.1 Components of Data Communication

The basic components or elements of the data communication system are as follows:

- | | | | | | |
|-----|--------------------------------|-----|--------|------|----------|
| i) | Message | ii) | Sender | iii) | Receiver |
| iv) | Communication media or channel | | | v) | Protocol |

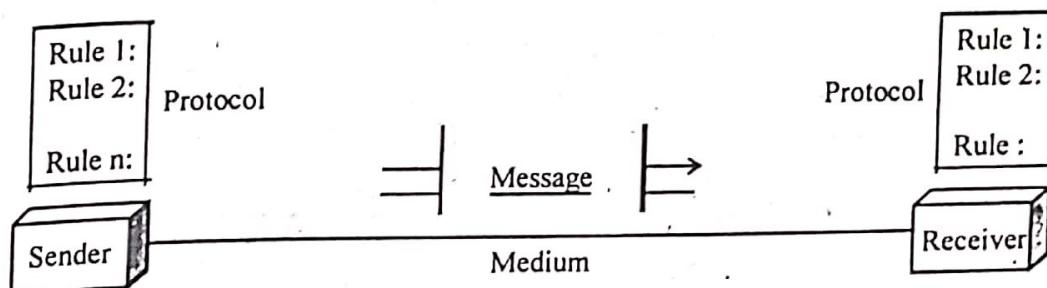


Figure: Components of Communication System

i) Message

The message is the information or data to be communicated. It may consist of text, numbers, pictures, sounds, videos, or a combination of these.

ii) Sender

A device that is used for sending messages (or data) over a network is called a *sender*. It is also called a *transmitter* or *sending device* or *source*. The sender can be a desktop computer, laptop, smartphone, camera, and fax machine.

iii) Receiver

A device that is used for receiving messages from sending device on the network is called a *receiver*. It is also called a *receiving device* or *sink*. The receiver can be a desktop computer, laptop, television set, smartphone, printer, and fax machine. GPS receiver also serves as a receiving device (receiver).

iv) Communication Media or Channel

The path through which message is transmitted from one location to another (source to destination) is called *communication media*. It is also called a *communication channel*. It can be a twisted pair cable or telephone cable, coaxial cable, and fiber optic cable. It can also be a wireless media such as Bluetooth, Wi-Fi, microwave, radio wave, and satellite. If the sender and receiver are within a building, a wire may be used as the medium. If they are located at different locations, then a medium may be a telephone line, fiber optics, microwave, or satellite system.

v) Protocol

A network protocol is a set of rules that defines a procedure for communication between a sender and a receiver. Without a protocol, two devices may be connected but not communicating. A protocol defines;

- ★ How the communication channel is established?
- ★ How data/message is transmitted?
- ★ How errors are detected and corrected during data communication?

7.6 COMMUNICATION CHANNEL

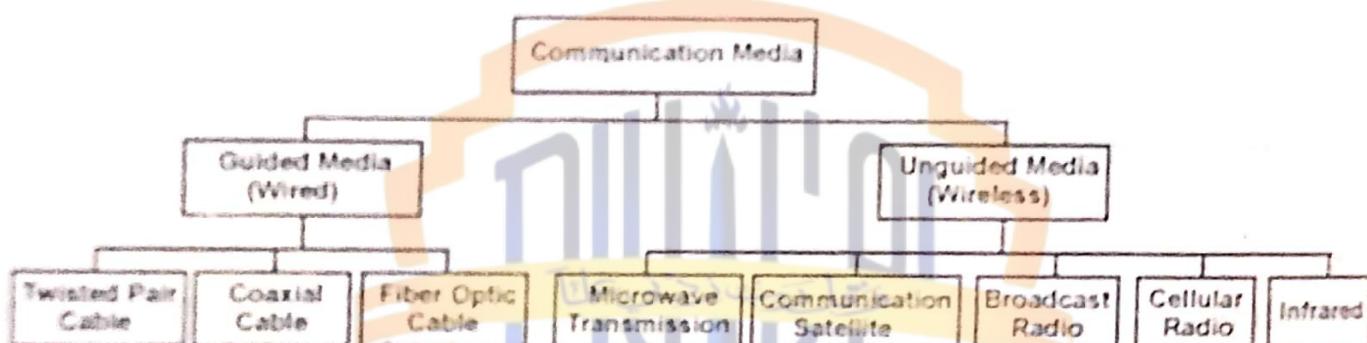
A path through which data is transmitted from one place to another is called a *communication channel*. It is also known as *communication media* or *transmission media*. The standard telephone line, twisted-pair cable, coaxial cable, fiber optic cable, microwave, and satellite are examples of communication channels.

In a communication channel, data is transmitted in the form of signals. The amount of data that can be transmitted through the communication medium in a unit of time is called *bandwidth*. The bandwidth of analog signals is measured in cycles per second or Hertz (Hz). The bandwidth of digital signals is measured in *bits per second* (bps). Different transmission media have different bandwidths. The higher the bandwidth of the transmission media, the more information can be transmitted at a time.

Types of Communication Channel

The communication channel or media is divided into two types:

- i) Guided Media
- ii) Unguided Media



7.6.1 Guided Media

The type of communication media in which communication devices are directly linked with each other via cables or physical media is called *guided media*. Guided communication media is also known as *physical transmission media*. The data signals are bounded to a cabling media. Therefore, guided media is also called *bounded media*. The guided media are usually used in LAN. The examples of guided or bounded media are twisted pair cable, coaxial cable, and fiber optic cable.

i) Twisted Pair Cable

Twisted pair cable is one of the most commonly used communication media. It is used for short-distance digital data transmission. Its data transmission speed is about 9600 bits per second at a distance of 100 meters. It is commonly used in local area network (LAN). It is also used in telephone lines to carry voice and data signals.

Twisted pair cable consists of a pair of copper wires. These wires are covered by insulating material (such as plastic). The wires are twisted together in pairs. Twisting of wires protects them from interference by external electromagnetic waves.

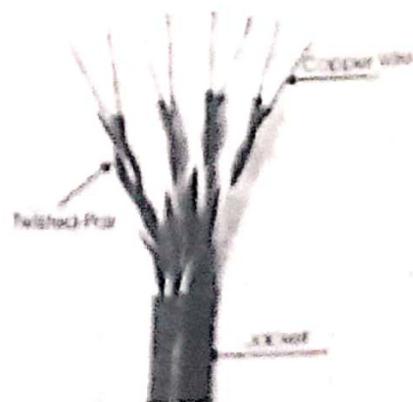


Figure: Twisted Pair Cable

ii) Coaxial Cable

Coaxial cable is also called *Coax*. Coaxial cables are mostly used for long-distance transmission. These cables are mainly used for cable TV, telephone network, and local-area network. These cables provide very high-quality data transmission without distortion or loss of data. These cables can transfer data with very high frequency. The bandwidth of the coaxial cable is 80 times greater than that of twisted pair cable. These cables can transmit data with 10 to 100 megabits per second (Mbps). Coaxial cables are more expensive than twisted-pair cables.

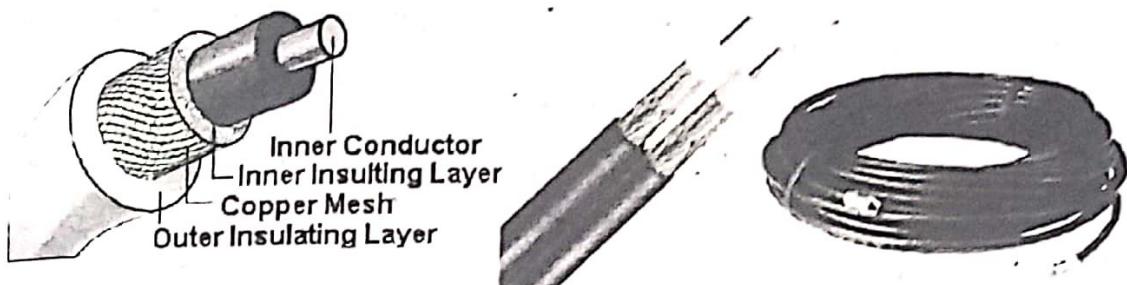


Figure: Coaxial Cable

Coaxial cable consists of a single solid copper wire, which is called the *inner conductor*. Usually, the inner conductor is surrounded by three layers:

- ★ **Inner Insulating layer:** It covers the inner conductor.
- ★ **Copper Mesh:** Mesh means net. It is a net of wire. It serves as ground. It reduces electromagnetic interference.
- ★ **Outer Insulating layer:** It covers the copper mesh.

These layers protect the cable from interference by external electromagnetic waves. The whole cable is protected by a plastic cover.

iii) Fiber Optic Cable

Fiber optic cable is a very fast communication medium. It consists of hundreds or thousands of thin strands (threads) of glass or plastic. Each strand is called *optical fiber* or *core*. It is as thin as a human hair. Each optical fiber or core is surrounded by a layer of glass called *cladding*. The cladding is further protected by a plastic coating called *Jacket*. An important characteristic (or property) of fiber optic is refraction. Refraction is the characteristic of a material to either pass or reflect light..

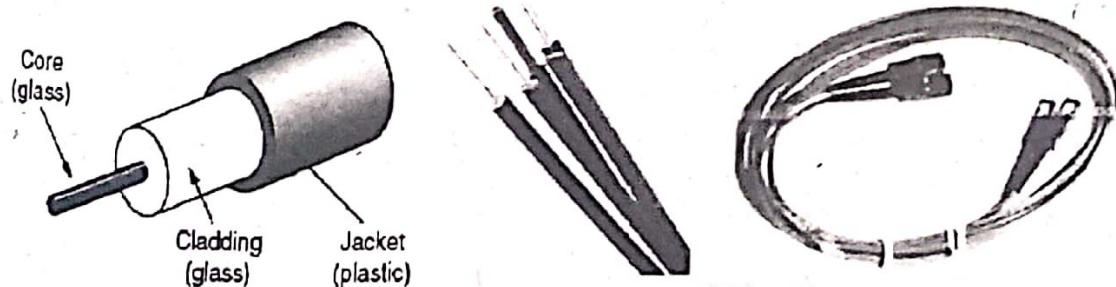


Figure: Fiber-Optic Cable

Fiber optic cable transmits data in the form of light waves. In fiber optics communication, converters are used on both sides. The converter at the transmitter side converts data from digital signals into light waves and transmits over the fiber optics. The converter at the receiver side receives data in the form of light waves and converts back into digital form.

Fiber optic cable provides high-quality transmission at a very high speed. It is up to billions of bits per second (usually 1Gbps to 2Gbps). Fiber optic transmission is not affected by electromagnetic waves. Both analog and digital signals (i.e. both voice and digital data) can be transmitted through fiber optic cable. It is more reliable and has lower data transmission errors. However, it is costly and difficult to install.

Today, many telephone and cable TV companies are using fiber optic cables in their networks. In the near future, all communication systems will use fiber optic cables.

7.6.2 Unguided Media

The type of communication media in which communication devices send and receive data signals through air or space is called *unguided media*. It is also called *wireless transmission media*. In this type of communication media data is communicated between communication devices in the form of a wave. Unguided media provide means to transmit data signals but do not guide them along a specific path. The data signals are not bounded to a cabling media. Therefore, unguided media is also called *unbounded media*.

The unguided transmission medium is used when it is impossible to install the cables. The data can be transmitted all over the world through this medium. The examples of unguided or wireless transmission media are microwave transmission, a communication satellite, broadcast radio, and cellular radio.

(i) Microwave Transmission

Microwaves are radio waves that provide very high-speed transmission. In microwave transmission, data is transmitted through air or space (like radio signals), instead of through cables or wires. A microwave uses *line-of-sight* transmission through space. The *line-of-sight* means that data signals (or waves) can only travel in straight lines and cannot bend.

In the microwave system, data is transmitted and received through microwave stations. A microwave station is also called a *relay station* or *booster*. Each relay station consists of an antenna, transmitter, receiver, and other equipments that are necessary for microwave transmission. The antennas are usually installed on the high towers or buildings usually 40 to 50 feet above the earth. These are placed within a distance of 20 to 30 miles to each other. There may be many relay stations (boosters) between the sender and receiver. Data is transmitted from one relay station to another. Each relay station receives data signals from the previous relay station, amplifies these signals, and retransmits to the next relay station. In this way, data is transmitted over larger distances. Today, the microwave transmission system is used by telephone companies, and cable television providers.

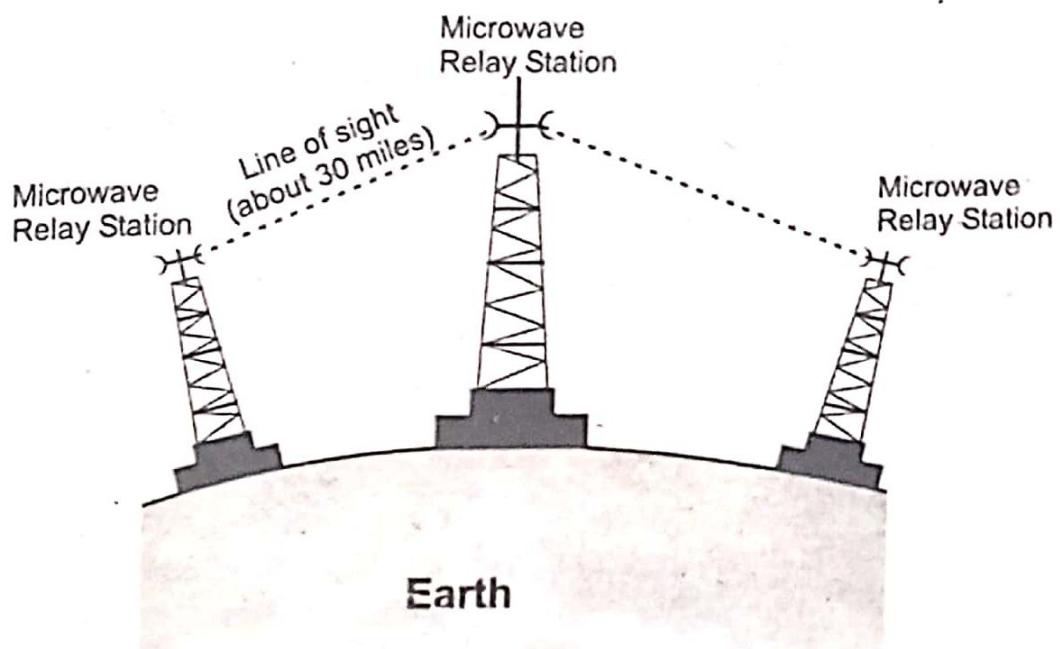


Figure: Microwave Communication System

(ii) Communication Satellite

Satellite communication is mostly used for long-distance communication. It has a very fast data transmission speed. The satellite communication system consists of satellites and many earth-based stations. The communication satellites are *space stations*. They serve as relay stations for the transmission of information. They are approximately 22,300 miles above the earth.

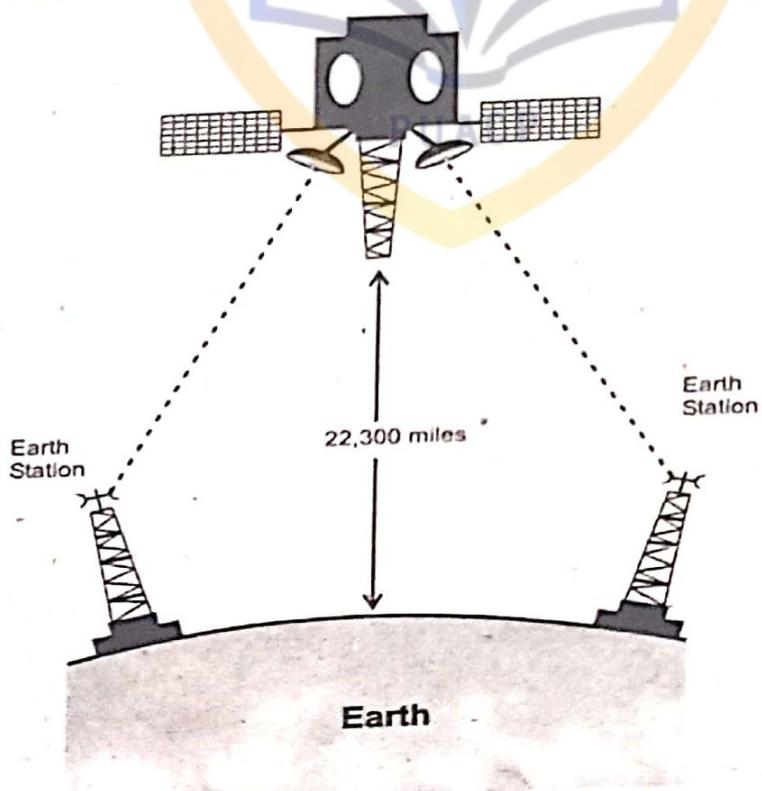


Figure: Communication Satellite System

Each earth station consists of a dish antenna. Earth station can send and receive data signals. The satellite receives microwave signals (or messages) from the earth station. It amplifies the signals and retransmits them to another earth station which can be located thousands of miles away. This entire process takes only a few seconds. In this way, data is transmitted from one location to another. Transmitting a signal from the ground or earth station to a satellite station in space is called *up-linking*. Transmitting a signal from a satellite station in space to a ground or earth station is called the *down-linking*.

The main advantage of a satellite communication system is that a large amount of data can be communicated at once. The disadvantage of satellite communication is that bad weather can affect the quality of satellite transmission. This communication system is also very costly to install and to maintain.

Nowadays, different communication satellites are used for different kinds of applications such as telephone calls, television, and radio broadcasting, military communication, collecting weather data, global positioning systems, and Internet connections.

(iii) Broadcast Radio

Broadcast radio is a wireless transmission medium. It is used to communicate information through radio signals in the air, over a long and short distances such as between cities, countries, within an office or home. In this medium, a transmitter is required to send messages (signals) and a receiver to receive them. To receive the radio signal, the receiver has an antenna that is located in the range of the signal. Some networks use a special device called a *transceiver* that can both send and receive messages in the form of radio signals.

Bluetooth is an example of short-range broadcast radio communication. It uses short-range radio waves to transmit data among Bluetooth-enabled devices. It can transmit data at a rate of 1 Mbps. Bluetooth is used in personal computers and mobile devices.

(iv) Cellular Radio

Cellular radio is a form of radio broadcast that is used for mobile communications such as cell phones and wireless modems. A cell phone is a telephone device that uses high-frequency radio waves to transmit voice and digital messages. Some mobile users connect their laptop computer or other mobile devices to a cell phone to access the web, send, and receive e-mail.

7.7 COMMUNICATION DEVICES

An electronic device that is used for sending and receiving data between the sending device and receiving device is called a *communication device*. Most of the communication devices have the ability to convert the digital signal of the computer into an analog signal so that the signals can be transmitted on the communication line to another end. The reverse is also true. The most important communication devices are described below.

(i) NIC

NIC stands for Network-Interface Card. NIC is a communication device that is used to connect a computer to a LAN. It is also called a *LAN card*. NIC is a circuit board which is installed on the motherboard. A computer must have a network card (NIC) to connect to the LAN. Nowadays, most computer systems have built-in network card into the motherboard.

(ii) HUB & Switch

Hub and Switch are communication devices. Both provide a central connection point for connecting computers/nodes together in a computer network. They have multiple ports to which computers are connected. Typically, Hub does not manage any of the traffic that comes through it. It broadcast data packets to every computer/node. Only the receiver computer/node accepts the message and other computers/nodes ignore the message. A switch is like a Hub but it is more intelligent than the Hub. It records the addresses of the computers connected to it in a table. It sends a message to the receiver computer/node only.

(iv) Modem

Modem stands for modulator and demodulator. It is a commonly used communication device that converts digital signals into analog signals and vice versa. It is used to send and receive data between two computers through the telephone line. Both sending and receiving computers must have modems.

Data is stored inside the digital computers in digital form. However, data is transmitted over the telephone line in the form of analog signals. The sending computer sends data to the receiving computer as follows:

- ★ The dialup modem of sending a computer converts digital signals into analog signals and sends it to the receiving computer through a telephone line. The process of converting digital signals into analog signals is called *modulation*.
- ★ The modem of receiving computer receives data from the telephone line in the form of analog signals. It converts these signals into digital signals and enters in the computer. The process of converting the analog signals into digital form is called *demodulation*.

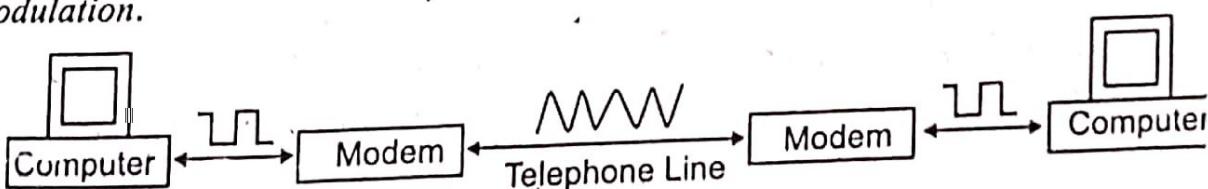


Figure: Data Transmission by Modem

A dialup modem can be fixed inside the system unit. It can also be a separate device outside the system unit. The modem which is fixed inside the system unit is called an *internal modem*. The modem which is outside the system unit is called an *external modem*. The external modem is very easy to set up and can easily be moved from one computer to another. It is also very fast and has advanced features than an internal modem. However, it is more expensive than an internal modem.

(v) Router

A router is a communication device that connects multiple computers/devices or other routers together and transmits data to its correct destination on a network. Typically, routers are used to connect two or more different or similar networks and transfers data packets from one network to another. The networks can be LANs or WANs.

The router stores the addressing information (routing information) of each computer on the connected networks. When a router receives a packet of data, it looks at the address attached with the data packet where the packet of data is to be sent. It determines the best route (path) to forward the data packet at its destination and then sends it accordingly.

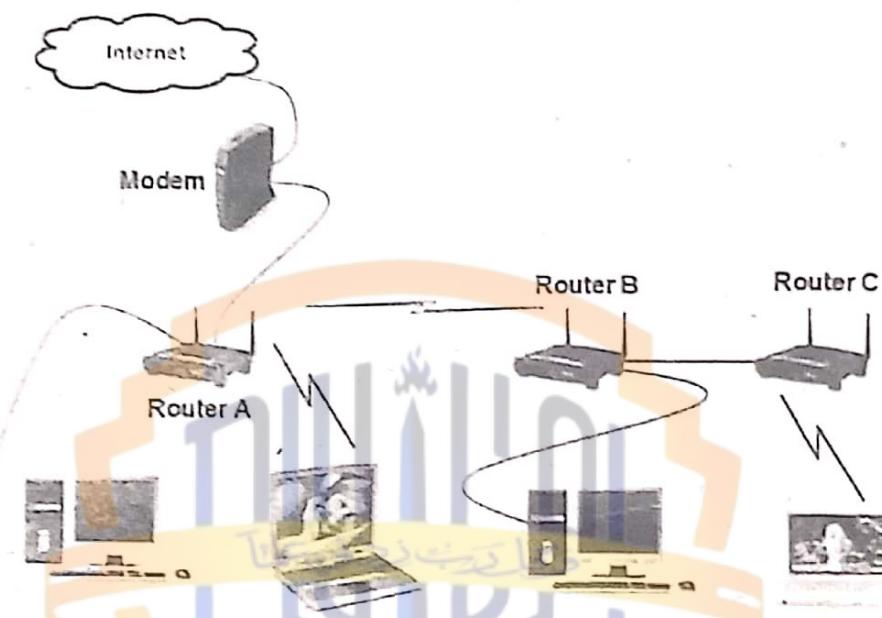


Figure: Routers in a network

(vi) Gateway

A gateway is a communication device (or networking device). It is used to connect two different types of networks (i.e. networks that use different protocols). It is an intelligent device. It translates data from one format to the other.

Different networks may have different types of data and of different formats. Gateway receives a data packet from one type of network. It reads the address of the computer on the networks where the data packet is to be sent. It converts the data packet into a format that the destination computer can understand. For example, the computers connected to a LAN require a gateway to access the Internet.

(vii) Bridge

A bridge is a communication electronic device that is used to connect two similar network segments. A segment is a part of a network. It also controls the data flow between them. When a bridge receives a message, it reads the addresses of both the sender and receiver. If the sender and receiver are in the same network segment, the bridge does not pass the message to the other network segment. The message is directly sent to the receiver. The bridge, therefore, reduces network traffic. So the performance of the network is increased.

Short Answers to the Questions

Q.1 Define computer network.

A collection of computers and other devices connected together via communication devices and communication channels for sharing information and resources is called a *computer network*. The resources may include printers, scanners, and storage devices (such as hard disks). In a computer network, computers or devices are connected together via communication devices and transmission media.

Q.2 Differentiate between LAN and WAN.

LAN covers a small area, while WAN covers a large area. The data transmission speed of LAN is very high than the WAN. In LAN, a connection is permanent using cables, while in WAN connection is not permanent. In LAN, computers are directly connected through a physical cable for data transmission. In WAN, computers are connected through a telephone line or microwave system for data transmission.

Q.3 Differentiate between server and client computers.

Following are the main differences between server and client computers:

- The server is a powerful and large computer, while the client is a small computer.
- The server controls the whole network and provides a centralized storage area for data and software, while the client depends on the server for different resources like centralized storage, printing, and data processing.

Q.4 Define the term network topology.

The way in which computers or other devices are connected in a network is called *network topology*. Shortly the term network topology refers to the physical layout or shape of the network.

Q.5 Differentiate between bus topology and ring topology.

In a Bus topology, all nodes (or devices) are connected to a common communication medium. In a ring topology, each computer is connected to the next computer and the last computer is connected to the first. In a Bus topology, data can flow in different directions, while in ring topology data flows in one direction around the ring.

Q.6 Define data communication.

The process of transferring data from one location to another in a networking environment is called *data communication*. In this process, data is transmitted from one location to another by using transmission media and communication devices such as transmitter and receiver.

Q.7 What is the difference between the sender and receiver?

A device that is used for sending messages (or data) over a network is called the *sender*. It is also called a *transmitter* or *sending device* or *source*. A device that is used for receiving messages from sending device on the network is called a *receiver*. It is also called a *receiving device* or *sink*.

Q.8 Define unguided media. Give its examples.

The type of communication media in which communication devices send and receive data signals through air or space is called *unguided media*. It is also called *wireless transmission media*. In this type of communication media data is communicated between communication devices in the form of a wave. The examples of unguided or wireless transmission media are microwave transmission, a communication satellite, broadcast radio, and cellular radio.

Q.9 What is the purpose of the router?

A router is a communication device that connects multiple computers/devices or other routers together and transmits data to its correct destination on a network. Typically, routers are used to connect two or more different or similar networks. The networks can be LANs or WANs.

Q.10 State the use of gateway in data communication.

A gateway is an electronic device or system which is used to connect two different types of networks (i.e. networks that use different protocols). It is an intelligent device. It translates data from one format to the other.

Multiple Choice Questions – MCQs

- 1) Which of the following networks covers a short distance?
(a) LAN (b) WAN
(c) MAN (d) The Internet

2) The Internet is the world's largest:
(a) VPN (b) LAN
(c) MAN (d) WAN

3) The set of rules to send and to receive data is called:
(a) Protocol (b) Software
(c) Procedures (d) Ethernet

4) Which one represents the shape of network?
(a) Protocol (b) Topology
(c) Technology (d) Hub

5) Which one is not a network topology?
(a) Bus topology (b) Ring topology
(c) Source topology (d) Star topology

6) Which of the following is not physical transmission medium?
(a) Twisted pair cable (b) Broadcast radio
(c) Coaxial cable (d) Fiber optic cable

- 7) In this transmission media, the data is transmitted as pulses of light.
- (a) Coaxial cable
 - (b) Fiber optic cable
 - (c) Twisted pair cable
 - (d) Both a & c
- 8) Which of the following is not a wireless transmission medium?
- (a) Broadcast radio
 - (b) Cellular radio
 - (c) Fiber optic
 - (d) Microwaves
- 9) The term line-of-sight transmission is used in:
- (a) Cellular radio
 - (b) Microwaves
 - (c) Communication satellite
 - (d) None of these
- 10) Transmitting a signal from earth station to a satellite station in space is called:
- (a) Down linking
 - (b) Up loading
 - (c) Up linking
 - (d) Signaling
- 11) The term modulation and demodulation is used in:
- (a) Router
 - (b) Bridge
 - (c) Modem
 - (d) Gateway
- 12) It is not a communication device:
- (a) Router
 - (b) Switch
 - (c) Expansion Slot
 - (d) NIC

Answers of MCQs

1 (a)	2 (d)	3 (a)	4 (b)	5 (c)	6 (b)	7 (b)	8 (c)	9 (b)	10 (c)
11 (c)	12 (c)								

EXERCISE

- Q#1 Define computer network. Explain different types of networks in detail.
- Q#2 Explain the uses of computer networks.
- Q#3 What is network topology? Also, discuss Star and Tree topologies with the help of diagrams.
- Q#4 Differentiate between the following: