Unit I

Introduction to Data Communication

Data communications and networking are the new technologies in our digital world. One goal is to be able to exchange data such as text, audio, and video from all points in the world. We want to access the internet to download and upload information quickly and accurately and at any time.

In modern days we are communicates from one place to another place just a fraction of a second. This is only possible in our digital techniques. Some communication techniques are using like Internet, Bluetooth, Computer Networking, faxes, telephones etc.

A Communications Model

Communication is the conveyance of a *message* from one entity, called the *source* or *transmitter*, to another, called the *destination* or *receiver*, via a *channel* of some sort.

To give a very basic example of such a *communication system* is conversation; people commonly exchange verbal messages, with the channel consisting of waves of compressed air molecules at frequencies, which are audible to the human ear.

Source: Device that generates the data to be passed on to the Destination device. It could be a user computer trying to make a query to a server computer.

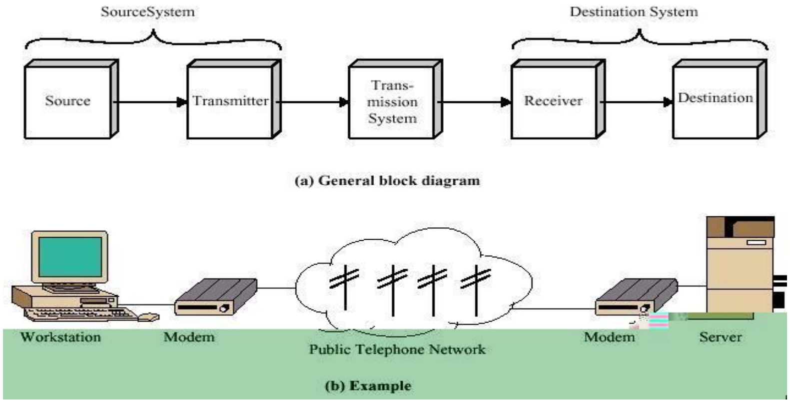
Transmitter: If the data generated by the *Source device* has to be transmitted through *Transmission Channel* or Transmission System then it has to be presented in a form that is acceptable to the *Transmission system.* This job is done by the *Transmitter.* For example, a *modem* takes a digital bit stream from the attached computer and transforms that stream of bits into an analog signal which can be handled by the telephone network.

Transmission System: This can be a single transmission line connecting the two systems communicating or a complex network to which numerous communicating systems are connected.

Receiver: This receives the signal from the transmission system and converts it into a form that is suitable to the destination device. For example, a *modem* accepts analog signal from a transmission channel and transforms it into digital bit stream.

Destination: Device to which the source device sends data.

Simple Data Communications Model**.**



Data Communications System Tasks

Some of the Key tasks to be performed by a Data Communications System are listed below.

- Signal Generation
- Interfacing
- Synchronization
- Exchange Management
- Transmission System Utilization
- Error Detection and Correction
- Flow Control
- Addressing
- Routing
- Message Formatting

Signals: All the data that are transmitted over the transmitting system propagate as Electromagnetic signals. Hence the communicating device must be able to generate and receive these signals. Signal generation should be such that the resultant signal is capable of being propagated through the transmission medium and interpretable as data at the receiver.

Interface: A device must interface with the transmission system in order to communicate.

Synchronization: Unless the receiver and transmitter are in Synchronization the receiver will not be able to make sense out of received signals. Receiver should know when the transmission of data starts, when it ends.

Exchange management: For meaningful data transaction there should be some kind management of data being exchanged. Both the transmitter and receiver should adhere to some common convention about the format of data, amount of data that can be sent at a time and so on. This requires a prior definition of message formatting.

Transmission system utilization: It refers to the need to make efficient use of Transmission Channel, which is generally shared by many communicating devices. Various techniques (Multiplexing) are available to allocate the total capacity of a transmission channel among connected devices. Care should be taken to avoid probable Congestion in some kind of multiplexing.

Error detection and correction: In any communication system transmitted data is prone to error. Either it is because of transmitted signal getting distorted in the transmission medium leading to misinterpretation of signal or errors introduced by the intermediate devices. Error detection and Correction is required in cases where there is no scope for error in the data transaction. We can think of file transfer between two computers where there is a need for this. But in some cases it may not be very important as in the case of telephonic conversation.

Flow control: There is a possibility of transmitter generating data faster than the receiver device capable of handling. To handle this there should be some kind of flow control mechanism agreed upon between the two communicating devices.

Addressing: When more than two devices share a transmitting facility, a source system must somehow indicate the identity (or address) of the destination.

Routing: The transmission system must ensure that the data being sent are routed only to the destination system.

Communication Network and Services

A communication network, in its simplest form, is a set of equipment and facilities that provides a communication service: the transfer of information between users located at various geographical points. Here we focus on networks that use electronic or optical technologies. Examples of such networks include telephone networks, computer networks, television broadcast networks, cellular telephone networks, and the Internet.

Radio and television broadcasting are probably the most common communication services. Various *stations* transmit an ensemble of signals simultaneously over radio or cable distribution networks. Aside from selecting the station of interest, the role of the user in these services is passive. Relatively high audio and video quality is expected, but a significant amount of delay (in the order of seconds or more) can be tolerated even in *live* broadcasts.

Telephone service is the most common real-time service provided by a network. Two persons are able to communicate by transmitting their voices across the network. The service is *connection-oriented* in the sense that the users must first interact with the network to set up a connection.

The telephone service has the real-time requirement in that users cannot interact as in face-to-face conversation if the delays are greater than a fraction of second (approximately 250 milliseconds). The service must also be reliable in the sense that once the connection is established it must not be interrupted because of failures in the network. At the minimum the delivered voice signal must be intelligible, but in most situations the users expect a much higher quality that enables the listener not only to recognize what the speaker says but also to discern subtleties in intonation, mood, and so on. A high degree of availability is another requirement: Telephone users expect the network to be capable of completing the desired connection almost all the time. Security and privacy of the conversation are consideration in some situations.

The telephone service can be enhanced in a number of ways. For example, the toll-free service is provided wherein the caller will not be billed but costs of the call are automatically billed to the subscriber of the service. Similarly, in credit-card or calling-card services, the cost of a call is automatically billed to the holder of the card. Clearly, security and fraud are issues here.

Telephone networks provide a broad class of call management services that use the originating number or the destination number to determine the handling of a call. *Caller ID* allows the originating number, and sometimes name, of the originating call to be displayed to the destination user when the receiving device is display capable. Voice mail allows a destination user to have calls forwarded to a message-receiving device when the destination user is not available.

Cellular telephone service extends the normal telephone service to mobile users who are free to move within a regional area covered by an interconnected array of smaller geographical areas called cells. Each cell has a radio transmission system that allows it to communicate with users in its area. The use of radio transmission implies design compromises that may result in lower voice quality, lower availability, and greater exposure to eavesdropping. In addition, the cellular system must handle the *handing off* of users as they move from one cell to another so that an ongoing conversation is not terminated abruptly. Some cellular providers also support a roaming service where a subscriber is able to place calls while visiting regional areas other than the subscriber's home base. Note that the mobility aspect to the roaming service is not limited to cellular (or wireless) communications. Indeed, the need for mobility arises whenever a subscriber wishes to access a service from anywhere in the world.

Electronic mail (e-mail) is another common network service. The user typically provides a text message and a name and/or address to a mail application. The application interacts with a local mail server, which in turn transmits the message to a destination server across a computer network. The destination user retrieves the message by using a mail application, such as *Outlook Express* software package of Microsoft. E-mail is not a real-time service in that fairly large delays can be tolerated. It is also not necessarily connection-oriented in that a network connection does not need to be set up expressly for each individual message. The service requires reliability in terms of the likelihood of delivering the message without errors *and* to the correct destination. In some instances the user may be able to request delivery confirmation. Again security and privacy may be a concern.

Data communications

Data is nothing but information. When we communicate, we are sharing information. The communication way is different by using local or remote. The local communication is usually occurs face to face. While remote communication takes place over distance. The term ‘Telecommunication’ is to communicate using telephones by exchange of voice based messages and also using fax this is a technique where used to exchange printed data on the basis of using telephones.

The data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable. For data communications to occur, the communicating devices must be part of a communication system made up of a combination of hardware and software programs.

Characteristics of Data Communication

1. Delivery
2. Accuracy
3. Timeliness
4. Jitter

The delivery is a very important aspect to deliver data to the proper destination. Data must be received by the intended device or user and only by that device or user.

Accuracy, the system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.

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

Jitter, Jitter 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 of Data Communications

The data communications system has five basic components

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

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

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

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

Protocol: A protocol is a set of rules that manage data communications. It represents an agreement between the communicating devices. Without a protocol, two cannot be understood by a person who speaks only Japanese.

Data Representation

Today we gathering information in different ways like, text, numbers, images, audio, and video.

Text: In data communications, text is represented as a bit pattern, a sequence of bits (0's and 1's). Different sets of bit patterns have been designed to represent text symbols. Each set is called a code, and the process of representing symbols is called coding. Today, the prevalent coding system is called Unicode, which uses 32 bits to represent a symbol or character used in any language in the world.

Numbers: Numbers are also represented by bit patterns. However, a code such as ASCII is not used to represent numbers; the number is directly converted to a binary number to simplify mathematical operations.

Images: Images are also represented by bit patterns. In its simplest form, an image is composed of a matrix of pixels (picture elements), where each pixel is a small dot. The size of the pixel is depending on the image.

Audio: Audio refers to the recording or broadcasting of sound or music. Audio is by nature different from text, numbers, or images. It is continuous, not discrete. Even when we use a microphone to change voice or music to an electric signal, we create a continuous signal.

Video: Video refers to the recording or broadcasting of a picture or movie. Video can either be produced as a continuous entity, or it can be a combination of images, each a discrete entity, arranged to convey the idea of motion.

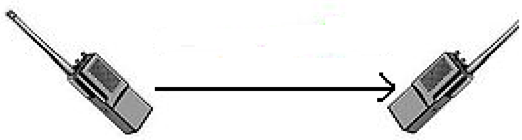
Transmission modes

Three types of transmission modes, they are.,

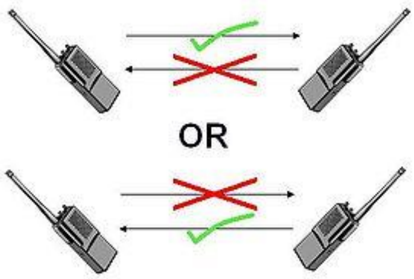
1.Simplex 2. Half-duplex 3. Full-duplex

Simplex: Simplex is a process the communication is of unidirectional. Ex. One way street. 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 keyboard can only introduce input; the monitor can only accept output. The simplex mode can use the entire capacity of the channel to send data in one direction.



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.



The half-duplex mode is like a one-lane (way/path) road with traffic allowed in both directions. When cars are travelling in one direction, cars going the other way must wait. 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 and CB (Citizens band) radios are both half-duplex systems.

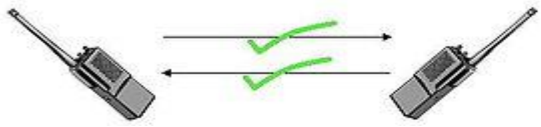
The half-duplex mode is used in cases where there is no need for communication in both directions at the same time; the entire capacity of the channel can be utilized for each direction.

Full-Duplex: In Full-duplex mode is also called as duplex, both stations can transmit and receive simultaneously.

The full-duplex mode is like a two-way street with traffic flowing in both directions at the same time,. 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 travelling in both directions.

One common example of full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time.

The full-duplex mode is used when communication in both directions is required all the time. The capacity of the channel, however, must be divided between the two directions.

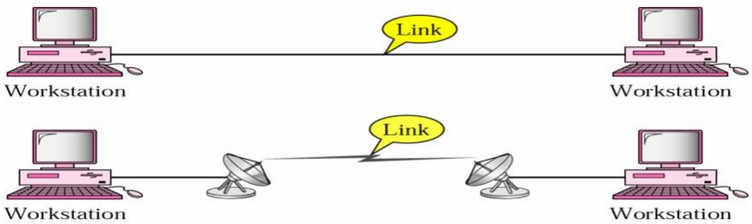


LINE CONFIGURATION

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

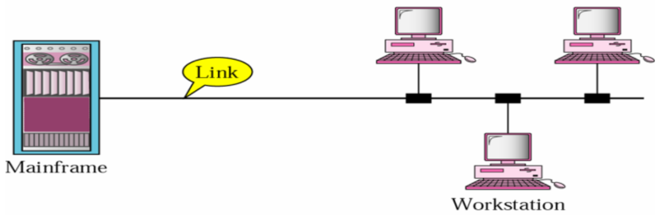
1. **Point-to-point**
2. **Multipoint**

Point-to-point: A point-to-point connection provides a dedicated link between two devices. The entire capacity of the link is reserved for transmission between those two devices. Most point-to-pint connections use an actual length of wire or cable to connect the two ends, but other options, such as microwave or satellite links, are also possible. When you change television channels by infrared remote control, you are establishing a point-to-point connection between the remote control and the television's control system.



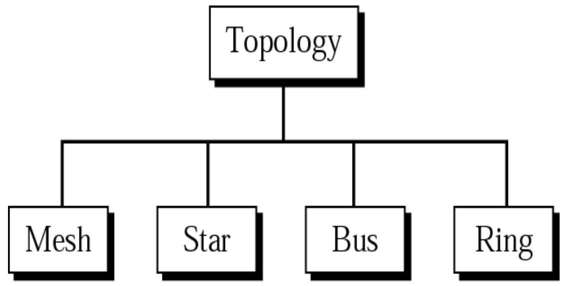
Multipoint: A multipoint or also called multidrop connection is one in which more than two specific devices share a single link.

In a multipoint environment, the capacity of the channel is shared, either spatially or temporally. If several devices can use the link simultaneously, it is a spatially shared connection. If users must take turns, it is a timeshared connection.



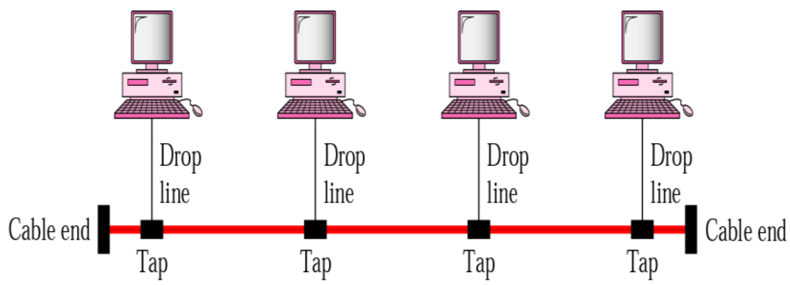
Network Topology

A network topology is the way the cabling is laid out. This doesn't means the physical layout, but the logical layout looks when viewed in a simplified diagram. There are four basic topologies possible: **Bus, Star, Ring, Mesh**, Tree, and **Hybrid** Topologies.



Bus Topology:

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



On the ends of the common cable, a device a called a terminator is utilized to absorb signals that have traversed the entire length of the bus. Since every one shares the same cable no two machines can transmit at once or the bits of data from each will collide destroying both pieces of information. This even is called a collision and obviously too many of them can be disastrous to traffic flow on a network. A data reflection can occur any time an electronic signal encounters a short or an open. The end result is the same reflected data collides with the "good" data on the LAN and traffic flow is impacted. A bus topology, on the other hand is multipoint.

Advantages of a Linear Bus Topology:

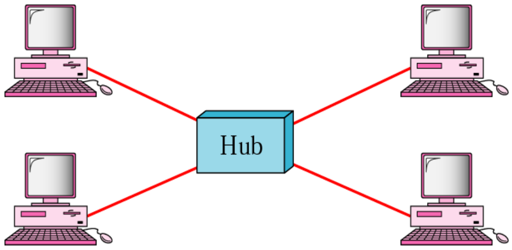
1. Easy to connect a computer or peripheral to a linear bus.
2. Requires less cable length than a star topology

Disadvantages of a Linear Bus Topology:

1. Entire network shuts down if there is a break in the main cable.
2. Terminators are required at both ends of the backboned cables.
3. It is difficult to identify the problem if the entire network shuts down.
4. Not good as a stand-alone solution in a large building.

STAR Topology

Star topology derives its name from the arrangement of devices so that they radiate from a central point. At the central point we usually see a device generically called a hub. Key benefits of the star topology is the hub unit which may vary in function from a simple signal splitter to one that amplifies and keeps statistics on data traveling through them. Star topology a popular choice in the networking market place. Hubs that amplify signals coming through are called active hubs or multi-port repeaters.



Star topologies do require more cable than a simple bus topology, but most use a relatively inexpensive type of cable called twisted pair cabling which helps control costs of wiring. The hubs themselves require investment and the level of that investment is direct attributable to how complex a hub is needed.

Trouble shooting is bit easier than Bus topology. At the very least, one may disconnect devices from a central hub to isolate a problem as opposed to visiting each individual machine. It's obvious how the central hub device offers advantages, but there is one drawback. The hub itself represents a single point of failure. If you lose a hub, you effectively lose all workstations attached to it.

Advantages of a Star Topology:

1. It includes robustness. If one link fails, only that link is affected.
2. Easy to install and wire.
3. No disruptions to the network when connecting or removing devices.
4. Easy to detect faults and to remove parts.

Disadvantages of a Star Topology:

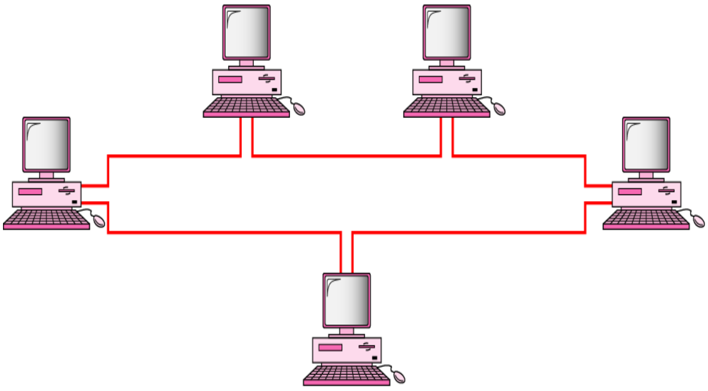
1. Requires more cable length than a linear topology.
2. Entire topology depends on hub. If the hub fails, nodes attached are disabled.
3. More expensive than linear bus topologies because of the cost of the concentrators.

Ring Topology

In a ring 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.

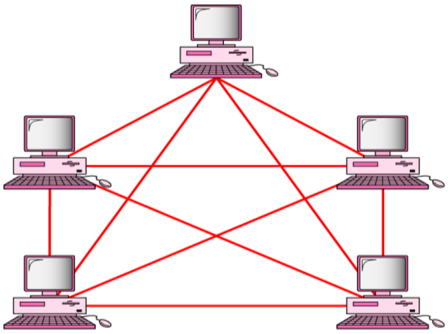
A ring is relatively easy to install and reconfigure. Each device is linked to only its immediate neighbours (either physically or logically). To add or delete a device requires changing only two connections. The only constraints are media and traffic considerations (maximum ring length and number of devices). In addition, fault isolation is simplified. Generally in a ring, a signal is circulating at all times. If one device does not receive a signal within a specified period, it can issue an alarm. The alarm alerts the network operator to the problem and its location

However, unidirectional traffic can be a disadvantage. In a simple ring, a break in the ring (such as a disabled station) can disable the entire network. This weakness can be solved by using a dual ring or a switch capable of closing off the break.Ring topology was prevalent when IBM introduced its local-area network Token Ring. Today, the need for higher-speed LANs has made this topology less popular.



Mesh Topology

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



To accommodate that many links, every device on the network must have n-1 input/output (I/O) ports to be connected to the other n-1 stations.

A mesh topology offers several advantages over other network topologies.

1. First, the use of dedicated links guarantees that each connection can carry its own data load, thus eliminating the traffic problems that can occur when links must be shared by multiple devices.
2. A mesh topology is robust. If one link becomes unusable, it does not incapacitate the entire system.
3. There is the advantage of privacy or security. When every message travels along a dedicated line, only the intended recipient sees it. Physical boundaries prevent other users from gaining access to messages.
4. Point-to-Point links make fault identification and fault isolation easy. Traffic can be routed to avoid links with suspected problems.

Disadvantages of Mesh Topology:

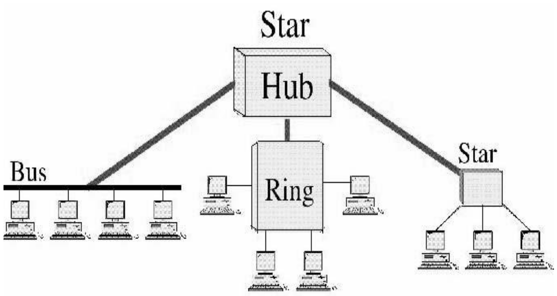
1. Amount of cabling and the number of I/O ports required. Because every device must be connected to every other device, installation and reconnection are difficult.

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

3. The hardware required to connect each link (I/O ports and cable) can be prohibitively expensive. For these reasons a mesh topology is usually implemented in a limited fashion, example, as a backbone connecting the main computers of a hybrid network that can include several other topologies.

Hybrid Topology:

Often a network combines several topologies a 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.



Categories of networks

Today when we speak of networks, we are generally referring to three primary categories: **Local Area Networks**, **Metropolitan Area Networks**, and **Wide Area Networks**. All the categories of networks are categorized by size, its ownership, the distance it covers, and its physical architecture.

LAN (Local Area Network)

Local area networks, generally called LANs, are privately-owned networks within a single building or campus of up to a few kilometers in size. They are widely used to connect personal computers and workstations in company offices and factories to share resources (e.g., printers) and exchange information. LANs are distinguished from other kinds of networks by three characteristics:

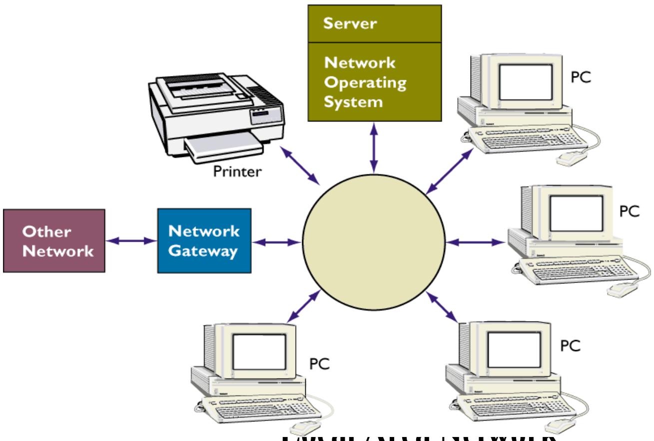
(1) Size,

(2) Transmission technology, and

(3) Topology.

LANs are restricted in size, which means that the worst-case transmission time is bounded and known in advance. Knowing this bound makes it possible to use certain kinds of designs that would not otherwise be possible. It also simplifies network management.

LANs may use a transmission technology consisting of a cable to which all the machines are attached, like the telephone company party lines once used in rural areas. Traditional LANs run at speeds of 10 Mbps to 100 Mbps, have low delay (microseconds or nanoseconds), and make very few errors. Newer LANs operate at up to 10 Gbps. In this book, we will adhere to tradition and measure line speeds in megabits/sec (1 Mbps is 1,000,000 bits/sec) and gigabits/sec (1 Gbps is 1,000,000,000 bits/sec).



Local Area Network

Characteristics & Uses of LAN

The Characteristics of the ideal LAN can be summarized as follows:
High Speed: Data rates of currently available LANs cover a wide range. The slowest transfer data at around 100 kbps while the fastest have data rates of up to 100 kbps.

Low Cost: Many applications of LANs involve low cost microprocessors systems; it is desirable that connection of such systems to a LAN should be economic. Another factor that influences the cost of a LAN is the wiring, which must be installed. There are both the costs of the wirer and its installation to consider. LANs use very inexpensive cable such as twisted pair telephone wire.

High reliability/Integrity: Since LAN is set of multiple interconnected systems; it offers a good backup capability in the event of one or two systems failing in the network. This enhances the reliability and availability of the systems to users.

Installation flexibility: LAN offers flexibility in locating the equipment. Most computers on a LAN are physically placed at the user table, which is most convenient for working and improves productivity significantly.

Expandability: Unlike a large centralized system, a LAN may evolve with time. It may be put into operation with a small investment, and more systems.

Uses of LAN

1. LAN provides a resource-sharing environment. All the LAN users may share expensive peripherals, hosts and databases.
2. LAN adhering to a certain standard, permits multi-vendor systems to be connected to it.
3. In LAN, the systems are generally so chosen as to meet most of the user requirements locally and the network is used only for resource and information sharing purposes.

Components of LAN

W**orkstations:** In LAN, a workstation refers to a machine that will allow user's access to a LAN and its resources while providing intelligence on board allowing local execution of applications. It may; allow data to be stored locally or remotely on a file server. Obviously, diskless workstations require all data to be stored remotely, including that data necessary for the diskless machine to boot up. Executable files may reside locally or remotely as well, meaning a workstation can run its own programs or those copied off the LAN.

Servers: A server is a computer that provides the data, software and hardware resources that are shared on the LAN. A LAN can have more than one server; each has its unique name on the network and all LAN users identify the server by its name.

1. **Dedicated Server:** A server that functions only as a storage area for data and software and allows access to hardware resources is called a dedicated server. Dedicated servers need to be powerful computers.

2. **Non-Dedicated Server:** In may LAN's, the server is just another work station. Thus, there is a user networking on the computer and using it as a workstation, but part of the computer also doubles up as a server. Such a server is called a non-dedicated server. Since, it is not completely dedicated to serving. LANs do not require a dedicated server since resource sharing amongst a few workstations is proportionately on a smaller scale.

3. **Some of the other servers like:**

1. **File Server**: A file server stores files that workstations can access and it also decides on the rights and restrictions that the users need to have while accessing files on LAN.
2. **Printer Server:** A printer server takes care of the printing requirement of a number of workstations.
3. **Modem Server:** It allows LAN users to use the modem to transmit long distance messages. Server attached to one or two modems would serve the purpose.

CLIENTS

A client is any machine that requires something from a server. In the m ore common machine connected to it. Each machine is a client. Thus a typical ten PC local area network may have one large server with all the major files and databases on it and all the other machines connected as clients. This type of terminology is common with TCP/IP networks, where no single machine is necessary the central repository.

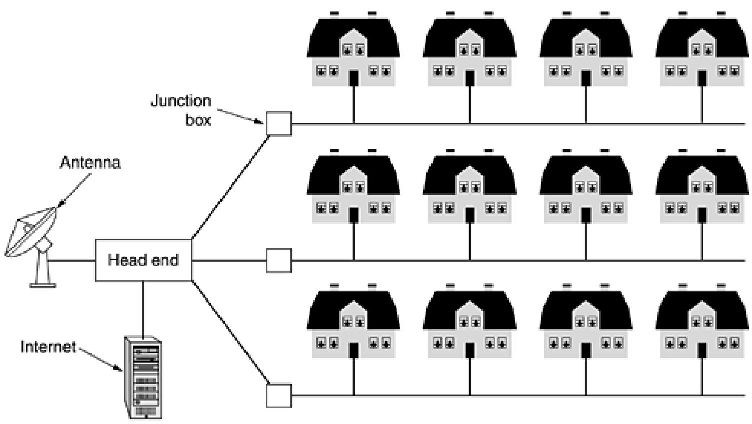
NODES

Small networks that comprise of a server and a number of PC. Each PC on the network is called a node. A node essentially means any device that is attached to the network. Because each machine has a unique name or number (so the rest of the network can identify it), you will here the term node name or node number quite often.

Metropolitan Area Network (MAN):

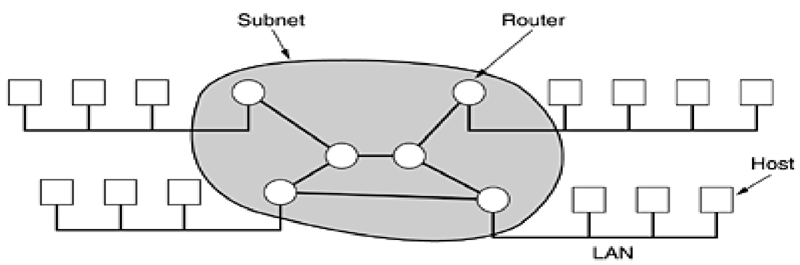
A metropolitan area network is designed to extend over an entire city. It may be a single network such as a cable television network or it may be a means of connecting a number of LANs into a larger network so that resources may be shared LAN to LAN as well as device-to divide. For example, a company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

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):

Wide-area networks have traditionally been considered to be those that cover a large geographical area, require the crossing of public right-of-ways, and rely at least in part on circuits provided by a common telephone carrier. Typically, a WAN consists of a number of interconnected switching nodes. Transmission from any one device is routed through these internal nodes to the specified destination device. These nodes (including the boundary nodes to which the devices are connected) are not concerned with the content of the data; rather, their purpose is to provide a switching facility that will move the data from node to node until they reach their destination. Traditionally, WANs have been implemented using one of two technologies: circuit switching and packet switching. More recently, frame relay and ATM networks have assumed major roles.



Network Components:
Basic computer network components

Computer networks share common devices, functions, and features including servers, clients, transmission media, shared data, shared printers and other hardware and software resources, network interface card(NIC), local operating system(LOS), and the network operating system (NOS).

Servers - Servers are computers that hold shared files, programs, and the network operating system. Servers provide access to network resources to all the users of the network. There are many different kinds of servers, and one server can provide several functions. For example, there are file servers, print servers, mail servers, communication servers, database servers, print servers, fax servers and web servers, to name a few.

Clients - Clients are computers that access and use the network and shared network resources. Client computers are basically the customers (users) of the network, as they request and receive services from the servers.

Transmission Media - Transmission media are the facilities used to interconnect computers in a network, such as twisted-pair wire, coaxial cable, and optical fiber cable. Transmission media are sometimes called channels, links or lines.

Shared data - Shared data are data that file servers provide to clients such as data files, printer access programs and e-mail.

Shared printers and other peripherals - Shared printers and peripherals are hardware resources provided to the users of the network by servers. Resources provided include data files, printers, software, or any other items used by clients on the network.

Network Interface Card - Each computer in a network has a special expansion card called a network interface card (NIC). The NIC prepares(formats) and sends data, receives data, and controls data flow between the computer and the network. On the transmit side, the NIC passes frames of data on to the physical layer, which transmits the data to the physical link. On the receiver's side, the NIC processes bits received from the physical layer and processes the message based on its contents.

Local Operating System - A local operating system allows personal computers to access files, print to a local printer, and have and use one or more disk and CD drives that are located on the computer. Examples are MS-DOS, Unix, Linux, Windows 2000, Windows 98, Windows XP etc.

Network Operating System - The network operating system is a program that runs on computers and servers, and allows the computers to communicate over the network.

Hub - Hub is a device that splits a network connection into multiple computers. It is like a distribution center. When a computer request information from a network or a specific computer, it sends the request to the hub through a cable. The hub will receive the request and transmit it to the entire network. Each computer in the network should then figure out whether the broadcast data is for them or not.

Switch - Switch is a telecommunication device grouped as one of computer network components. Switch is like a Hub but built in with advanced features. It uses physical device addresses in each incoming messages so that it can deliver the message to the right destination or port.

Like a hub, switch doesn't broadcast the received message to entire network, rather before sending it checks to which system or port should the message be sent. In other words, switch connects the source and destination directly which increases the speed of the network. Both switch and hub have common features: Multiple RJ-45 ports, power supply and connection lights.

Signals

One of the major functions of the physical layer is to move data in the form of electromagnetic signals across a transmission medium.

Analog and Digital data

The term ***analog data*** refers to information that is continuous, such as the sounds made by a human voice, take on continuous values. When someone speaks, an analog wave is created in the air. This can be captured by a microphone and converted to an analog signal or sampled and converted to a digital signal.

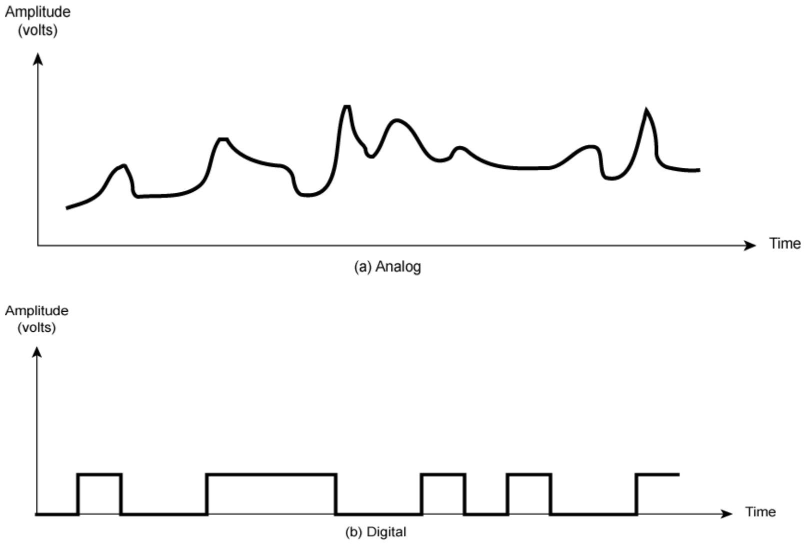
Ex:-An analog clock that has hour, minute, and second hands gives information in a continuous form.

Digital data refers to information that has discrete states. Its take on discrete values. Ex. Data are stored in computer memory in the form of 0s and 1s. They can be converted to a digital signal or modulated into an analog signal for transmission across a medium.

Ex:- An digital clock that reports the hours and the minutes will change suddenly from 9:45 to 9:46.

Analog and Digital Signals

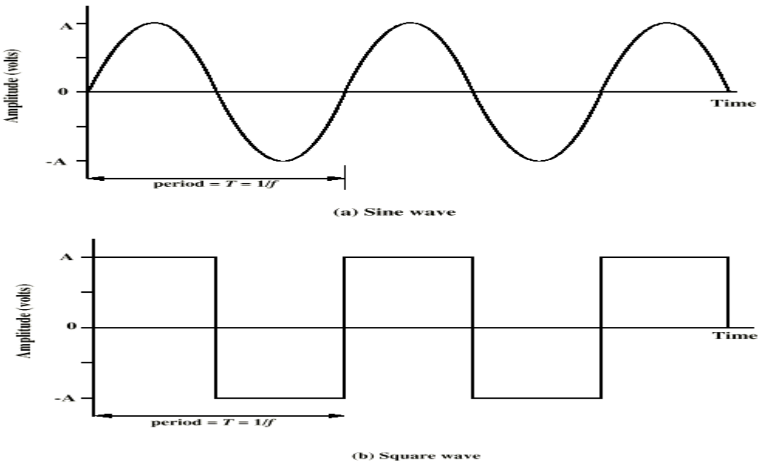
An analog signal has infinitely many levels of intensity over a period of time. As the wave moves from value A to B, it passes through and includes an infinite number of values along its path.



The above picture represents an analog signals and digital signals. Is by plotting them on a pair of perpendicularly axes. The vertical axis represents the value or strength of a signal. The horizontal axis represents time.

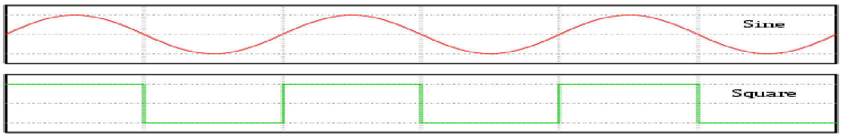
Periodic and Nonperiodic Signals:

Both analog and digital signals can take one of two forms: periodic or nonperiodic. A periodic signal completes a pattern within a measurable time frame, called one full pattern is called a cycle. A nonperiodic signal changes without exhibiting a pattern or cycle that repeats over time. In data communications, we commonly use periodic analog signals (because they need less bandwidth) and nonperiodic digital signals.



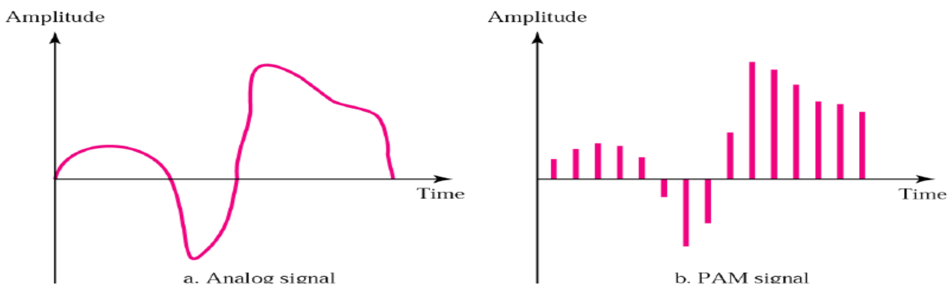
Periodic Analog Signals: Periodic analog signals can be classified into simple or composite. A simple periodic analog signal, a sine wave, cannot be decomposed into simpler signals. A composite periodic analog signal is composed of multiple sine waves.

Sine Wave:
The sine wave is the most fundamental form of a periodic analog signal. When we visualize it as a simple oscillating curve, its change over the course of a cycle is smooth and consistent, a continuous, rolling flow.

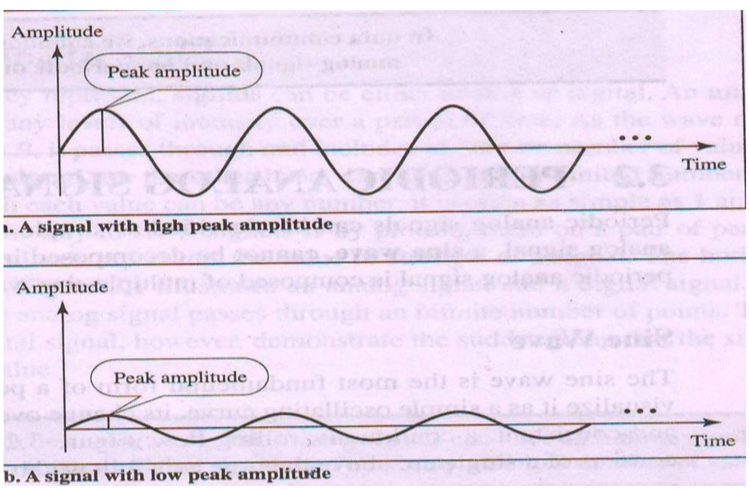


A square wave is a kind of non-sinusoidal waveform, most typically encountered in electronics and signal processing. An ideal square wave alternates regularly and instantaneously between two levels.

Pulse Amplitude: In telecommunication, pulse amplitude is the magnitude of a pulse parameter, such as the voltage level, current level, field intensity, or power level.Pulse amplitude is measured with respect to a specified reference and therefore should be modified by qualifiers, such as "average", "instantaneous", "peak", or "root-mean-square".Pulse amplitude also applies to the amplitude of frequency- and phase-modulated waveform envelopes.

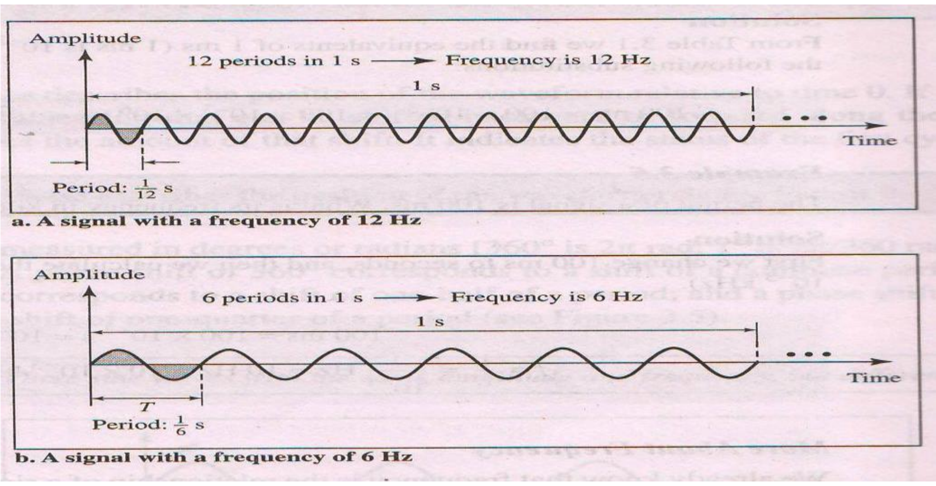


Peak Amplitude: The peak amplitude of a signal is the absolute value of its highest intensity, proportional to the energy it carries. For electric signals, peak amplitude is normally measured in volts. Ex: the power in your house can be represented by a sine wave with peak amplitude of 155 to 170 V. however; it is common knowledge that the voltage of the power in U.S. homes is 110 to 120v.



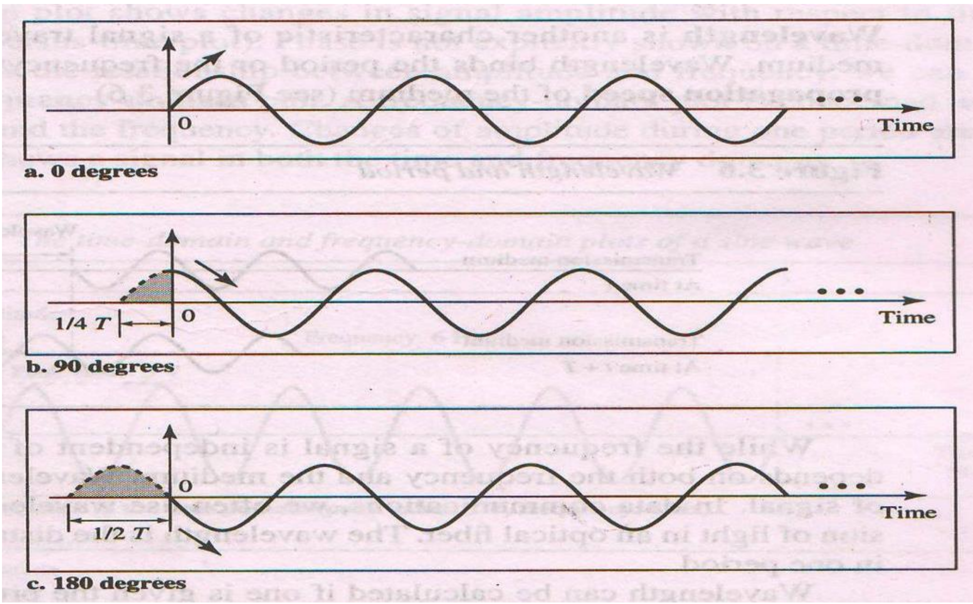
Two signals with the same phase and frequency, but different amplitudes.

Period and Frequency:Period refers to the amount of time, in seconds, a signal needs to complete 1 cycle. Frequency refers to the number of periods in 1s. Period and frequency are just one characteristic defined in two ways. Period is the inverse of frequency, and frequency is the inverse of period, as the following formulas.



Period is formally expressed in seconds. Frequency is formally expressed in Hertz(Hz), which is cycle per second.

Phase: The term phase describes the position of the waveform relative to time 0. If we think of the wave as something that can be shifted backward or forward along the time axis, phase describes the amount of that shift. It indicates the status of the first cycle. Phase is measured in degrees or radians.



The above diagram shows that, three sine waves with the same amplitude and frequency, but different phase.

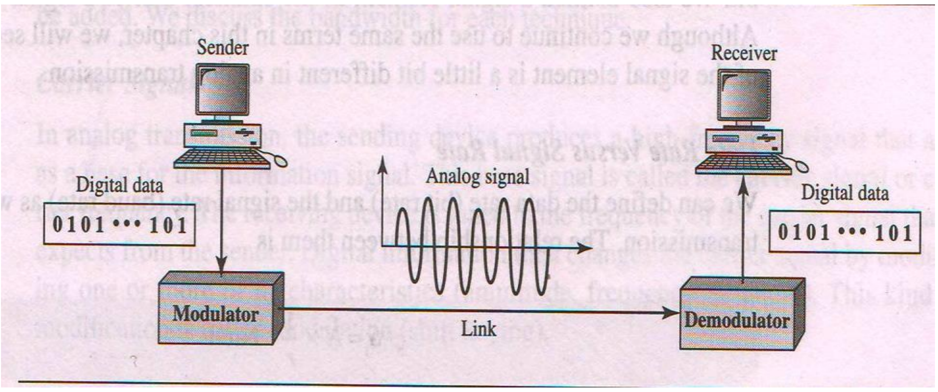
1. A sine wave with a phase of 0 degree starts at time 0 with a zero amplitude. The amplitude is increasing.
2. A sine wave with a phase of 90 degree starts at time 0 with a peak amplitude. The amplitude is decreasing.
3. A sine wave with a phase of 180 degree starts at time 0 with a zero amplitude. The amplitude is decreasing.

Another way is phase is in terms of shift or offset.

1. A sine wave with a phase of 0 degree is not shifted.
2. A sine wave with a phase of 90 degree is shifted to the left by ¼ cycle.
3. A sine wave with a phase of 180 degree is shifted to the left by ½ cycle.

Digital - to - Analog Encoding (Conversion)

It is the process of changing one of the characteristics of an analog signal based on the information in a digital signal.



A sine wave is defined by three characteristics: Amplitude, Frequency and Phase. When we vary any one of these characteristics, we create a different version of that wave. So, by change one characteristic of a simple electric signal, we can use it to represent digital data. In this process there are three mechanisms for modulating digital-to-analog signal. They are.,

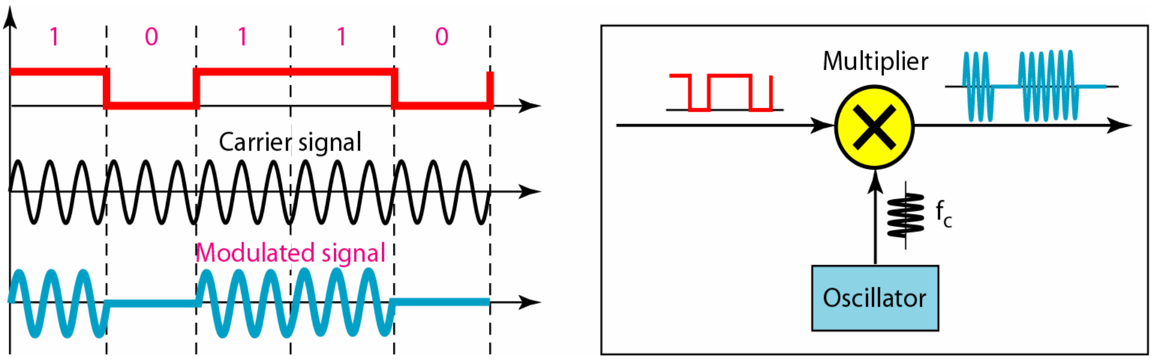
- Amplitude Shift Keying(ASK)
- Frequency Shift Keying(FSK)
- Phase Shift Keying(PSK)

Amplitude Shift Keying (ASK):

In ASK, the amplitude of the carrier signal is varied to create signal elements. Both frequency and phase remain constant while the amplitude changes.

Binary ASK (BASK):
Since we have seen several levels (kinds) of signal elements, each with different amplitude, ASK is normally implemented using only two levels. This is referred to as **binary amplitude shift keying** or **on – off – keying** (OOK). In OOK one of the bit values is represented by no voltage to reduce the amount of energy required to transmit information. The **peak amplitude** of one signal is zero where as the amplitude of carrier frequency is same for others.

Amplitude   Bit rate: 5



1s

Ba
ud
rate
:5

Bandwidth: Carrier signals are only simple sinewaves, but modulation creates signals with continues frequencies

$BW = (1+d) \times N_{baud}$

Where Bw – bandwidth

N_{baud} - Baud rate

d – factor related to the condition of the line (with minimum value of 0)

Demodulation: only the presence or absence of a sinusoid in a given time interval needs to be determined

Advantage: Its easy to modulate\demodulate and can take little bandwidth when compared to FSK. It has coherent and non coherent features.

Disadvantage :ASK is very susceptible to noise interference – noise usually (only) affects the amplitude, therefore ASK is the modulation technique most affected by noise

Application: ASK is used to transmit digital data over optical fiber

Frequency Shift Keying (FSK):

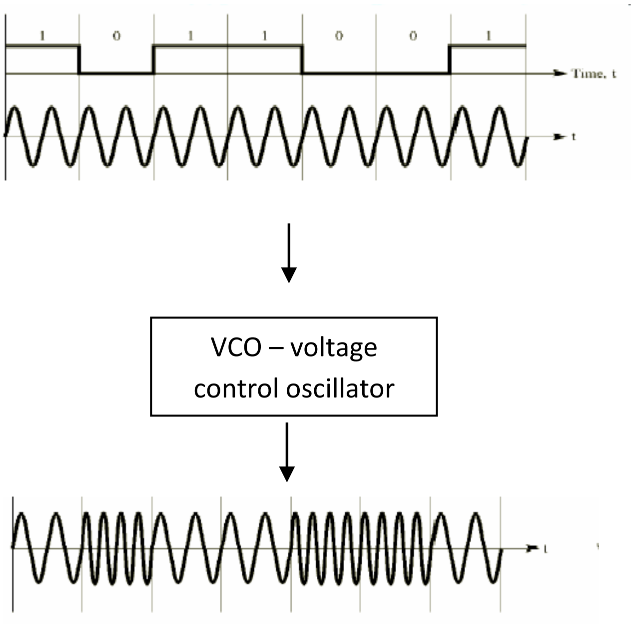
In this technique, the frequency of the carrier signal is varied to represent binary 1 or 0. The frequency of the modulated signal is constant for the duration of one signal element, but changes for the next signal element if the data element changes. Both peak amplitude and phase remains constant.

Binary FSK (BFSK): In binary FSK is to consider two carrier frequencies. In the figure we have selected two carrier frequencies, f1 and f2. we use the first carrier if the data element is 0; we use the second if the data element is 1. Normally the frequencies are very high, and the difference between them is very small.

FSK avoids most of the noise problems of ASK. Because the receiving device is looking for specific frequency changes over a given number of periods, it can ignore voltage spikes. The limiting factors of FSK are the physical capabilities of the carrier.

Bandwidth for FSK: The bandwidth required for FSK transmission is equal to the baud rate of the signal and the frequency shift (difference between the two carrier frequencies).

BW = $(f_{c1} - f_{c0}) + N_{baud}$



Result: The VCO oscillator keeps regular frequency when the amplitude is positive, the frequency is increased.

Demodulation: demodulator must be able to determine which of two possible frequencies is present at a given time

Advantage: FSK is less susceptible to errors than ASK – receiver looks for specific frequency changes over a number of intervals, so voltage (noise) spikes can be ignored

Disadvantage: FSK spectrum is 2 x ASK spectrum

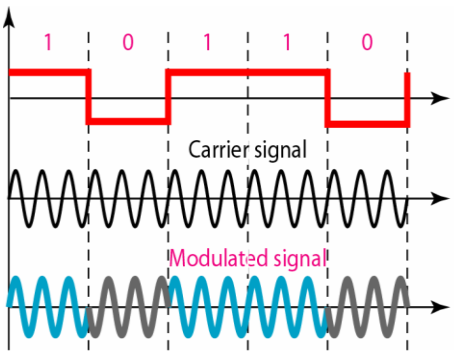
Application: over voice lines, in high-freq. radio transmission, etc.

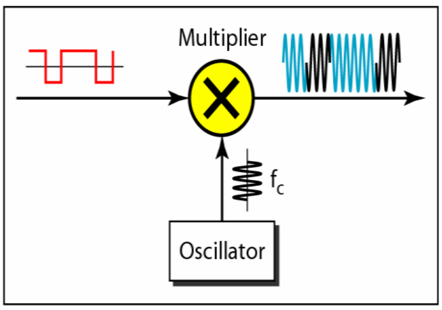
Phase Shift Keying (PSK):

In this technique, the phase of the carrier is varied to represent two or more different signal elements. Both peak amplitude and frequency remain constant as the phase changes.

Binary PSK (BPSK)

The simplest PSK is binary PSK, in which we have only two signal elements, one with a phase of 0^0, and the other with a phase of 180^0. PSK is less susceptible to noise degradation that affects ASK, or to the bandwidth limitations of FSK. This means that smaller variations in the signal can be detected reliably by the receiver. Therefore, instead of utilizing only two variations of a signal, each representing one bit, can use four variations and let each phase shift represent two bits.





Bandwidth for PSK: The minimum bandwidth required for PSK transmission is the same as that required for ASK transmission.

$$BW = (1 + d) \times N_{baud}$$

Advantage:

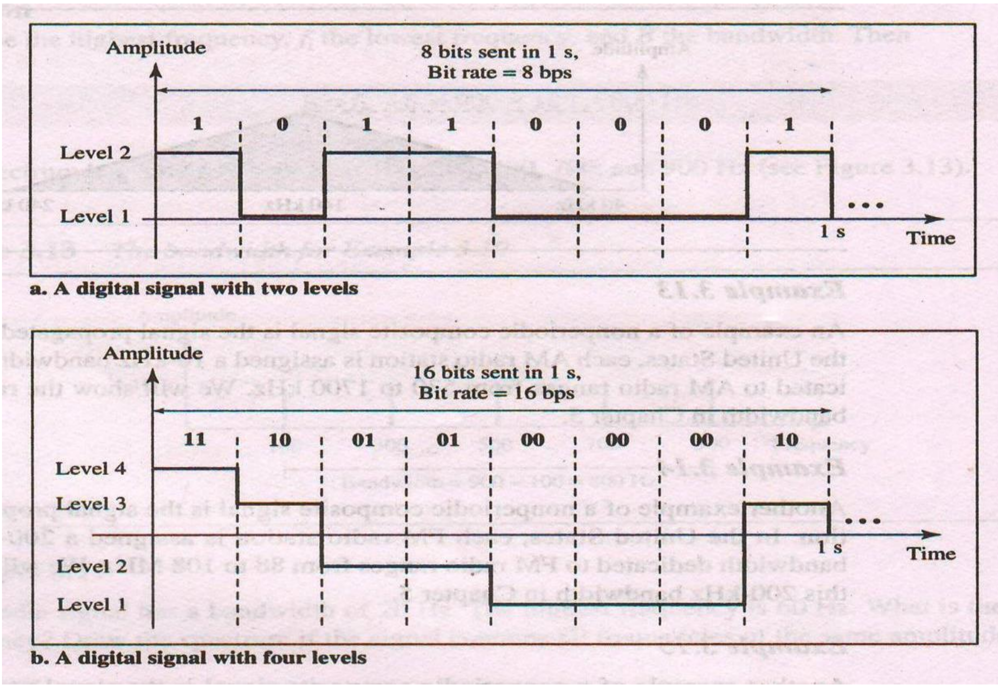
- higher data rate than in PSK (2 bits per bit interval), while bandwidth occupancy remains the same
- 4-PSK can easily be extended to 8-PSK, i.e. n-PSK
- however, higher rate PSK schemes are limited by the ability of equipment to distinguish small differences in phase

Application:

PSK uses a finite number of phases; each assigned a unique pattern of binary digits

Digital Signals:

Information can also be represented by a digital signal. For example, a 1 can be encoded as a positive voltage and a 0 as zero voltage. A digital signal can have more than two levels. In this case, we can send more than 1 bit for each level.



Bit Rate – Most digital signals are Nonperiodic, and thus period and frequency are not appropriate characteristics. Another term-bit rate (instead of frequency)- is used to describe digital signals. The bit rate is the number of bits sent in 1s, expressed in bits per second(bps).

Bit Length- The bit length is the distance one bit occupies on the transmission medium
Bit length = propagation speed x bit duration

Baud Rate - Refers to the number of signal units per second that are required to represent those bits.

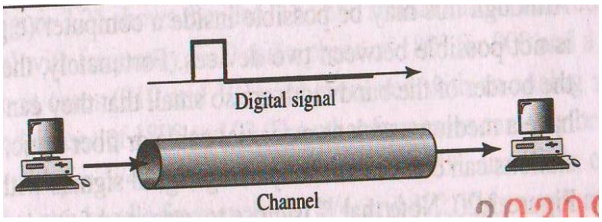
Carrier Signal - A high-frequency signal that acts as a basis for the information signal is called the carrier signal or carrier frequency.

Transmission of Digital signals:

Transmission of digital signals is one of two different approaches.

1. Baseband Transmission:

Baseband transmission means sending a digital signal over a channel without changing the digital signal to an analog signal.

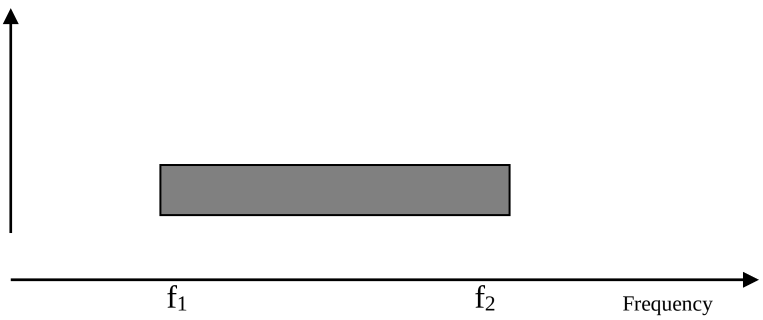


It require that we have a low-pass channel, a channel with a bandwidth that starts from zero. This is the case if we have a dedicated medium with bandwidth constituting only one channel. For example, the entire bandwidth of a cable connecting two computers is one single channel. As another example, we may connect several computers to a bus, but not allow more than two stations to communicate at a time. Again we have a low-pass channel, and we can use it for baseband communication.

2. Broadband Transmission:

Broadband transmission or modulation means changing the digital signal to an analog signal for transmission. Modulation allows us to use a bandpass channel- a channel with a bandwidth that does not start from zero. This type of channel is more available than a low-pass channel.

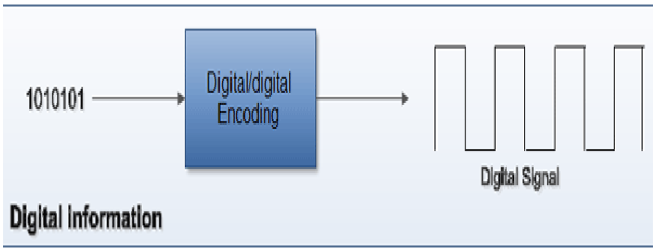
Amplitude



Analog to Digital: Analog to digital encoding is the representation of analog information by a digital signal. These include PAM (Pulse Amplitude Modulation), and PCM (Pulse Code Modulation).
Digital to Analog: These include ASK (Amplitude Shift Keying), FSK (Frequency Shift Keying), PSK (Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), are QAM (Quadrature Amplitude Modulation).
Analog to Analog: These are Amplitude modulation, Frequency modulation and Phase modulation techniques, It is required that information must be encoded into signals before it can be transported

across communication media. In more precise words we may say that the waveform pattern of voltage or current used to represent the 1s and 0s of a digital signal on a transmission link is called digital to digital line encoding. There are different encoding schemes available:

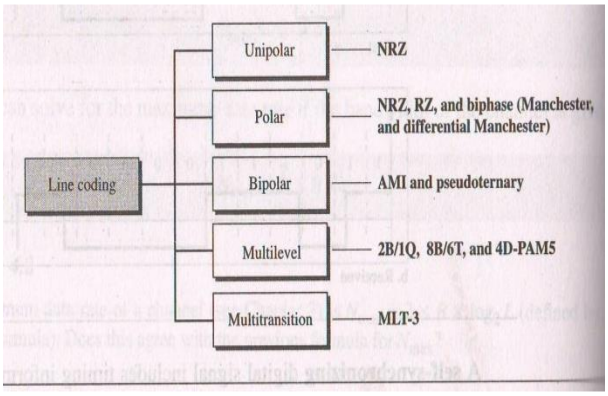
Digital-to Digital Encoding: It is the representation of digital information by a digital signal.



Line code: In telecommunication, a line code (also called digital baseband modulation or digital baseband transmission method) is a code chosen for use within a communications system for baseband transmission purposes. Line coding is often used for digital data transport.

Line coding: Line coding i the process of converting digital data to digital signals. It consists of representing the digital signal to be transported by an amplitude- and time-discrete signal that is optimally tuned for the specific properties of the physical channel (and of the receiving equipment). The waveform pattern of voltage or current used to represent the 1s and 0s of a digital data on a transmission link is called line encoding.
The common types of line encoding are unipolar, polar, bipolar, and Manchester encoding.There are basically following types of digital· to-digital encoding available like:

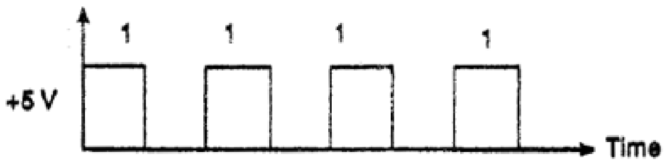
- Unipolar
- Polar
- Bipolar.



Unipolar: In a Unipolar scheme, all the signal levels are on one side of the time axis, either above or below.

NRZ (Non-Return-to-Zero) : Traditionally, a unipolar scheme was designed as a non-return-to-zero (NRZ) scheme in which the positive voltage defines bit 1 and the zero voltage defines bit 0. It is called NRZ because the signal does not return to zero at the middle of the bit.

amplitude

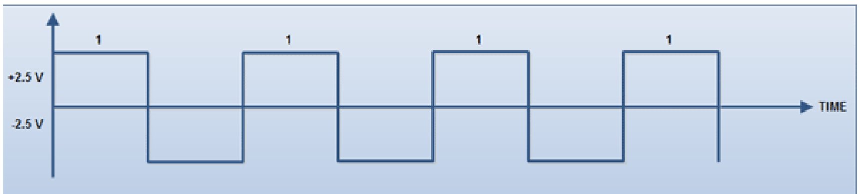


Unipolar encoding

Compared with its polar counterpart this scheme is very costly. The normalized power is double that for polar NRZ. For this reason, this scheme is normally not used in data communications today.

Polar

In polar schemes, the voltages are on the both sides of the time axis. Polar encoding uses two levels of voltages say positive and negative.



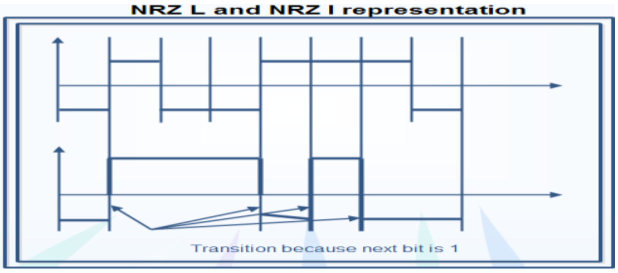
Polar Encoding Representation

Non-Return to Zero (NRZ)

In NRZ·L, the level of the signal is 1 if the amplitude is positive and 0 in case of negative amplitude.

In NRZ·I, whenever a positive amplitude or bit I appears in the signal, the signal gets inverted, Figure explains the concepts of NRZ-L and NRZ·I more precisely.

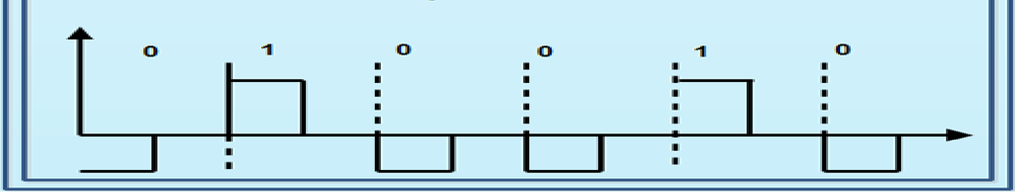
NRZ L and NRZ I representation



Return to Zero (RZ)

RZ uses three values to represent the signal. These are positive, negative, and zero. Bit 1is represented when signal changes from positive to zero. Bit 0 is represented when signal changes from negative to zero. Figure explains the RZ concept.

RZ Representation



Biphase

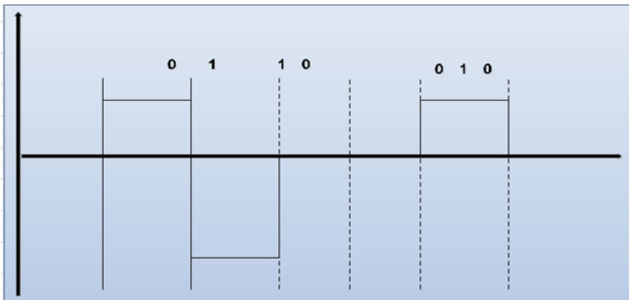
Biphase is implemented in two different ways as Manchester and Differential Manchester encoding.

In Manchester encoding, transition happens at the middle of each bit period. A low to high transition represents a 1 and a high to low transition represents a 0.In case of Differential Manchester encoding, transition occurs at the beginning of a bit time, which represents a zero.

These encoding can detect errors during transmission because of the transition during every bit period. Therefore, the absence of a transition would indicate an error condition. They have no DC component and there is always a transition available for synchronizing receives and transmits clocks.

Bipolar

Bipolar uses three voltage levels. These are positive, negative, and zero. Bit 0 occurs at zero level of amplitude. Bit 1 occurs alternatively when the voltage level is either positive or negative and therefore, also called as Alternate Mark Inversion (AMI). There is no DC component because of the alternate polarity of the pulses for Is. Figure describes bipolar encoding.



Bipolar represention

Terminology

- Unipolar – all signal elements have the same sign
- polar – one logic state represented by positive voltage and the other by negative voltage
- data rate – rate of data (R) transmission in bits per second
- duration or length of a bit – time taken for transmitter to emit the bit (1/R)
- modulation rate – rate at which the signal level changes, measured in baud = signal elements per second.

Transmission Medias

A transmission medium can be defined as anything that can carry information from a source to a destination. Ex. The transmission medium for two people having a dinner conversation is the air. The air can also be used to convey the message in a smoke signal or semaphore. For a written message, the transmission medium might be a mail carrier, a truck, or airplane.

In data communication the definition of the information and the transmission medium is more specific. The transmission medium is usually free space, metallic cable, or fiber-optic cable. The information is usually a signal that is the result of a conversion of data from another form.

The use of long-distance communication using electric signals started with the invention of the telegraph by Morse in the 19th century. Communication by telegraph was slow and dependent on a metallic medium. Extending the range of the human voice became possible when the telephone was

invented in 1869. Telephone communication at that time also needed a metallic medium to carry the electric signals that were the result of a conversion from the human voice.
The communication was, however, unreliable due to the poor quality of the wires. The lines were often noisy and the technology was unsophisticated.

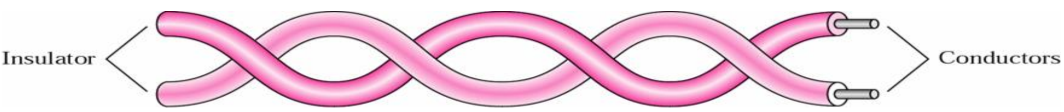
Wireless communication started in 1895 when Hertz was able to send high frequency signals. Later, Marconi devised a method to send telegraph-type messages over the Atlantic Ocean.

We have come a long way. Better metallic media have been invented (twisted pair and coaxial cables, for example). The use of optical fibers has increased the data rate incredibly. Free space (air, vacuum, and water) is used more efficiently, in part due to the technologies (such as modulation and multiplexing).

In telecommunication, transmission media can be divided into two broad categories: **Guided and Unguided. Guided media include twisted-pair cable, coaxial cable and fiber-optic cable. Unguided medium is free space.**

Guided Media:
Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable. A signal travelling along any of these media is directed and contained by the physical limits of the medium. Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transports **signals in the form of electric current**. Optical fiber is a cable that accepts and **transports signals in the form of light**.

Twisted-Pair Cable:
A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together.



One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two.

In addition to the signal sent by the sender on one of the wires, interference (noise) and crosstalk may affect both wires and create unwanted signals.

If the two wires are parallel, the effect of these unwanted signals is not the same in both wires because they are at different locations relative to the noise or crosstalk sources (e.g., one is closer and the is farther). This results in a difference at the receiver. By twisting the pairs, a balance is maintained. For example, suppose in one twist, one wire in closer to the noise source and the other is farter; in the next twist, the reverse is true. Twisting makes it probable that both wires are equally affected by external influences (noise or crosstalk). This means that the receiver, which calculates the difference between the two, receives no unwanted signals. The unwanted signals are mostly canceled out. From the above conversation, it is clear that the number of twists per unit of length (e.g., inch) has some effect on the quality of the cable.

Unshielded Versus Shielded Twisted-Pair Cable:

The most common twisted-pair cable used in communications is referred to as unshielded twisted-pair (UTP). IBM has also produced a version of twisted-pair cable fro its use called shielded twisted-pair (STP). STP cable has a metal foil or braided-mesh covering that encases each pair of insulated conductors. Although metal casing improves the quality of cable by preventing the penetration of noise or crosstalk, it is bulkier and more expensive.

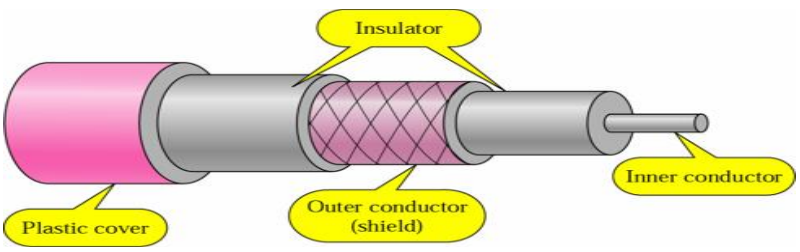
Connectors: The most common UTP connector is RJ45 (RJ stands for registered jack). The RJ45 is a keyed connector, meaning the connector can be inserted in only one way.

Performance: To measure the performance of twisted pair cable is to compare attenuation versus frequency and distance. A twisted pair cable can pass a wide range of frequencies.

Applications: Twisted pair cables are used in telephone lines to provide voice and data channels. The local loop – the line that connects subscribers to the central telephone office.Local-area networks, such as 10 Base-T and 100 Base-T, also use twisted-pair cables.

Co-axial Cable:

Coaxial Cable (or coax) carries signals of higher frequency range than twisted-pair cable, in part because the two media are constructed quite differently. Instead of having two wires, coax has a central core conductor of solid or standard wire (usually copper) enclosed in an insulation sheath, which is intern, encased in an outer conductor of metal foil, braid, or a combination of the two (also usually copper). The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit. This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.



Coaxial cables standards are categorized by their radio government (RG) ratings.

RG – 11. Used in thick Ethernet.

RG – 58 Used in thin Ethernet.

RG – 59 Used as a cable TV connector

Coaxial Cable Connectors: To connect coaxial cable to devices, we need coaxial connectors. The most common type of connector used today is the **Bayone-Neill-Concelman** (BNC), connector. There are three popular types of these connectors: The BNC connector, the BNC T connector, The BNC terminator. The BNC connector is used to connector the end of the cable to device, such as a

TV set. The BNC T connector is used in Ethernet networks to branch out to a connection to a computer or the device. The BNC terminator is used at the end of the cable to prevent the reflection of the signal.

Performance: The attenuation is much higher in coaxial cables than in twisted-pair cable. In other words, although coaxial cable has a much higher bandwidth, the signal weakens rapidly and requires the frequent use of repeaters.

Application of Coaxial cable:

1. Coaxial cable was widely used in analog telephone networks where a single coaxial network could carry 10,000 voice signals.

2. Then it was used in digital telephone networks where a single coaxial cable could carry digital data up to 600 Mbps.

3. Cable TV networks also use coaxial cables.

4. Today the Coaxial cable was replaced by using fiber-optic cable.

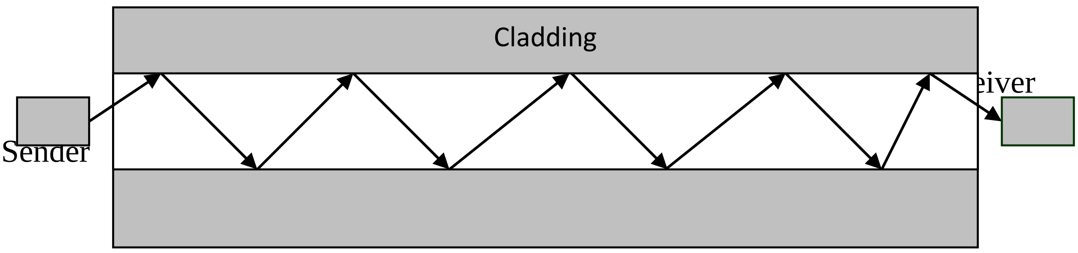
5. The common application of Coaxial cable is in traditional Ethernet Lan's , because of high bandwidth and consequently high data rate.

Fiber-Optic Cable:

A fiber-optic cable is made of glass or plastic and transmits signals in the form of light. The glass core of a fiber optic cable is surrounded by and bound to a glass tube called "cladding". Cladding adds strength to the cable while disallowing any stray light wave from leaving the central core. A plastic then surrounds this cladding or PVC outer jacket which provides additional strength and protection for the inwards. Some fiber optic cables incorporate Kevlar fibers for added strength and durability. Kevlar is the stuff of which bulletproof vests are made, so it's tough.

Working principal of OFC: OFC works on the principal of TOTAL INTERNAL REFLECTION OF LIGHT.

Propagation Modes: Current technology supports two modes for propagating light along optical channels, each requiring fiber with different physical characteristics. Multimode can be implemented in two forms: Step-index or graded-index.



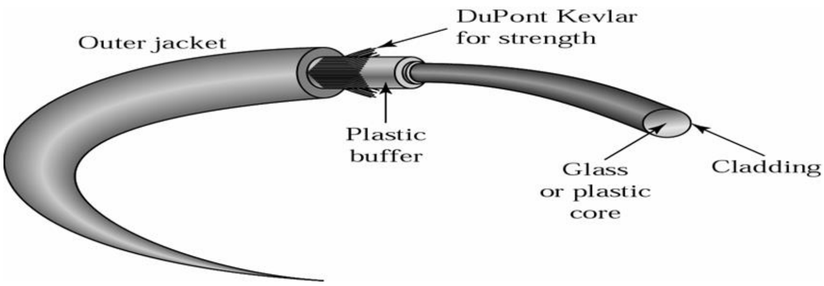
Multimode is so named because multiple beams from a light source move through the core in different paths. How these beams move within the cable depends on the structure of the core.

In multimode step-index fiber, the density of the core remains constant from the center to the edges. A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding. At the interface, there is an abrupt change due to a lower density; this alters the angle of the beams motion. The term step index refers to the suddenness of the change, which contributes to the distortion of the signal as it passes through the fiber.

A second type of fiber, called multimode graded-index fiber, decreases this distortion of the signal through the cable. The word index here refers to the index of refraction. As we saw above, the index of refraction is related to density. A graded-index fiber, therefore, is one with varying densities. Density is highest at the center of the core and decreases gradually to its lowest at the edge.

Single-mode fiber itself is manufactured with a much smaller diameter than that of multimode fiber, and with substantially lower density (index of refraction). The decrease in density results in a critical angle that is close enough to 90^0 to make the propagation of beams almost horizontal. In this case propagation of different beams is almost identical and delays are negligible.

Performance: The plot of attenuation versus wavelength is a very interesting phenomenon is fiber-optic cable. Attenuation is flatter than in the case of twisted-pair cable and coaxial cable. The performance is such that we need fewer (actually 10 times less) repeaters when we use fiber-optic cable.



Applications:
OFC is used as a back bone networks because its wide bandwidth is cost- effective.

Some cable TV companies used a combination of optical fiber and coaxial cable, that creating a hybrid network.

Local area networks such as 100Base-FX network (Fast Ethernet) and 1000Base-X also use OFC

Advantages and disadvantages of optical fiber:
Advantages:

- Higher bandwidth. Fiber-optic cable can support dramatically higher bandwidths (and hence data rates) than either twisted-pair or coaxial cable. Currently, data rates and bandwidth utilization over fiber-optic cable are limited not by the medium but by the signal generation and reception technology available.
- Less signal attenuation. Fiber-optic transmission distance is significantly greater than that of other guided media. A signal can run for 50 km without requiring regeneration. We need repeaters every 5 km for coaxial or twisted-pair cable.
- Immunity to electromagnetic interference. Electromagnetic noise cannot affect fiber-optic cables.
- Resistance to corrosive materials. Glass is more resistant to corrosive materials than copper.

- Light weight. Fiber-optic cables are much lighter than copper cables.
- Greater immunity to tapping. Fiber-optic cables are more immune to tapping than copper cables. Copper cables create antenna effects that can easily to tap.

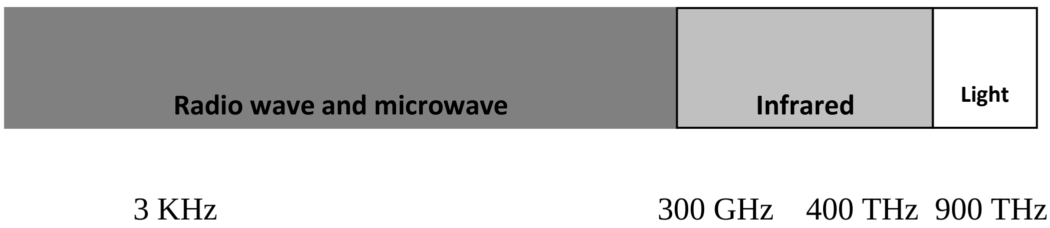
Disadvantage:

- Installation and maintenance. Fiber-optic cable is a relatively new technology. Its installation and maintenance require expertise that is not yet available everywhere.
- Unidirectional light propagation. Propagation of light is unidirectional if we need bidirectional communication, two fibers are needed.
- Cost. The cable and the interfaces are relatively more expensive than those of other guided media. If the demand for bandwidth is not high, often the use of optical fiber cannot be justified.

Unguided media

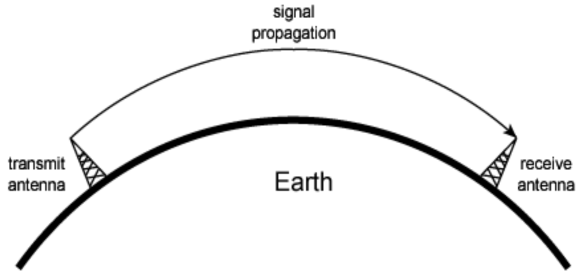
Unguided media, or wireless communication, transport electromagnetic waves without using a physical conductor. Instead, signals are broadcast through air (or, in a few cases, water), and thus are available to anyone who has a device capable of receiving them.Unguided signals can travel from the source to destination in several ways: **ground propagation, sky propagation, and line-of-sight propagation.**

Typical Electromagnetic spectrum ranging from 3 KHz to 900 THz, used for wireless communication.



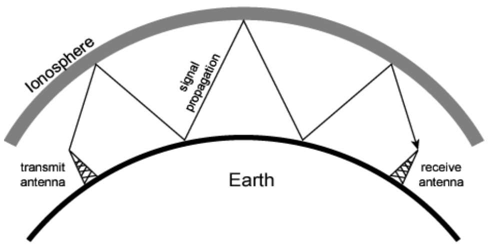
Unguided signals can travel from the source to destination in several ways: They are Ground propagation, Sky propagation, and line-of-sight propagation.

Ground propagation: In this type of propagation radio waves travel through the lowest portion of the atmosphere, hugging the earth. These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet. Distance depends on the amount of power in the signal: the greater the power, the greater the distance.



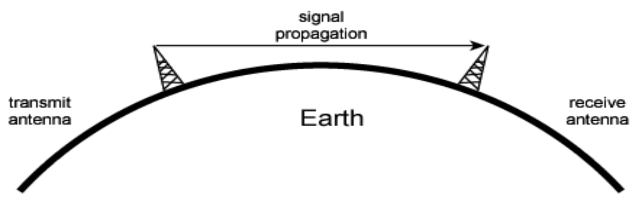
(a) Ground-wave propagation (below 2 MHz)

Sky propagation: This propagation includes higher-frequency radio waves radiate upward into the ionosphere (the layer of atmosphere where particles exist as ions) where they are reflected back to earth. This type of transmission allows for greater distances with lower output power.



(b) Sky-wave propagation (2 to 30 MHz)

Line-of-Sight propagation: Very high-frequency signals are transmitted in straight lines directly from antenna to antenna. Antennas must be directional, facing each other, and either tall enough or close enough together not be affected by the curvature of the earth. Line-of-sight propagation is tricky because radio transmissions cannot be completely focused.



(c) Line-of-sight (LOS) propagation (above 30 MHz)

Radio Frequency Allocation:

The section of the electromagnetic spectrum defined as a radio communication is divided into eight ranges, called bands, each regulated by government authorities. These bands are rated from very low frequency (VLF) to extremely high frequency (EHF).

Band	**Range**	**Propagation**	**Application**
VLF (Very low frequency)	3-30kHz	Ground	Long-range radio navigation
LF (low frequency)	30-300kHz	Ground	Radio beacons and navigational locators
MF(middle frequency)	300kHz- 3MHz	Sky	AM radio
HF(high frequency)	3-30MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF(very high frequency)	30-300MHz	Sky and line-of-sight	VHFTV, FMradio
UHF(ultrahigh frequency)	300MHz-3GHz	Line-of-sight	UHFTV, cellular phones, paging,

			satellite
SHF(superhigh frequency)	3-30GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30-300 GHz	Line-of-sight	Radar, satellite

The wireless transmission is divided into three major groups, **Radio waves, Microwaves, and infrared waves.**

Propagation of Radio Waves:
In radio waves the electromagnetic waves ranging in frequencies between 3 KHz and 1 GHz are normally called radio waves. Waves ranging in frequencies between 1 and 300 GHz are called microwaves. Radio wave transmission utilizes five different types of propagation: ***surface, Tropospheric, Ionospheric, line-of-sight, and space. Radio waves,*** for the most part, are omnidirectional (send out signals in all directions). When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and receiving antennas do not have to be aligned. A sending antenna sends wave that can be received by any receiving antenna. The omnidirectional property has a disadvantage, too. The radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signals using the same frequency or band.

Radio waves, particularly those of low and medium frequencies, can penetrate walls. This characteristic can be both an advantage and a disadvantage. It is an advantage because, for example, an AM radio can receive signals inside a building. It is a disadvantage because we cannot isolate a communication to just inside or outside a building. The radio wave band is relatively narrow, just under 1 GHz, compared to the microwave band. When this band is divided into subbands, the subbands are also narrow, leading to a low data rate for digital communications.

Omni directional Antenna: Radio waves use omnidirectional antennas that send out signals in all directions. Based on the wavelength, strength, and the purpose of transmission,.

Applications:
The omnidirectional characteristics of radio waves make them useful for multicasting, in which there is one sender but many receivers. AM and FM radio, television, maritime radio, cordless phones, and paging are examples of multicasting.

Microwave:
Electromagnetic waves having frequencies between 1 and 300 GHz are called micro waves. Microwaves are unidirectional. When an antenna transmits microwave waves, they can be narrowly focused. This means that the sending the receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas. The following characteristics of microwave propagation;

1. Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct sight of each other, towers that are far apart need to be very tall. The curvature of the earth

as well as other blocking obstacles does not allow two short towers to communicate by using microwaves. Repeaters are often needed for long distance communication.

2. Very high-frequency microwaves cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside buildings

3. The microwave band is relatively wide, almost 299 GHz. Therefore wider sub bands can be assigned, and a high data rate is possible
Use of certain portions of the band requires permission from authorities.

Unidirectional Antenna: Microwaves need unidirectional antennas that send out signals in one direction. Two types of antennas are used for microwave communication, the **parabolic dish** the **horn**

A parabolic dish antenna is based on the geometry of a parabola: every line parallel to the line of symmetry (line of sight) reflects off the curve at angles such that all the lines intersect in a common point called the focus. The parabolic dish works as a funnel, catching a wide range of waves and directing them to a common point. In this way, more of the signal is recovered than would be possible with a single-point receiver.

Outgoing transmissions are broadcast through a horn aimed at the dish. The microwaves hit the dish and are deflected outward in a reversal of the receipt path.

A **horn antenna** looks like a gigantic scoop. Outgoing transmissions are broadcast up a stem (resembling a handle) and deflected outward in a series of narrow parallel beams by the curved head. Received transmissions are collected by the scooped shape of the horn.

Applications:

Microwaves, due to their unidirectional properties, are very useful when unicast (one-to-one) communications is needed between the sender and the receiver. They are used in cellular phones, satellite networks and wireless LANs.

Infrared Waves:

Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication. Infrared waves, having high frequencies, cannot penetrate walls. This advantageous characteristic prevents interference between one system and another; a short-range communications system in one room cannot be affected by another system in the next room. When we use our infrared remote control, we do not interfere with the use of the remote by our neighbors. However, this same characteristic makes infrared signals useless for long-range communication. In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

1. Generally is excellent potential for data transmission. Such a wide bandwidth can be used to transmit digital data with a very high data rate.

2. The Infrared Data Association (IrDA), an association for sponsoring the use of infrared waves, has established standards for using these signals for communication between devices such as keyboards, mouse, PCs, and printers.

Repeaters: To increase the distance served by terrestrial microwave, a system of repeaters can be installed with each antenna. A signal received by one antenna can be converted back into transmittable from and relayed to t

he next antenna. The distance required between repeaters varies with the frequency of the signal and the environment in which the antennas are found. A repeater may broadcast the regenerated signal either at the original frequency or at a new frequency, depending on the system.

Terrestrial microwave with repeaters provides the basic for most contemporary telephone systems worldwide.

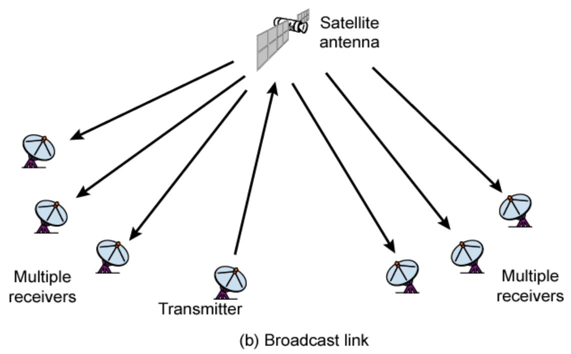
Satellite Communication

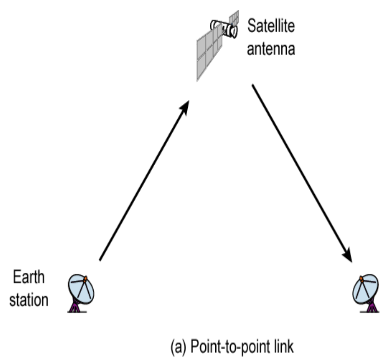
Satellite transmission is much like line-of-sight microwave transmission in which one of the stations is a satellite orbiting the earth. The principal is the same as terrestrial microwave with a satellite acting as a super tall antenna and repeater. Although in satellite transmission signals must still travel in straight lines, the limitation imposed on distance by the curvature of the earth are reduced. In this way, satellite relays allow microwave signals to span continents and oceans with a single bounce.

Satellite microwave can provide transmission capability to any from any location on earth, no matter how remote. The advantage makes high-quality communication available to undeveloped parts of the world without requiring a huge investment in ground based infrastructure. Satellites themselves are extremely expensive, of course but leasing time or frequencies on one can be relatively cheap.

Broadcast Radio:

- Omni directional
- FM radio
- UHF and VHF television
- Line of sight
- Suffers from multipath interference





Reflections

Satellite Point to Point Link

Infrared

- Modulate no coherent infrared light
- Line of sight (or reflection)
- Blocked by walls
- e.g. TV remote control, IRD port

Cellular Telephony

Cellular telephony is designed to provide stable communication connections between two moving device or between one mobile unit and one stationary (land) unit. A service provide must be able to locate and track a cellar, assign a channel to the call and transfer the signal from channel to channel as the caller moves out of the range of one channel and into the range of another.
To make this tracking possible, each cellular services area divided into small regions called cells. Each cell contains an antenna and is controlled by a small office called the cell office. Each cell office, in turn, is controlled by a switching office called a mobile telephone switching office (MTSO). The MTSO coordinates communication between all of the cell offices and the telephone central office. It is a computerized canter that is responsible for connecting calls as well as recording call information and billing.

Cell size is not fixed and can be increased or decrease depending on the population of the area. The typical radius of a cell is 1 to 12 miles. High – density areas require more, geographically smaller cells to meet traffic demands than do lower density areas. Once determined, cell size is optimized to prevent the interference of adjacent cell signals. The transmission power of each cell is kept low to prevent its signal from interfering with those of other cells.

Transmitting

To place a call from a mobile station, the caller enters a code of 7 or 10 digits (a phone number) and presses the send button. The mobile station then scans the band, seeking a setup channel with a strong signal, and sends the data (phone number) to the closest base station using that channel. The base station relays the data to the MSC. The MSC sends the data on to the telephone central office. If the called party is available, a connection is made and the result is relayed back to the MSC. At this point, the MSC assigns an unused voice channel to the call, and a connection is established. The mobile station automatically adjusts its tuning to the new channel, and communication can begin.

Receiving: When a mobile phone is called, the telephone central office sends the number to the MSC. The MSC searches for the location of the mobile station by sending query signals to each cell in a process called paging. Once the mobile station is found, the MSC transmits a ringing signal and, when the mobile station answers, assigns a voice channel to the call, allowing voice communication to begin.

Roaming: One feature of cellular telephony is called roaming. Roaming means, in principle, that a user can have access to communication or can be reached where there is coverage. A service provider usually has limited coverage. Neighbouring service providers can provide extend coverage through a roaming contract. The situation is similar to snail mail between countries. The charge for delivery of a letter between two countries can be divided upon agreement by the two countries.

Orbits: An artificial satellite needs to have an orbit, the path in which it travels around the Earth. The orbit can be equatorial, inclined, or polar.

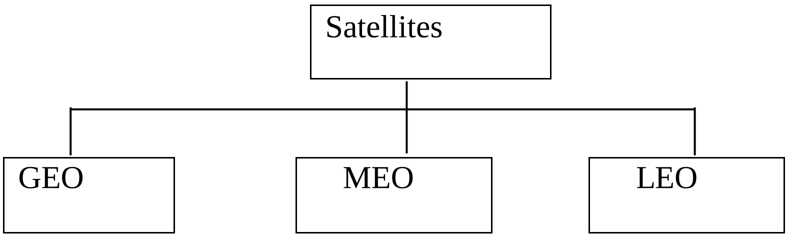
The period of a satellite, the time required for a satellite to make a complete trip around the Earth, is determined by **Kepler's law**, which defines the period as a function of the distance of the satellite from the center of the Earth.

Footprint: Satellite process microwaves with bidirectional antennas (line-of-site). Therefore, the signal from a satellite is normally intended at a specific area called the footprint. The signal power

at the center of the footprint is maximum. The power decreases as we move out from the footprint center. The boundary of the footprint is the location where the power level is at a predefined threshold.

Categories of Satellites:
There are three categories of satellites they are as follows,.

Based on the location of the orbit, satellites can be divided into three categories: geostationary Earth orbit (GEO), low-Earth-orbit (LEO), and middle-Earth-orbit (MEO).



Frequency Bands for satellite Communication

The frequencies reserved for satellite microwave communication are in the gigahertz (GHz) range. Each satellite sends and receives over two different bands. Transmission from the Earth to the satellite is called the uplink. Transmission from the satellite to the Earth is called the downlink.

Band	Downlink, GHz	Uplink, GHz	Bandwidth, MHz
L	1.5	1.6	15
S	1.9	2.2	70
C	4.0	6.0	500
Ku	11.0	14.0	500
Ka	20.0	30.0	3500

GEO Satellites:
Line-of-sight propagation requires that the sending and receiving antennas be locked onto each other’s location at all times (one antenna must have the other in sight). For this reason, a satellite that moves faster or slower than the Earth’s rotation is useful only for short periods. To ensure constant communication, the satellite must move at the same speed as the Earth so that it seems to remain fixed above a certain spot. Such satellites are called geostationary.

Because orbital speed is based on the distance from the planet, only one orbit can be geostationary. This orbit occurs at the equatorial plane and is approximately 22,000 mi from the surface of the Earth.

But one geostationary satellite cannot cover the whole Earth. One satellite in orbit has line-of-sight contact with a vast number of stations, but the curvature of the Earth still keeps much of the planet out of sight. It takes a minimum of three satellites equidistant from each other in geostationary Earth orbit (GEO) to provide full global transmission. The view if from the North Pole.

MEO Satellites

Medium-Earth-orbit (MEO) satellites are positioned between the two Van Allen belts. A satellite at this orbit takes approximately 6-8 hours to circle the Earth.

Global Positioning System:

One example of a MEO satellite system is the Global Positioning System (GPS), constructed and operated by the US Department of Defence, orbiting at an altitude about18, 000 km (11,000 mi) above the Earth. The system consists of 24 satellites and is used for land, sea, and air navigation to provide time and locations for vehicles and ships. GPS uses 24 satellites in six orbits. The orbits and the locations of the satellites in each orbit are designed in such a way that, at any time, four satellites and visible from any point on Earth. A GPS receiver has an almanac that tells the current position of each satellite.

Trilateration: GPS is based on a principal called Trilateration. On a plane, if we know our distance from three points, we know exactly where we are.

LEO Satellites:

Low-Earth-orbit satellites have polar orbits. The altitude is between 500 and 2000 km, with a rotation period of 90 to 120 min. the satellite has a speed of 20,000 to 25,000 km/h. A Leo system usually has a cellular type of access, similar to the cellular telephone system. The footprint normally has a diameter of 8000 km. because LEO satellites are close to Earth, which is acceptable for audio communication.

An LEO system is made of a constellation of satellites that work together as a network; each "satellite acts as a switch". Satellite that is close to each other are connected through inter-satellite links (ISLs). A mobile system communicates with the satellite through a user mobile link (UML). A satellite can also communicate with an Earth station (gateway) through a gateway link (GWL).

LEO satellites can be divided into three categories: little LEOs, big LEOs, and broadband LEOs. The little LEOs operate under 1 GHz. They are mostly used of low-data-rate messaging. The big LEOs operate between 1 and 3 GHz. Globalstar and Iridium systems are examples of big LEOs. The Broadband LEOs provide communication similar to fiber optic networks.