Unit 1- Part 1

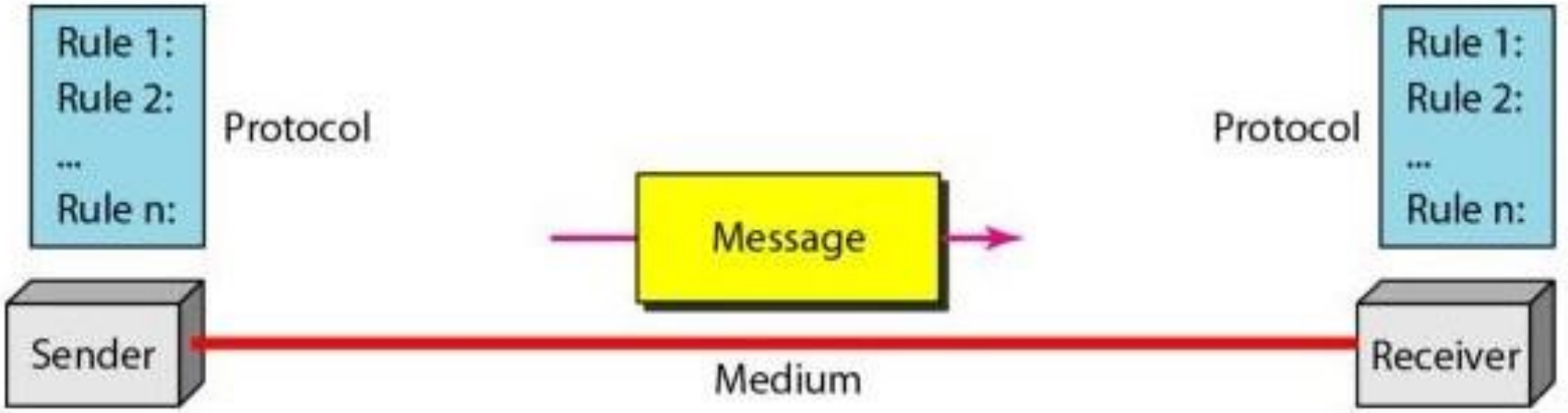
Introduction to Data communications and Networking

Introduction to Data Communication & Networking

- Communication can be defined as exchange of information between two humans.
- Data communication can be defined the exchange of information between two computers.
- One computer (sender) can send a message to another (receiver) computer over a wire called Transmission Medium as shown in figure:

Introduction to Data Communication & Networking

- Message: Information(data) to be communicated
- Sender
- Receiver
- Transmission medium: Physical path by which a message travels
- Protocol: A set of rules that govern data communication



Introduction to Data Communication & Networking

- **Message:**

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

- **Sender:**

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

- **Receiver:**

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

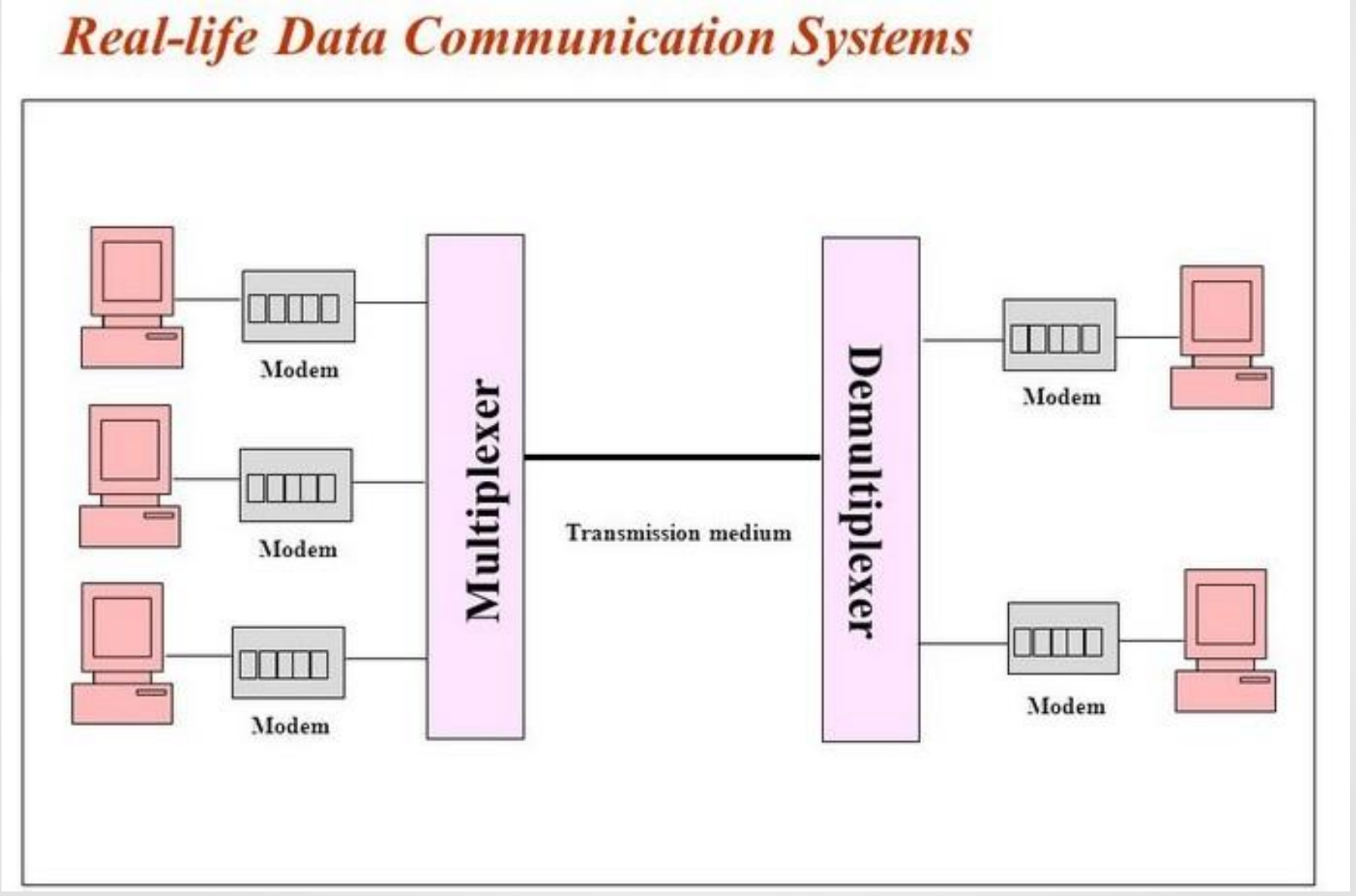
Transmission medium:

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

Protocol:

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

Introduction to Data Communication & Networking



Introduction to Data Communication & Networking

- **Modem:** A modem is connected to every computer that is involved in data commnication.

- **Multiplexer and Demultiplexer:** The main function of the multiplexer is that it combines input signals, allows data compression, and shares a single transmission channel.
- A multiplexer is a circuit that accept many input but give only one output. A demultiplexer function exactly in the reverse of a multiplexer, that is a demultiplexer accepts only one input and gives many outputs. Generally multiplexer and demultiplexer are used together, because of the communication systems are bi directional.

- **Transmission medium:** Transmission medium or wire is the means of transferring data from sender to the receiver. Modern data communication can also be wireless.

Introduction to Data Communication & Networking

- The data communication involves exchange of data between two comptuers. computer works with the binary language of zeros and ones. Therefore, one computer generates a stream of zeros and sends it to another computer to which it is connected in some fashion.
- For enabling data communication, a combination of hardware and software is essential.
- Following are the characteristics of data communication system:
  - **Correct delivery:** When a sender transmits data for an intended recipient, the data must reach only the intended recipient and not someone else.
  - **Accurate delivery:** The data sent must be received in the same form as the one in which it was sent. There must not be any sort of alternations to it in transit.
  - **Timely delivery:** The data must travel from the sender to the receiver in a finite amount of time. The term finite is quite vague, and would depend on the reasons why the data communication is taking place.

Protocol

- Two key aspects of data communication systems need a good amount of understanding.
  - **Transmission media:** the physical path over which data travels from the sender to the receiver.
  - Ex: twisted-pair of copper wires,coaxial cable, optical fiber or wireless media such as radio waves.
  - **Protocol:** a set of rules and conventions. Ex: The sender and the receiver, the two key parties in data communication must agree on a common set of rules, i.e. protocols before they can communicate with each other.
    - **The protocol defines following:**
      - Syntax (What is to be communicated?)
      - Semantic (How it is to be communicated?)
      - Timing (When it should be communicated?)

Protocol

- **Syntax (What is to be communicated)–** The syntax defines the structure or format of data. This means that the order in which it is to be sent is decided. For instance, a protocol could define that the first 16 bits of a data transmission must always contain the receiver's address.

- **Semantics (How it is to be communicated) –** The semantics define the interpretation of the data that is being sent. For example, the semantics could define that if the last two bits of the receiver's address field contain a 00, it means that the sender and the receiver are on the same network.

- **Timing (When it should be communicated) –** This refers to an agreement between the sender and the receiver about the data transmission rates and duration. For instance, a protocol could demand that the sender must send 1000 bytes and then wait for an acknowledgement from the receiver before sending any more data.

Standards

- **Standards**
- Standards are necessary in every walk of life. For instance, when you want to replace a light bulb in your home because it has been damaged, you expect the new bulb to fit in the holder straightaway and work like the old bulb did. What is the use if the bulb does not fit in the holder, or if it fits in the holder but does not illuminate because it requires a different voltage level?

- Data communication standards are classfied into two categories:
  - **De facto**
  - **De Jure**

Standard

- **De facto Standard**
- Standards developed by a private company which are used widely as a result of the choices of consumers.
- Adopted widely by an industry and its customers.They are also known as market-driven standards.
- Eg: Something that is used so widely that it is considered a standard for a given application although it has no official status.(Driving seats)

- De facto standards can be divided into proprietary and non-proprietary.
- **Properitary** - Closed proprietary standards are owned by a single company. Only that company's customers and partners are allowed to use them. Competitors are banned from implementing products that use closed proprietary standards.
- **Non- Proprietary** - Open proprietary standards also are owned by a single company, yet the company allows anyone to use them.

Standard

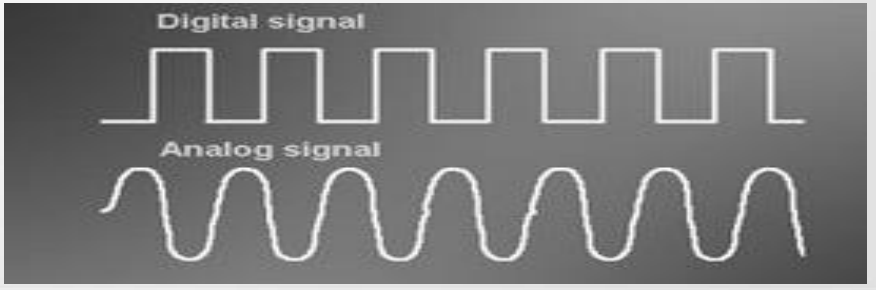
De jure Standard

- De jure means according to “Law and Regulation.”
- Standards registered at a recognized standards organization such as the International Electrotechnical Commission (IEC) and the International Telecommunication Union (ITU), The International Organization for Standardization (ISO) etc.
- They are endorsed by a formal standards organization.
- The organization ratifies each standard through its official procedures and gives the standard its stamp of approval.

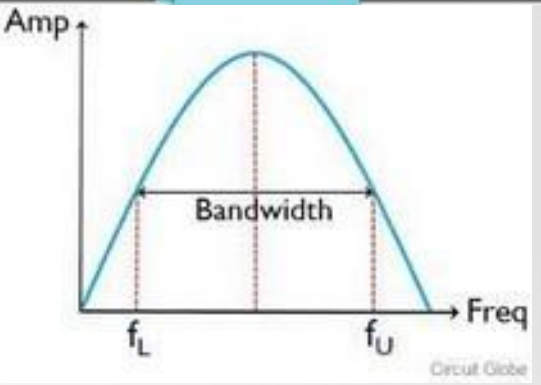
Analog and Digital Signal

- **Analog and Digital Signal**
- Analog and digital signals are used to transmit information, usually through electric signals.
- Analog signals are signals with continuous values in both time and value.
- Digital signals are discrete in time and value where we have nothing or something.Digital signals are signals that are represented by binary numbers, "1" or "0".

- **The difference between analog and digital technologies is that in analog technology, information is translated into electric pulses of varying amplitude. In digital technology, translation of information is into binary format (zero or one).**



Bandwidth



- **Bandwidth** describes the maximum data transfer rate of a network or Internet connection. It measures how much data can be sent over a specific connection in a given amount of time.
- The **bandwidth** of a composite signal is the difference between the highest and the lowest frequencies contained in that signal.
- A strength of the signal at any point is known as **amplitude**.
- Time taken for the completion of one cycle is called **period**.
- The number of cycle or periods a signal completes in one second called **frequency**.
- In analog transmission (such as of voice signals) bandwidth is measured in cycles per second (or Hertz)
- In digital transmission (such as of data from one computer to another) bandwidth is measured in bits per second (BPS).

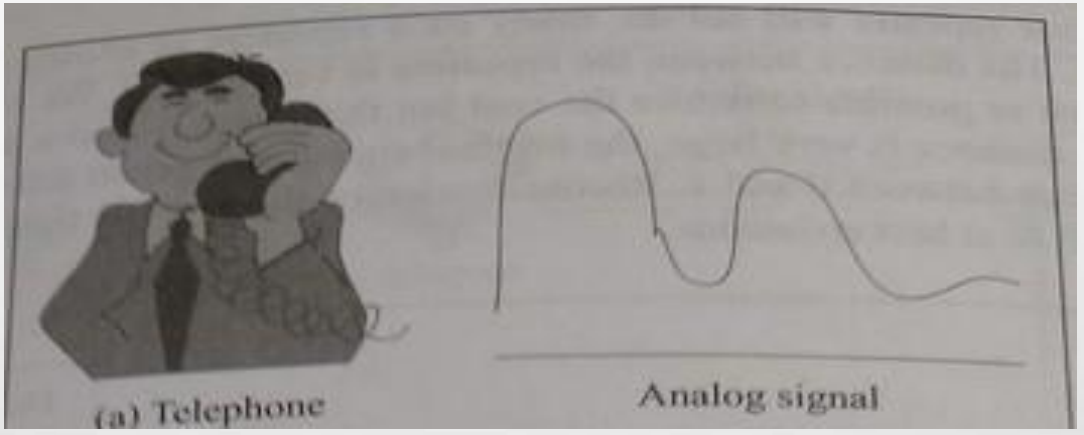
Signal Transmission

Signal Transmission

- Analog Signal, Analog Transmission
- Digital Signal, Digital Transmission
- Digital Signal, Analog Transmission
- Analog Signal, Digital Transmission

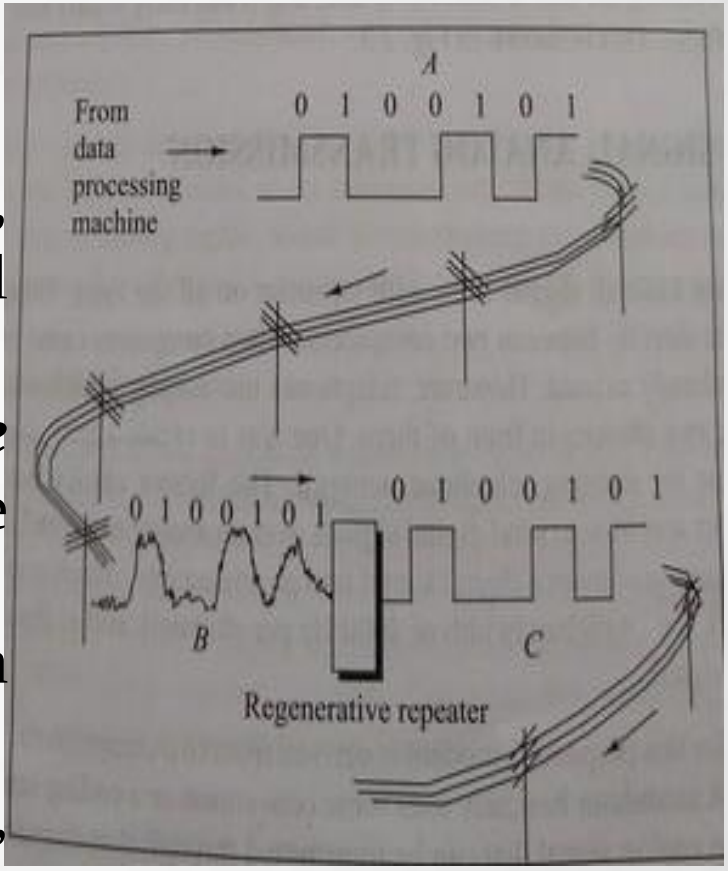
Signal Transmission

- **Signal Transmission: Analog Signal, Analog Transmission**
- Analog transmission refers to the transmission of analog signal.
- The human voice generates an anlog (i.e. continuously varying) signal, which is transmitted as an analog signal over the medium.
- The signal suffers **Attenuation**.
- Amplifiers are used to overcome this problem, but then amplifiers amplify noise along with the original signal. Singal gets distorted, it can’t be reconstructed at all.
- At the destination, it is very difficult to imagine, from the received distorted signal, what the signal shoul have been.



Signal Transmission

- **Signal Transmission: Digital Signal, Digital Transmission**
- Computer generates digital signal
- As digital signal traverses over the medium, noise adds further distortion. The signal becomes unrecognizable from the original one.
- The hardware equipment called ***regenerative repeater*** or ***repeater*** is used to regenerate the digital signal.
- Only one repeater will not do it, many such repeaters will be required on the same line.
- If the distance between repeater is very large, the original signal may get so distorted. Any line with repeaters placed at the appropriate distance is called a digital line.



repeater

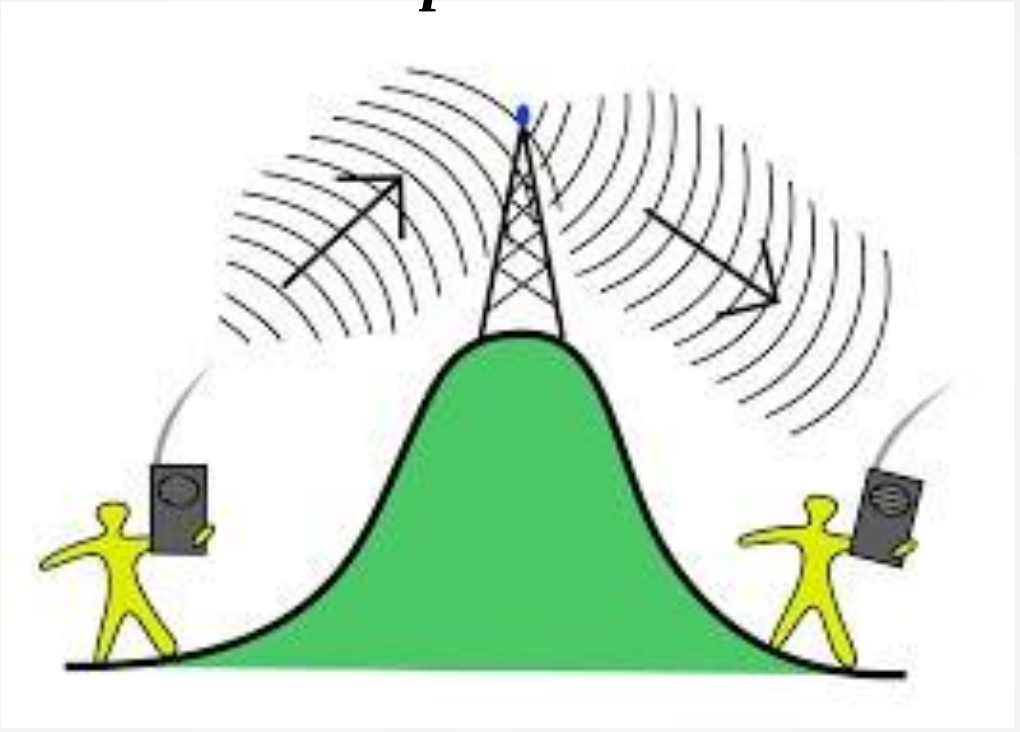


Figure 14.19 Repeater

Signal Transmission

- **Signal Transmission: Digital Signal, Analog Transmission**
- Some technique is necessary to convert a digital signal into analog, which could be carried over the telephone network, and at the other end, convert it back into a digital signal. **Modem** is used for this purpose.
- A modem is derived from two components: **A Modulator and A Demodulator**
- **A modulator** uses some convention or a coding scheme and converts a digital signal into an analog signal.

- **A demodulator** converts the analog signal back into the digital signal.
- When data from one computer is sent to another via some analog carrier, it is first converted into analog signals. Analog signals are modified to reflect digital data, i.e. binary data.

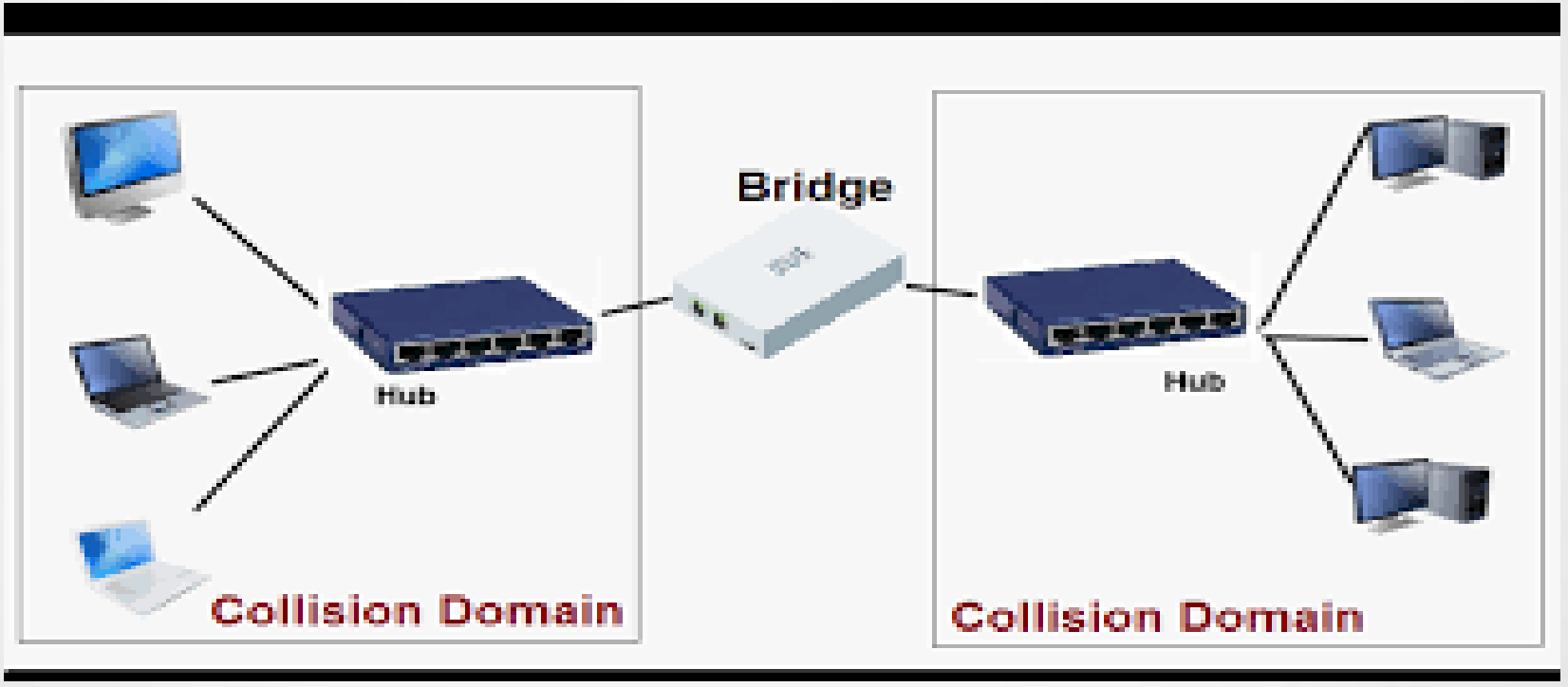
Bridge

We can use **switches to connect multiple segments of a network. But we can't use them to connect two or more networks.**

It is because a switch can **not distinguish one network from another.** Even a broadcast in one LAN will be sent to all the connected LANs when they are connected by switches.

Switch **don't have any intelligence to find out an efficient** path when a communication starts from one LAN and terminates in more networks are to be connected.

A bridge similar to a switch but is **designed to provide additional service like broadcasting in a particular LAN segment**, finding out the network limited to that network only. Thus, it helps in keeping logically separate segments separate physically.


Bridge
Hub
Hub
Collision Domain
Collision Domain

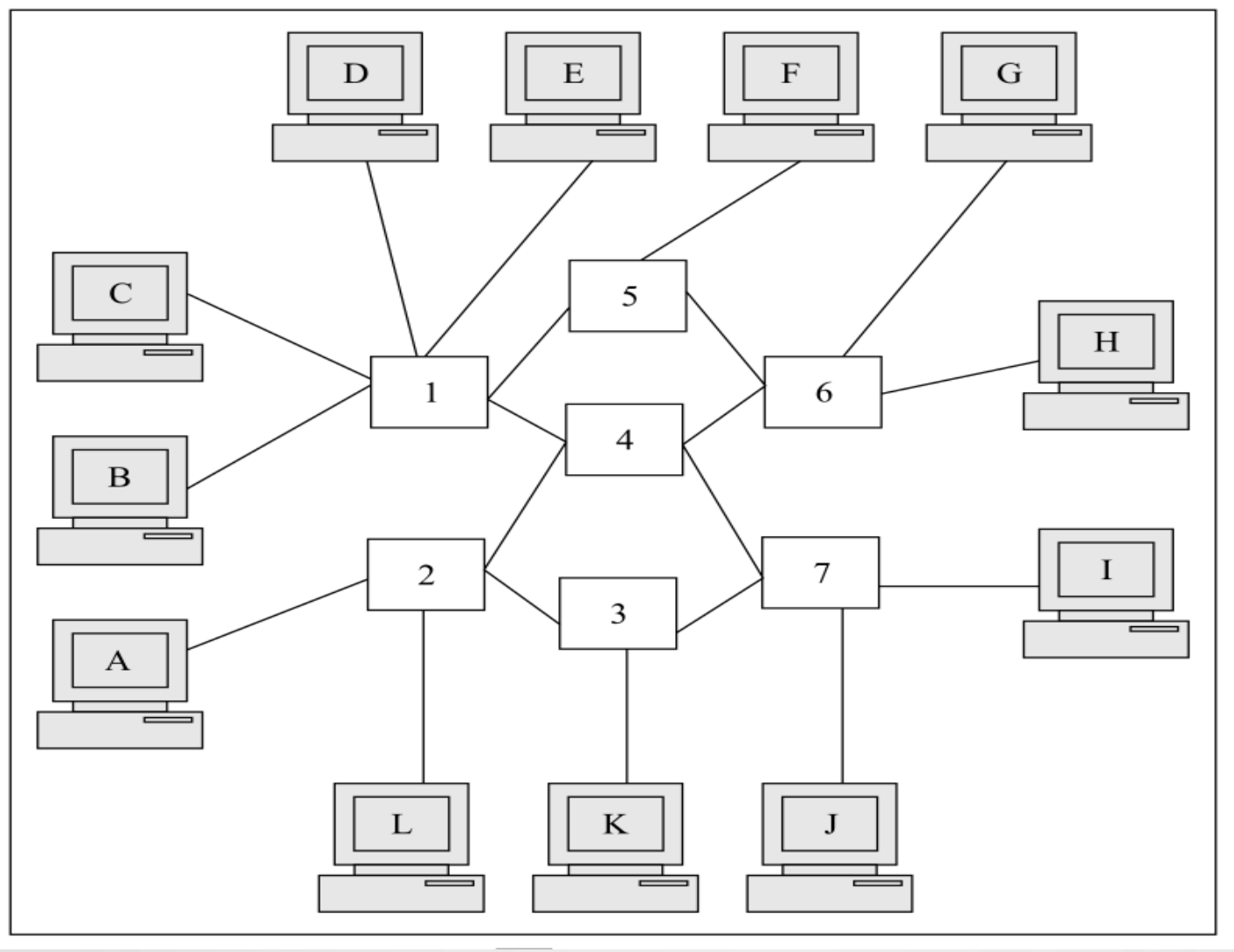
Gateway

- Sometimes a device called a **gateway** is also used to connect networks. It conventionally operate art higher layers. i.e. **transport and application.**
- Their basic aim is **not to connect networks but to provides an application seamless access to remote networks.**
- The **proxy server is an example** of **that network administrator use to provide an internet address to all those members of the network** who are not directly connected to the internet.

Switch

A switched network is made up of a number of **interlinked nodes**, called switches. A switch is a hardware (as well as software) device that allows a connection to be established between two or more devices, which are linked to it (but the devices are not connected to each other).

Each of these switches is connected to multiple links, and thus allows a connection to be established between two computers.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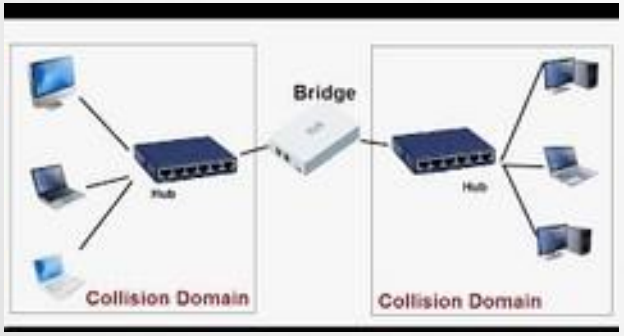
Internetworking devices - Repeater

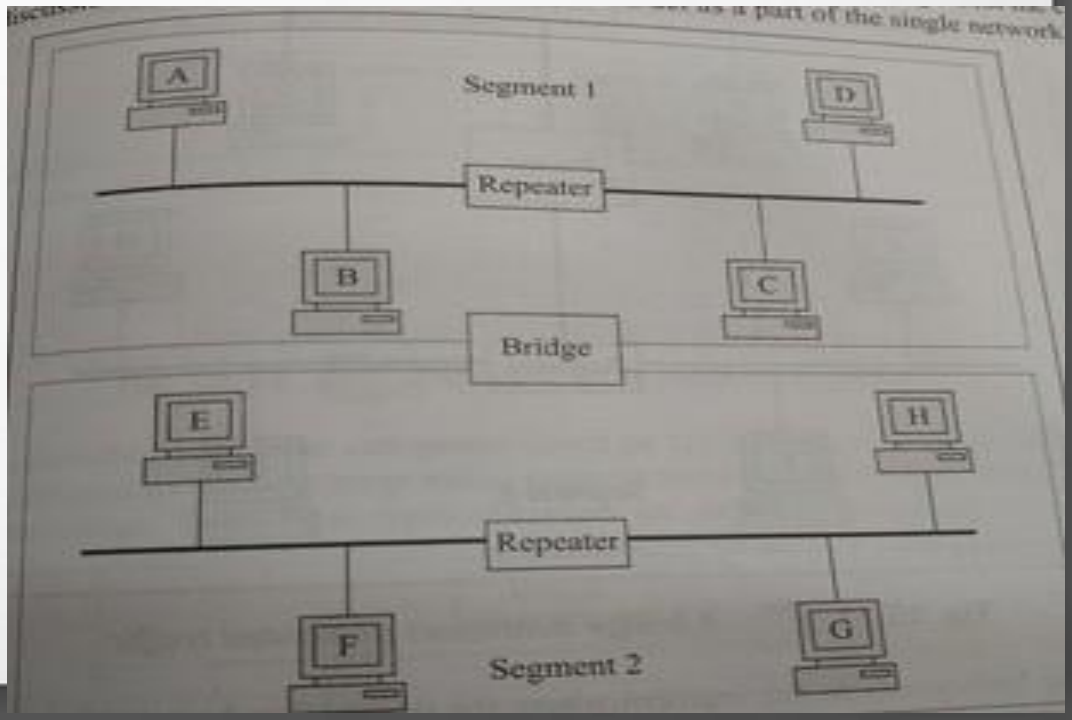
- Repeaters are also called **regenerator.**
- **Repeater regenerates a signal.**
- Even digital signals become weak when they travel long distances.
- In telecommunications, a repeater is an electronic device that receives a signal and retransmits it.
- Repeaters are used to extend transmissions so that the signal can cover longer distances or be received on the other side of an obstruction.
- Repeaters amplify the received/input signal to a higher frequency domain so
- that it is reusable, scalable and available.
- Signals travelling across a physical wire travel some distancebefore they become weak or corrupted as they get interfered with other signals/voice.
- **It operates at the physical layer.**

Internetworking devices - Repeater

Internetworking devices - Bridges

- **A bridge is a computer that has its own processor, memory and two NIC cards to connect to two portions of a network.**
- A bridge does not run application programs but it facilitates hosts-to-host communication within a network.
- **It operates at the physical layer and data link layer of OSI layer.**
- The main idea of bridge is to divide a big network into smaller subnetworks called **segments.**

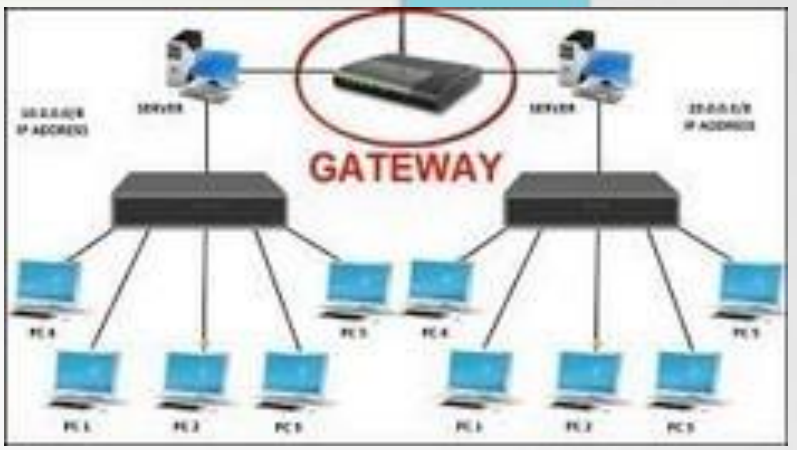




Internetworking devices - Routers

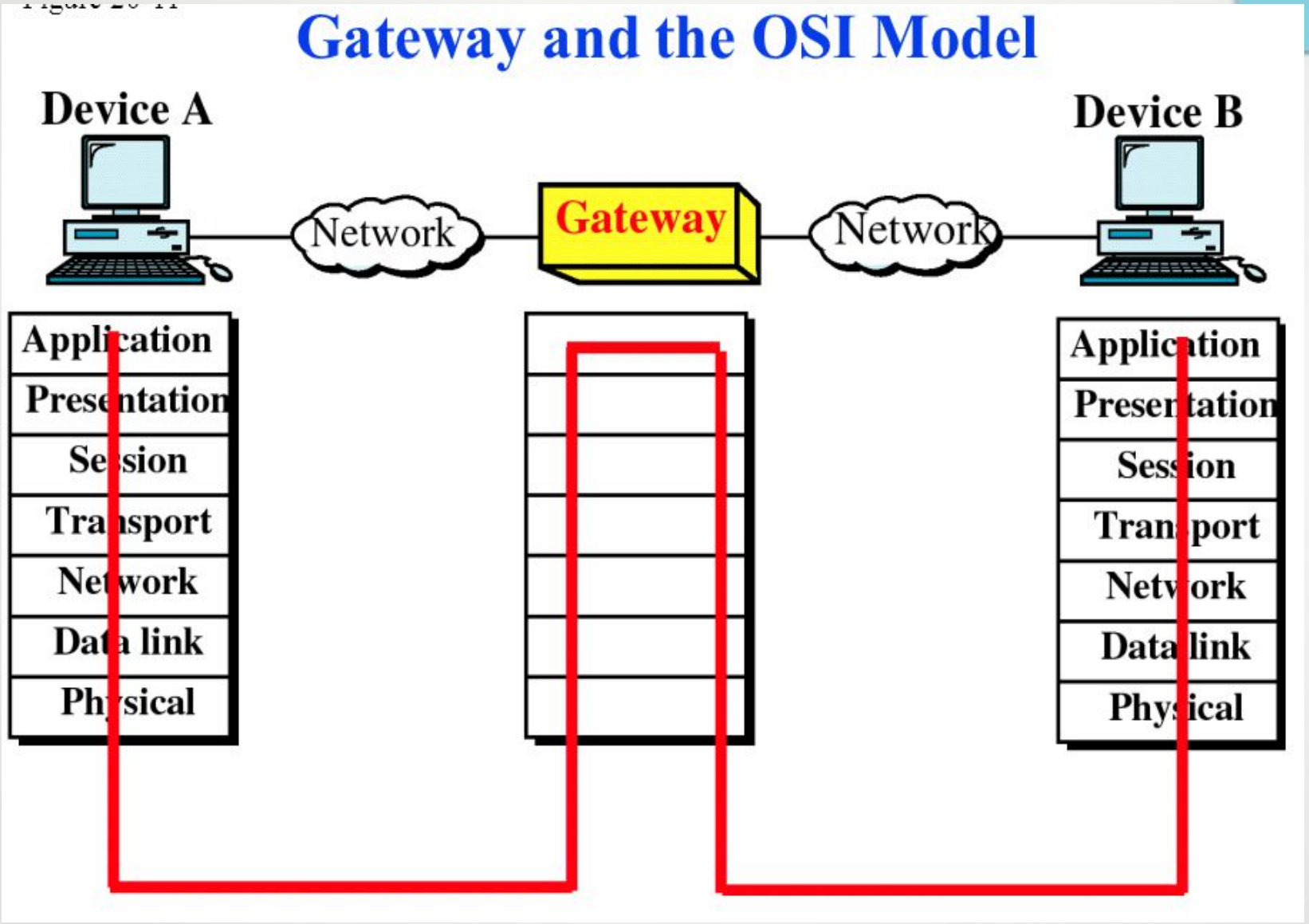
- **A Router operates at the physical, data link and network layer of the OSI model.**
- **A router is termed as intelligent device.**
- **It interconnects two or more network.**
- Network can differ in physical characteristics such as frame size, transmission rates, topologies, addressing, etc.
- A router is a device that forwards data packets along networks.
- A router is connected to at least two networks, commonly two LANs or WANs or a LAN and its ISP's network.
- Routers are located at gateways, the places where two or more networks connect.
- These nodes maintain routing tables and execute routing algorithms to take routing decisions.
- When an intermediate node is equipped with the capability to take decisions, it called router instead of switch.

Internetworking devices - Gateway



- A gateway operates at **all the seven layers** of the OSI model.
- A router can forward packets across different network types. However they are not using the same protocol a router would not be able to forward packets from one network to another.
- **Example: if network is a Token Ring using TCP/IP and network B is Novell Netware network, a gateway can relay frames between the two.**
- Gateway is not only resposible for translating between different frame formats but also different protocols.
- A gateway is a very powerful computer as compared to a bridge or a router.
- It is used to connect **huge incompatible networks**.

Internetworking devices - Gateway



Internetworking devices - Switch

- A switch is a multiport device that improves network efficiency.
- The switch maintains limited routing information about nodes in the internal network, and it allows connections to systems like hubs or routers.
- Switches can read the hardware addresses of incoming packets to transmit them to the appropriate destination.
- A switch can work at either the Data Link layer or the Network layer of the OSI model.
- A multilayer switch is one that can operate at both layers, which means that it can operate as both a switch and a router.
- A multilayer switch is a high-performance device that supports the same routing protocols as routers.

Internetworking devices - Switch

- The switch can perform error checking before forwarding data, that makes it very efficient as it does not forward packets that have errors and forward good packets selectively to correct port only.
- Switches can be subject to distributed denial of service (DDoS) attacks; flood guards are used to prevent malicious traffic from bringing the switch to a halt.
- Switch port security is important so be sure to secure switches: Disable all unused ports and use DHCP snooping, ARP inspection and MAC address filtering.

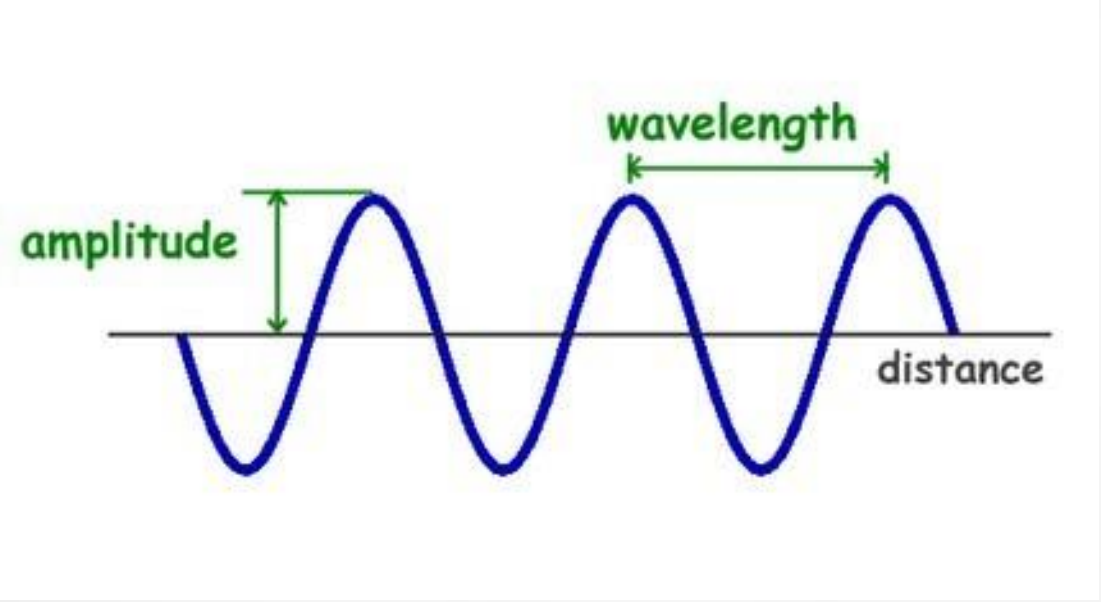
Signal Transmission

- **Signal Transmission: Digital Signal, Analog Transmission**
- An analog is characterized by its amplitude, frequency and phase. There are three kinds of digital-to-analog conversions possible:

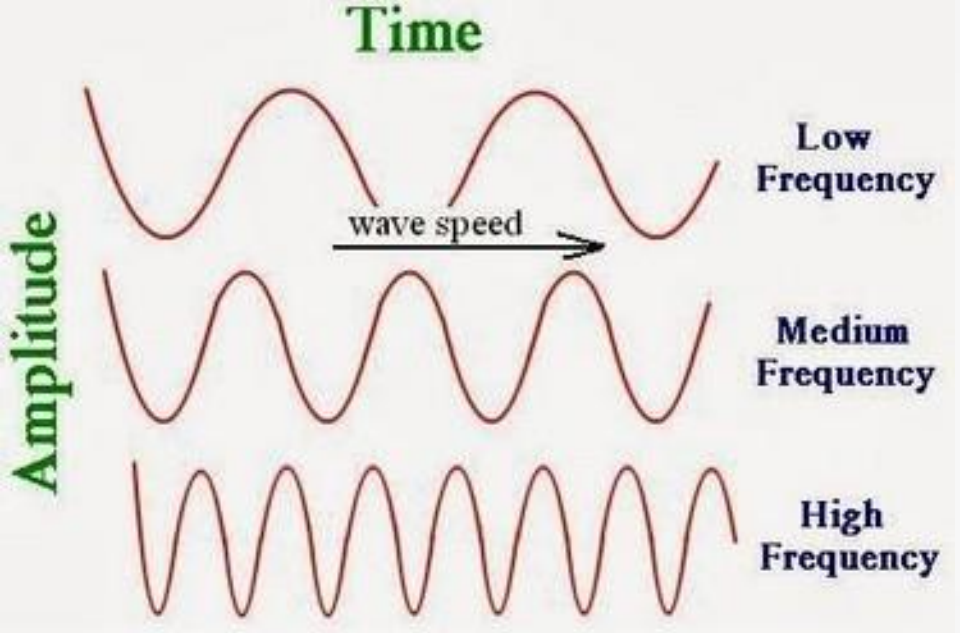
1.Amplitude Shift Keying 2.Frequency Shift Keying 3.Phase Shift Keying

Amplitude

- The greatest distance that a wave, especially a sound or radio wave, moves up and down



Frequency

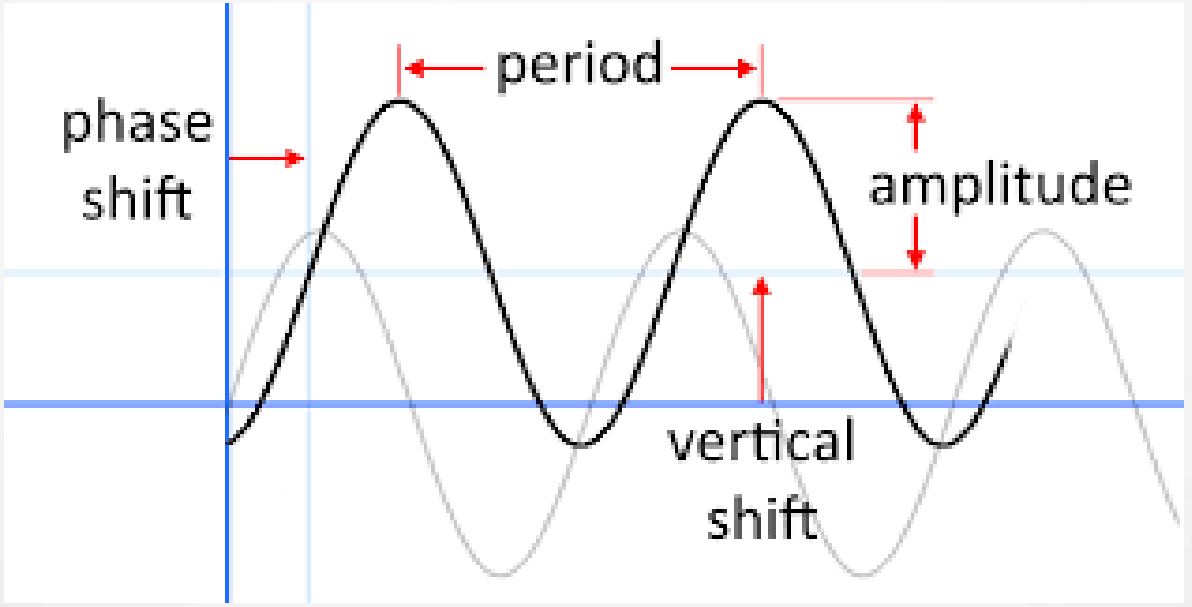


Frequency is the number of waves that pass a given point in 1 second

($\frac{\text{waves}}{\text{second}}$ = Hertz)

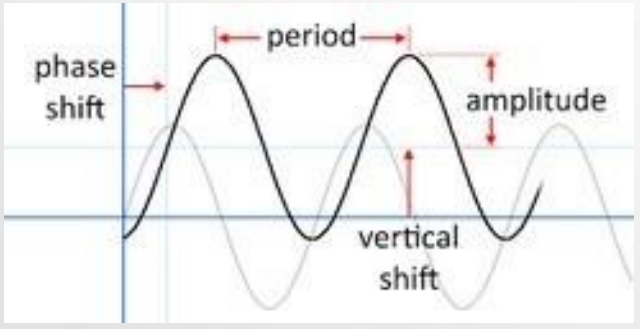
Phase

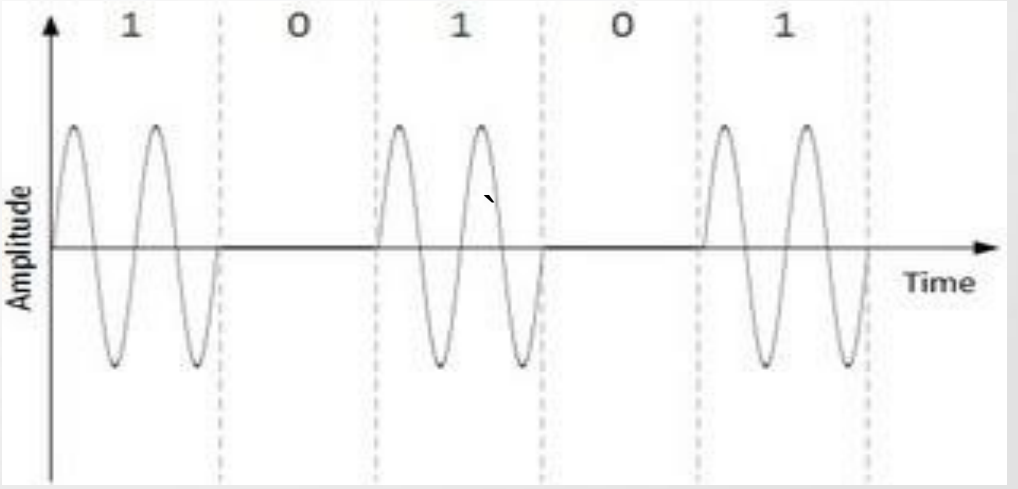
The Phase Shift is how far the function is shifted horizontally or vertically from the usual position.



Signal Transmission

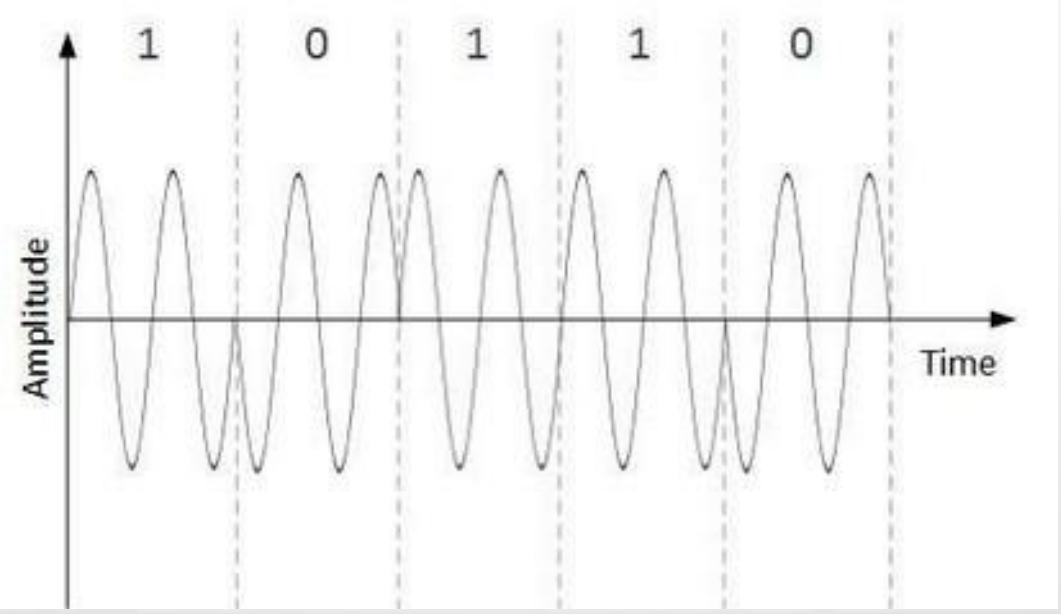
- **Signal Transmission: Digital Signal, Analog Transmission Amplitude Shift Keying:**
  - A bit string 10011010011 modulated as an analog signal.
  - Only the amplitudes of the signal change as per the values 0 and 1, but the phase and frequency are same.
  - The frequency is between 0 to 4000 Hz. So the signal can be send over telephone line.
  - When binary data represents digit 1, the amplitude is held otherwise it is set to 0. Both frequency and phase remain same as in the original carrier signal.





Signal Transmission

- **Signal Transmission: Digital Signal, Analog Transmission Phase Shift Keying:**
- The amplitude and the frequency of the carrier signal unchanged.
- Only change the phase to denote 0s and 1s.
- i.e. Start with a phase of 0 degrees to represent binary 0 and then change the phase to 180 degrees to represent binary 1.

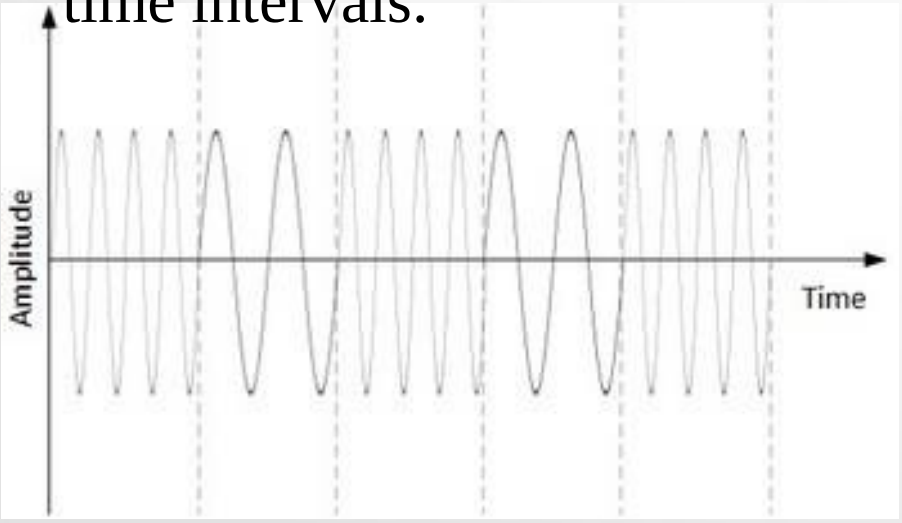


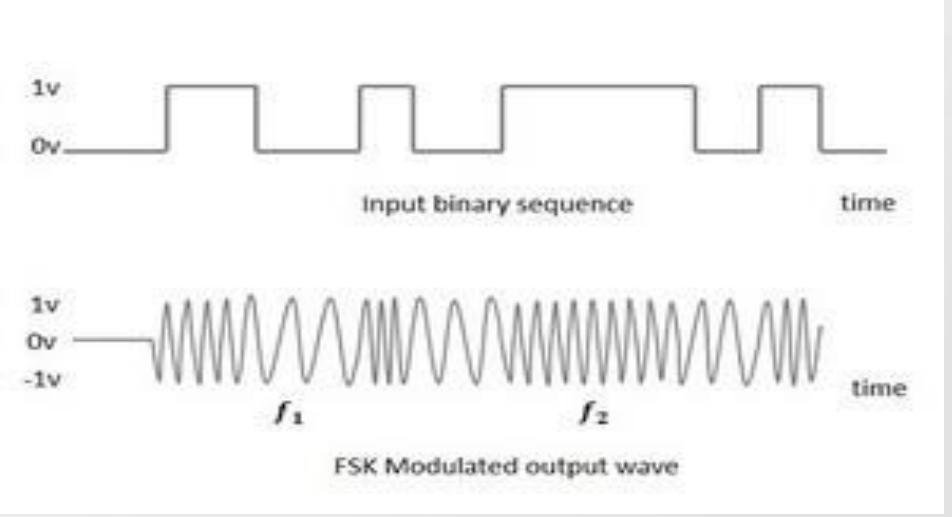
Signal Transmission

Digital Signal, Analog Transmission

Frequency Shift Keying:

- The amplitude and the phase of the carrier signals are kept unaltered.
- A certian frequency *f1* to denote 1 and *f2* to denote 0 is assigned.
- The frequency of the carrier signal is varied to represent binary 1 (using f1) and binary 0(f2).
- The signal component with slower cycle is *f1* and the signal component that shows rapid cycle portions if *f2*.
- The modem at the destination *decodes* these signals into 0s and 1s by measuring the frequencies of the received signals at regular predefined time intervals.





Signal Transmission

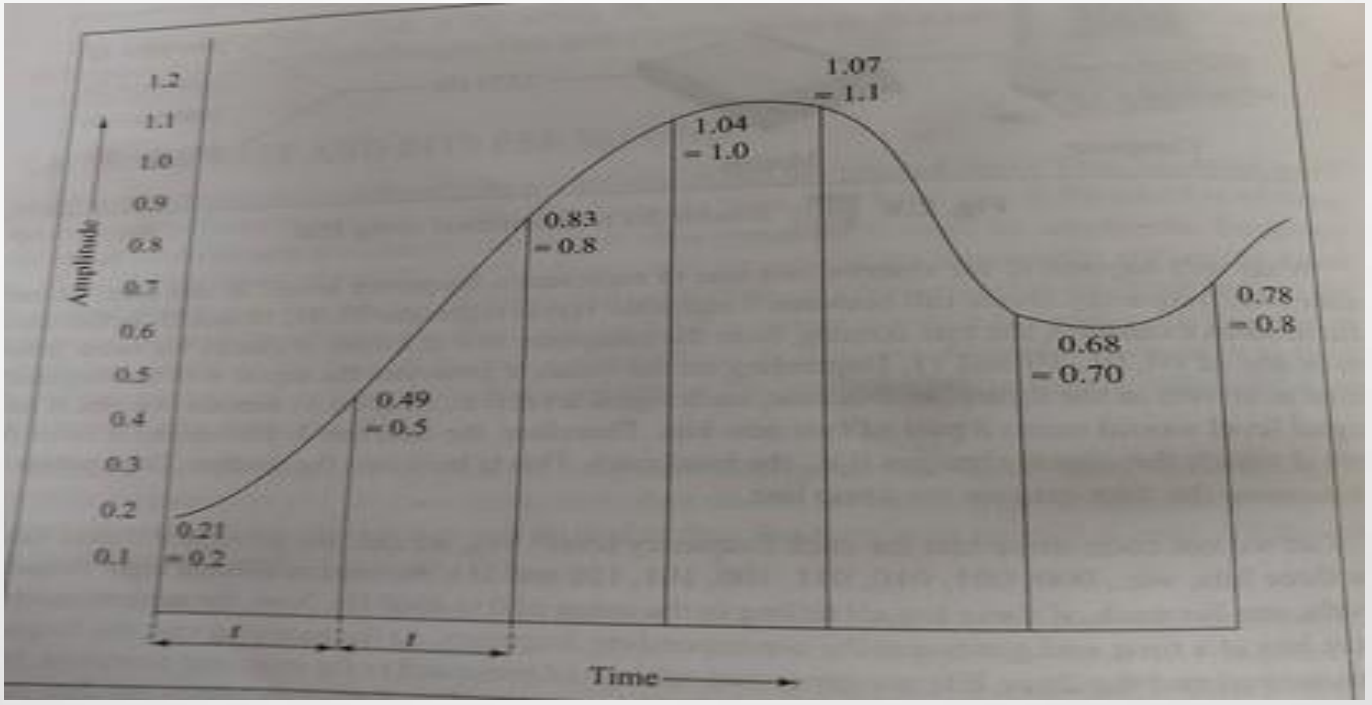
Signal Transmission: Analog Signal, Digital Transmission

- Pulse-code modulation (PCM) is a method used to digitally represent sampled analog signals.
- The idea is to represent an analog signal into digital bits and then transmit as a digital signal.
- PCM - Pulse Code Modulation is one of the most commonly used method to convert analog data into digital form.
- The basic steps in PCM are as given below:
- **At Source:**
  - Sample the analog signal at regular interval Say t
  - Convert the analog signal into some discrete values.
  - Convert thse values into binary numbers by assigning a fixed number of bits for each value.
  - Convert the binary numbers as a digital signal by concatenating all these binary numbers.

Signal Transmission

Signal Transmission: Analog Signal, Digital Transmission

- **At Destination:**
  - Convert the digital signal into binary numbers.
  - Seperate out the discrete values of signals by using the number of bits for each discrete value.
  - Reconstruct the original analog signal.



Bit Rate & Baud Rate

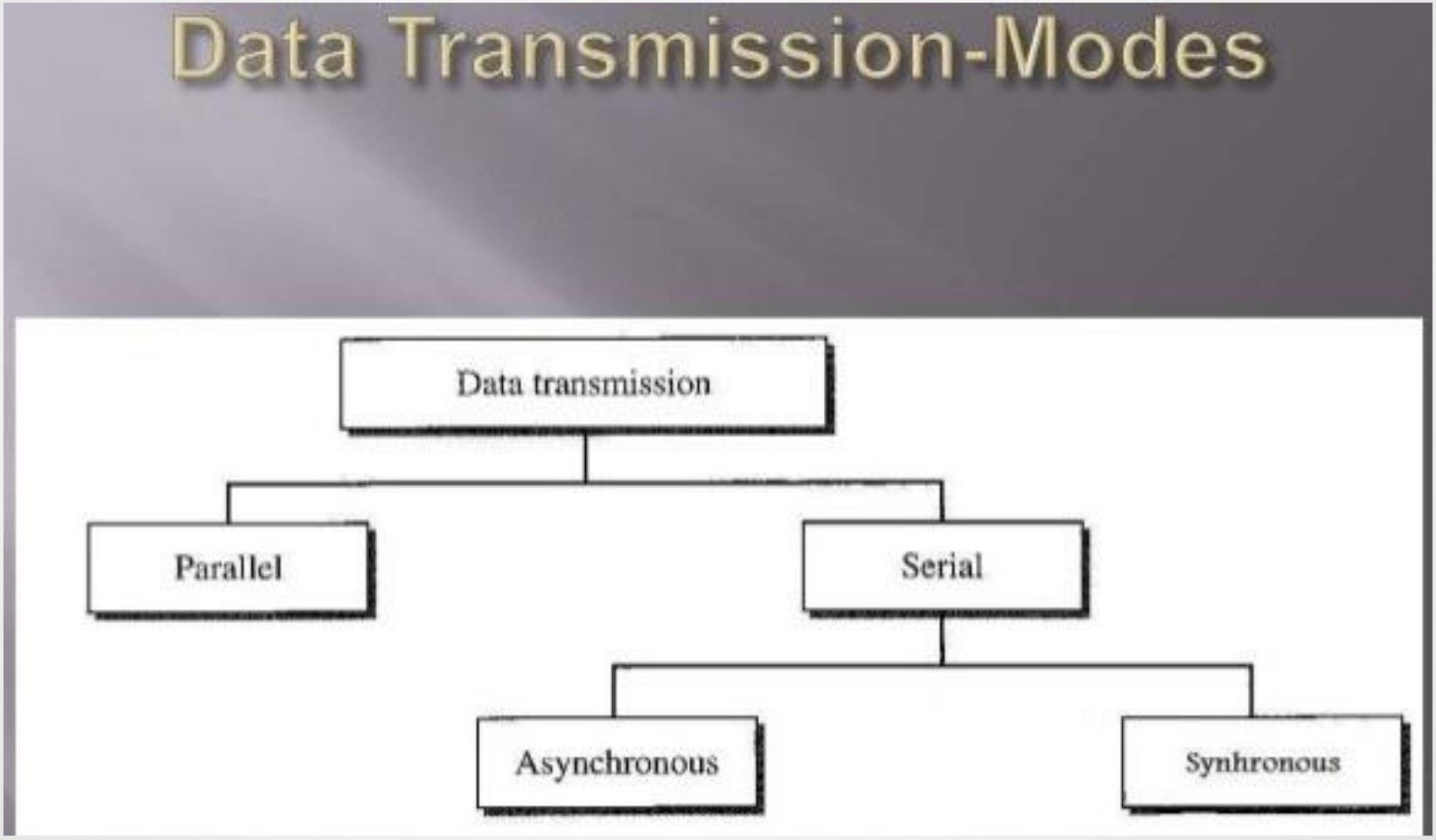
Bit Rate:

- Bit Rate is how many data bits are transmitted per second. Bit rates measure the number of data bits (that is 0′s and 1′s) transmitted in one second in a communication channel. A figure of 2400 bits per second means 2400 zeros or ones can be transmitted in one second.

Baud Rate:

- Baud rate refers to the number of signal or symbol changes that occur per second. A baud rate is the number of times a signal in a communications channel changes state or varies. For example, a 2400 baud rate means that the channel can change states up to 2400 times per second. The term “change state” means that it can change from 0 to 1 or from 1 to 0.
- An analog signal carries 4 bits in each signal unit. If 1000 signal units are sent per second, find the baud rate and the bit rate.
- Baud rate = 1000 bauds per second
- Bit rate = 1000 * 4 =4000 bps

Modes of Data Transmission

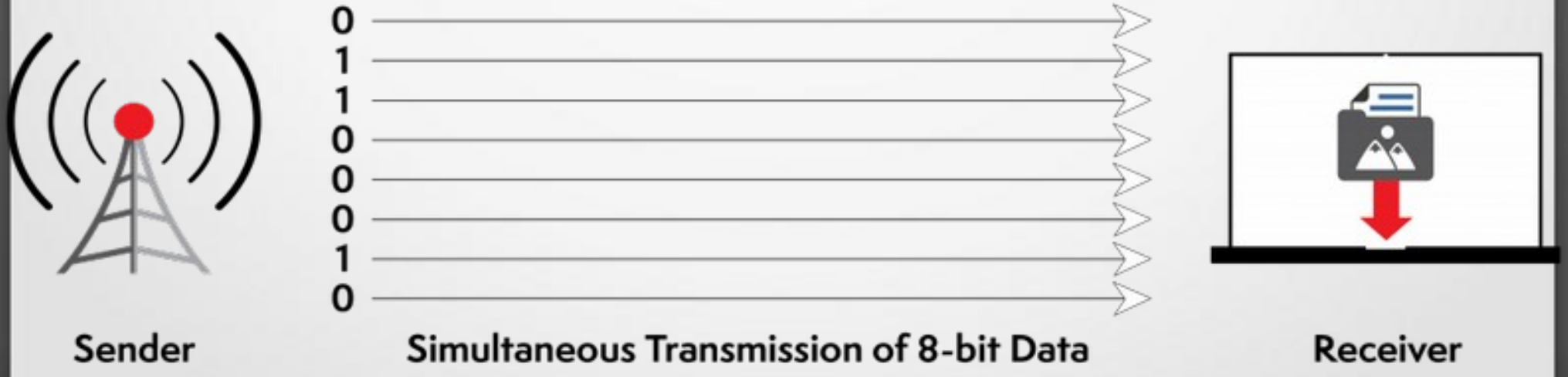


Modes of Data Transmission

- Data Transmission refers to the process of transferring data between two or more digital devices.
- Data is transferred in the form of bits between two or more digital devices.
- There are two methods used to transmit data between digital devices:
  - **Parallel transmission**
  - **Serial transmission.**

Modes of Data Transmission

- **Parallel transmission:**
- **Multiple data bits are transmitted over multiple channels at the same time.**
- Data can be sent much faster than using serial transmission.
- It requires those many wires parallel to each other, each carrying a single bit. E.g. 8 wires are needed to pass 01100010 in parallel communication.



Modes of Data Transmission

Parallel transmission:

- **It is very expensive method because it requires several wires as well as various sending and receiving equipment.**
- It demands extraordinary accuracy, which is not guaranteed over long distances.
- Digital pulses may not traverse at the same speed, This rise to the problem of **Skew**.
- To avoid skew problem, parallel transmission is used only for a short distance. E.g. Data transmission from CPU registers to memory or vice versa

Modes of Data Transmission

- **Serial transmission:**
- **Serial data transmission sends data bits one after another over a single channel.**
- The data bits are organized in a specific order, since they can only be sent one after another. There is some hardware equipment involved in converting the data from parallel to serial.
- At the destination, all the bits are collected, measured and put together as bytes in the memory. This requires conversion from serial to parallel.

Modes of Data Transmission

- **Serial transmission:**
  - **Serial transmission is normally used for long-distance data transfer.**
  - It is also used in cases where the amount of data being sent is relatively small.
  - Serial transmission has two classifications: asynchronous and synchronous.

Modes of Data Transmission

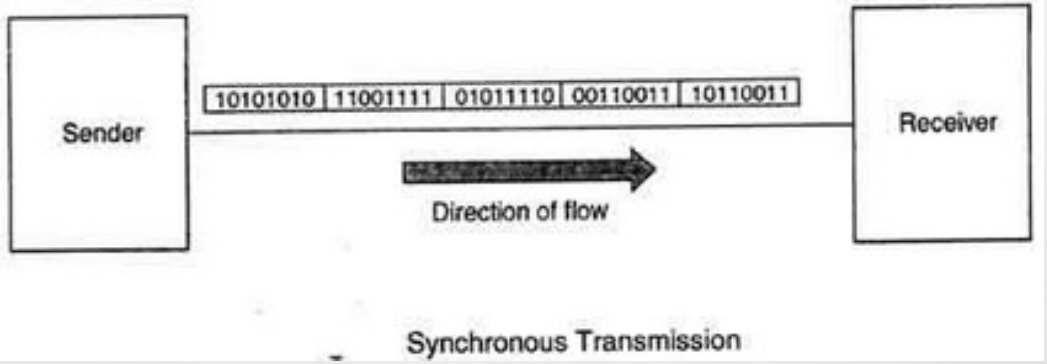
Asynchronous Serial Transmission

- **Data bits can be sent at any point in time.**
- Stop bits and start bits are used between data bytes to synchronize the transmitter and receiver and to ensure that the data is transmitted correctly.
- The time between sending and receiving data bits is not constant, so gaps are used to provide time between transmissions.
- It is also a more cost effective method.
- data transmission can be slower, but this is not always the case.

Modes of Data Transmission

Synchronous Serial Transmission

- **Data bits are transmitted as a continuous stream in time with a master clock.**
- The data transmitter and receiver both operate using a synchronized clock frequency; therefore, start bits, stop bits, and gaps are not used.
- The data moves faster and timing errors are less frequent because the transmitter and receiver time is synced.
- In comparison with asynchronous serial transmission, this methodis usually more expensive.

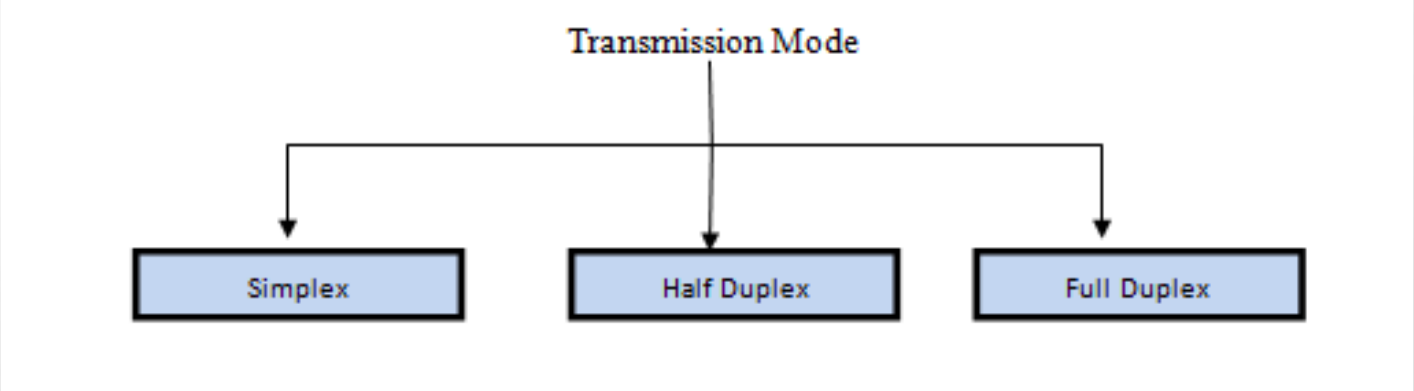


Synchronous Transmission

Modes of Data Transmission

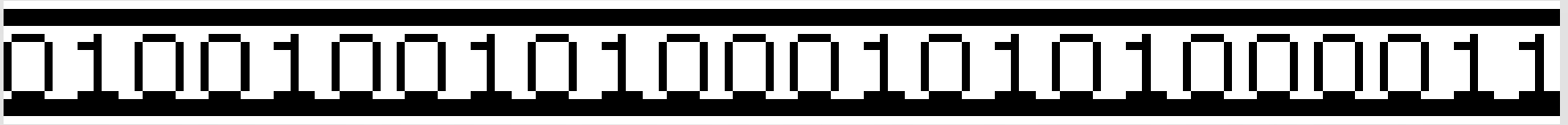
Simplex, Half Duplex, Full Duplex

- Transmission mode refers to the mechanism of transferring of data between two devices connected over a network. It is also called Communication Mode. These modes direct the direction of flow of information. There are three types of transmission modes. They are:
  - **Simplex Mode Half**
  - **duplex Mode Full duplex**
  - **Mode**

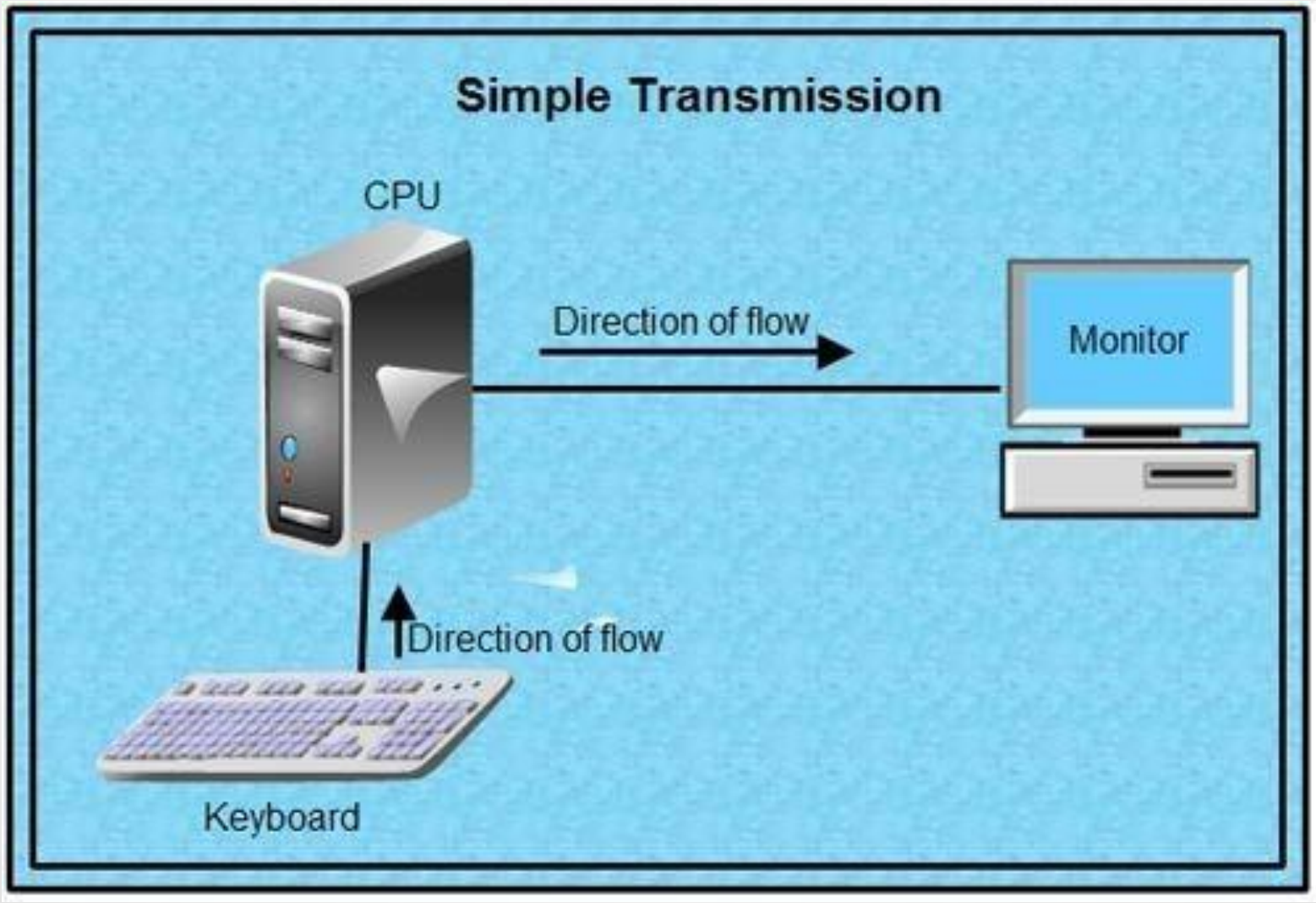


Modes of Data Transmission

- **Simplex Mode:**
  - The communication is unidirectional only.
  - **A simplex communication channel only sends information in one direction.**
  - **We cannot send a message back to the sender. Unidirectional communication is done in Simplex Systems where we just need to send a command/signal, and do not expect any response back.**
  - **Examples of simplex Mode are loudspeakers, television broadcasting, television and remote, keyboard and monitor etc.**
  - **For example, a radio station usually sends signals to the audience but never receives signals from them.**
  - **E.g. Keyboard to computer monitor data transmission.**
  - **In Simplex, entire bandwidth can be used during the transmission.**

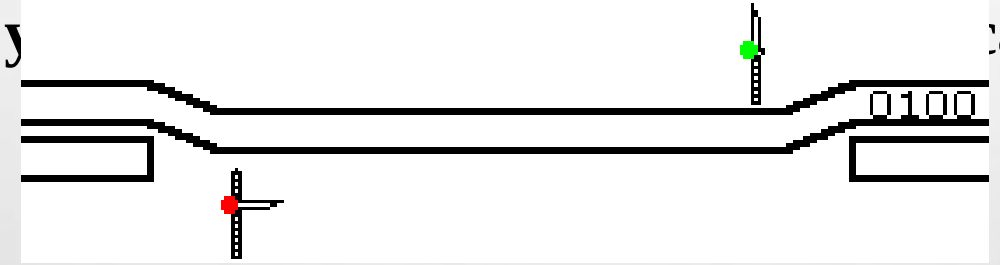


Modes of Data Transmission

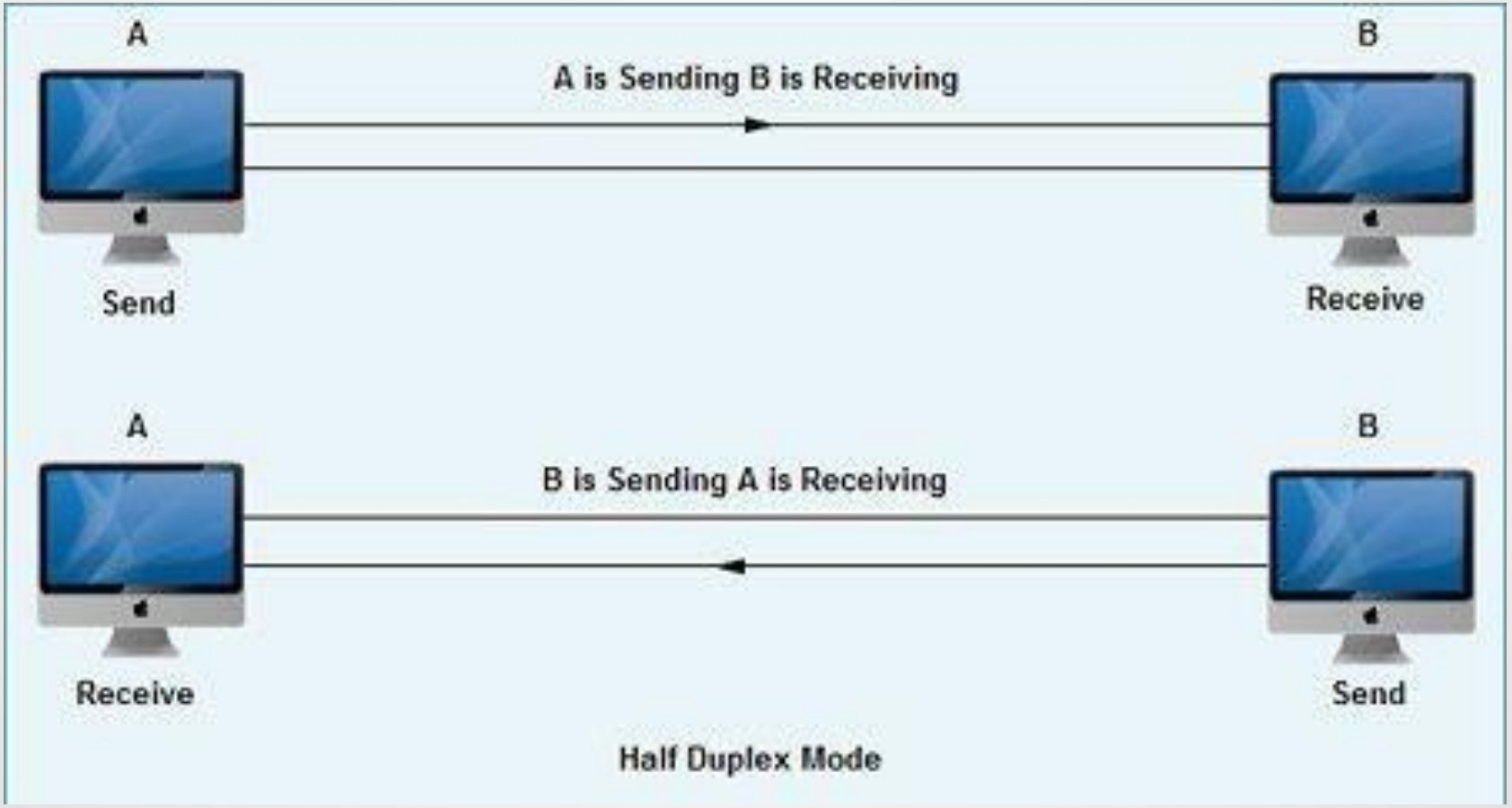


Modes of Data Transmission

- **Half Duplex Mode:**
  - Both devices can transmit; not at the same time.
  - **When one device is sending data, the other must only receive it, and vice versa.**
  - **half-duplex transmission implies a bidirectional line (one that can carry data in both directions) but data can be sent in only one direction at a time.**
  - **Half duplex communication is slower. However, it is more convenient than simplex.**
  - **Walkie-talkie is a typical half duplex device. It has a "push-to-talk" button which can be used to turn on the transmitter but turn off the receiver. Therefore, once you push the button, you cannot hear the person y an hear you..**

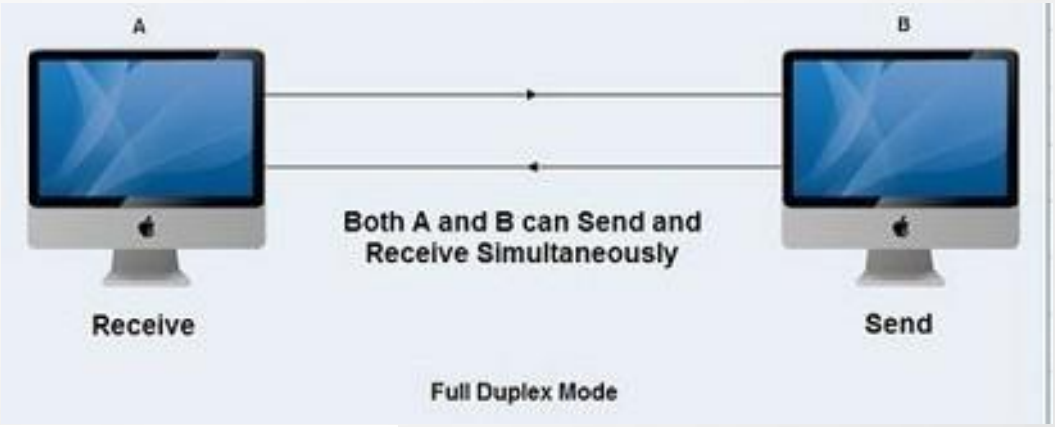


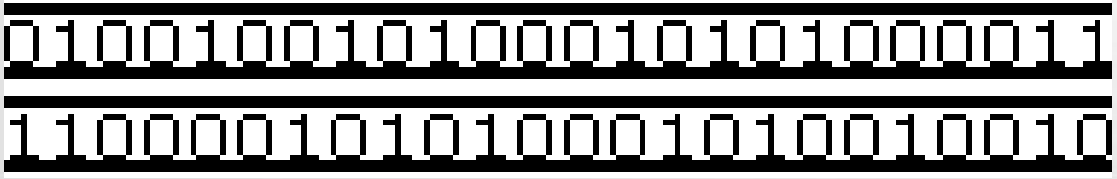
Modes of Data Transmission



Modes of Data Transmission

- **Full Duplex Mode:**
  - In full duplex system we can send data in both the directions as it is bidirectional at the same time in other words, data can be sent in both directions simultaneously.
  - Both the connected devices can transmit and receive at the same time
  - Example of Full Duplex is a Telephone Network in which there is communication between two persons by a telephone line, using which both can talk and listen at the same time.





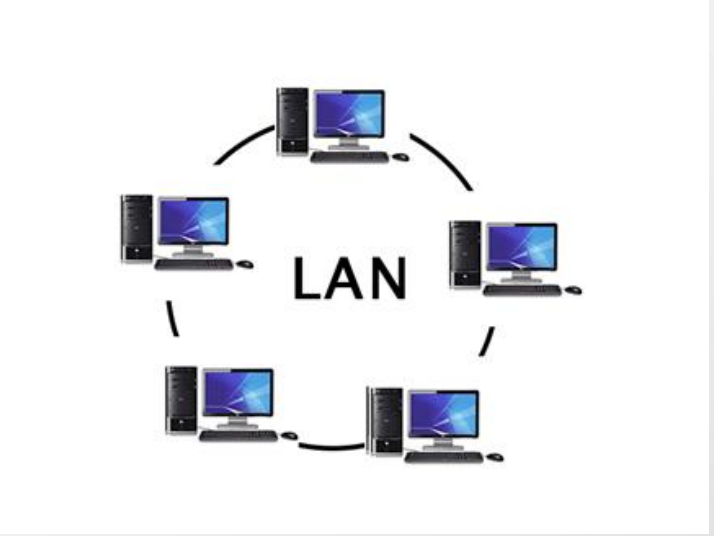
Types of Network

- LAN(Local Area Network)
- PAN(Personal Area Network)
- MAN(Metropolitan Area Network)
- WAN(Wide Area Network)

LAN (Local Area Network)

- **LAN(Local Area Network)**

- Local Area Network is a group of computers connected to each other in a small area such as building, office.
- LAN is used for connecting two or more personal computers through a communication medium such as twisted pair, coaxial cable, etc.
- It is less costly as it is built with inexpensive hardware such as hubs, network adapters, and ethernet cables.
- The data is transferred at an extremely faster rate in Local Area Network.
- Local Area Network provides higher security.



PAN Network

- Personal Area Network is a network arranged within an individual person, typically within a range of 10 meters.
- Personal Area Network is used for connecting the computer devices of personal use is known as Personal Area Network.
- Thomas Zimmerman was the first research scientist to bring the idea of the Personal Area Network.
- Personal Area Network covers an area of 30 feet.
- Personal computer devices that are used to develop the personal area network are the laptop, mobile phones, media player and play stations.

MAN(Metropolitan Area Network)

- A metropolitan area network is a network that covers a larger geographic area by interconnecting a different LAN to form a larger network.
- Government agencies use MAN to connect to the citizens and private industries.
- In MAN, various LANs are connected to each other through a telephone exchange line.
- It has a higher range than Local Area Network(LAN).

- **Uses Of Metropolitan Area Network:**
- MAN is used in communication between the banks in a city.
- It can be used in an Airline Reservation.
- It can be used in a college within a city.
- It can also be used for communication in the military.

WAN (Wide Area Network)

- A Wide Area Network is a network that extends over a large geographical area such as states or countries.
- A Wide Area Network is quite bigger network than the LAN.
- A Wide Area Network is not limited to a single location, but it spans over a large geographical area through a telephone line, fibre optic cable or satellite links.
- The internet is one of the biggest WAN in the world.
- A Wide Area Network is widely used in the field of Business, government, and education.

Examples Of Wide Area Network:

Mobile Broadband: A 4G network is widely used across a region or country.

Last mile: A telecom company is used to provide the internet services to the customers in hundreds of cities by connecting their home with fiber.

Private network: A bank provides a private network that connects the 44 offices. This network is made by using the telephone leased line provided by the telecom company.