Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology
(Deemed to be University Estd. u/s 3 of UGC Act, 1956)

Department of Computer Science and Engineering

COURSE CODE – TITLE: 1151CS111 – COMPUTER NETWORKS

UNIT-2

PHYSICAL LAYER

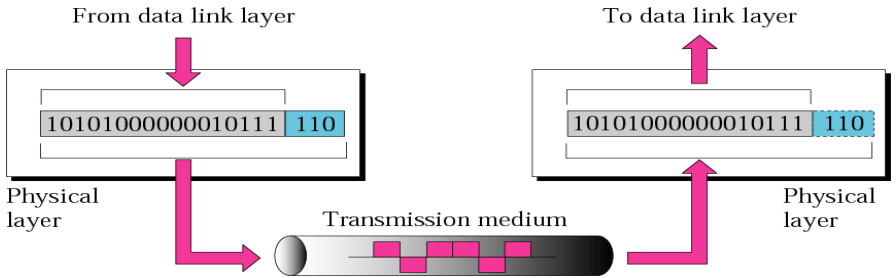
Course Instructor
Mr. P. Vinoth kumar
Assistant Professor (CSE)

PHYSICAL L AYER

The physical layer is responsible for the movement of individual bits from one hop (node) to the next.

Determines the specs for all physical components

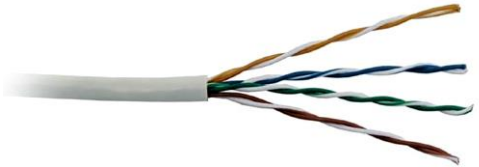
- Cabling
- Interconnect methods (topology / devices)
- Data encoding (bits to waves)
- Electrical properties



What are the Physical Layer components on my computer?

NIC (Network Interface Card)

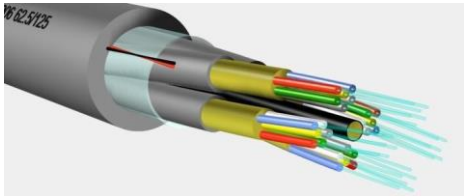
Has a unique 12 character Hexadecimal number permanently burned into it at the manufacturer. The number is the MAC Address/Physical address of a computer



Media:

Twister Pair Cable

Fiber Optic Cable



Coax. Cable

Air

Digital Transmission

Data or information can be stored in two ways

1.Analog

2.Digital

- For a computer to use that Data it must be in discrete digital form.
- Like data, signals can also be in analog and digital form.
- To transmit data digitally it needs to be first converted to digital form.

Data conversion format:

1. Analog-to-digital conversion

2. Digital-to-digital conversion

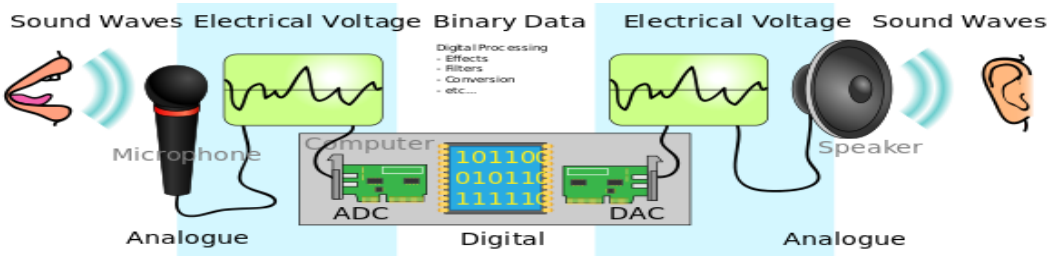
Analog-to-digital conversion

- Analog data is wave form continuous stream of data whereas digital data is discrete
- To convert analog wave into digital data we use Pulse Code Modulation

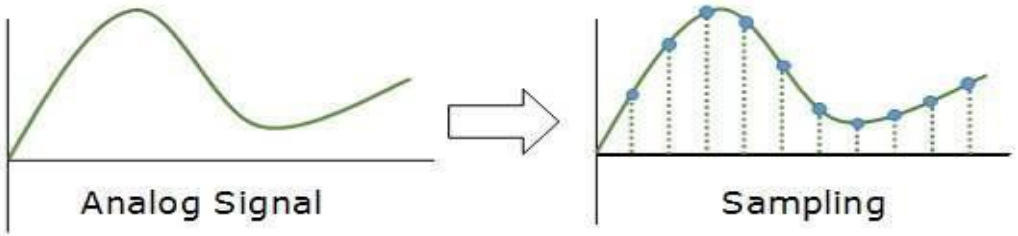
Pulse Code Modulation is one of the most commonly used method to convert analog data into digital form.

It involves three steps:

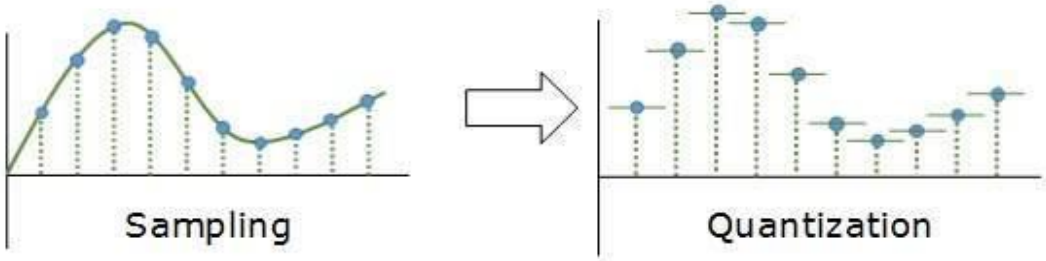
1. **Sampling**
2. **Quantization and**
3. **Encoding**



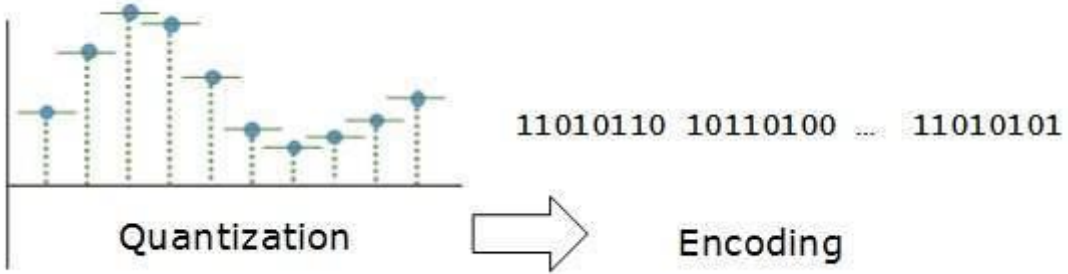
Sampling



Quantization



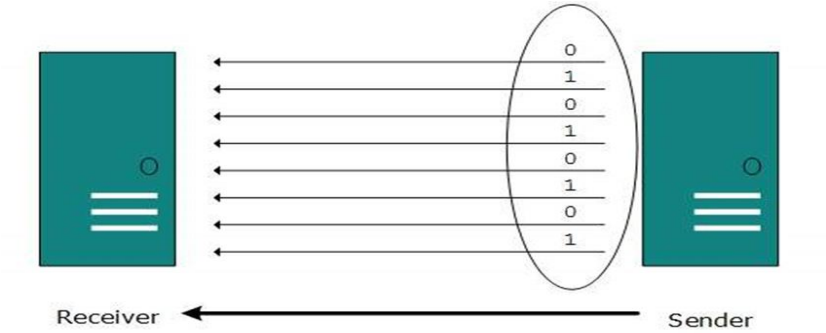
Encoding



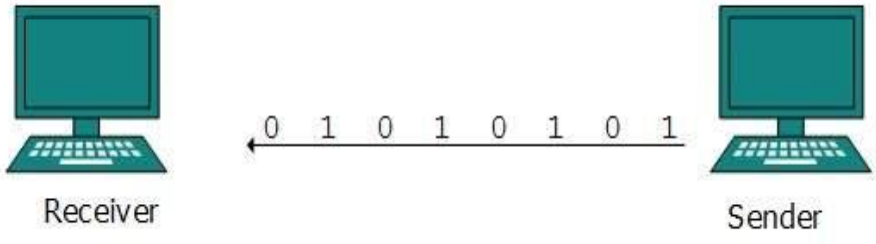
Transmission Modes

How data is to be transferred between to computer is decided by the transmission mode

1. Parallel Transmission



2. Serial Transmission



Two serial Txn modes:
Synchronous
Asynchronous

Analog Transmission

When data in either digital or analog forms; needs to be sent over an analog media

it must first be converted into analog signals

There can be two cases according to data formatting.

In real world scenarios, filters are used to filter and pass frequencies of interest

1.Bandpass: A bandpass is a band of frequencies which can pass by the filter

2.Low-pass: Low-pass is a filter that passes low frequencies signals.

Digital-to-Analog Conversion

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.

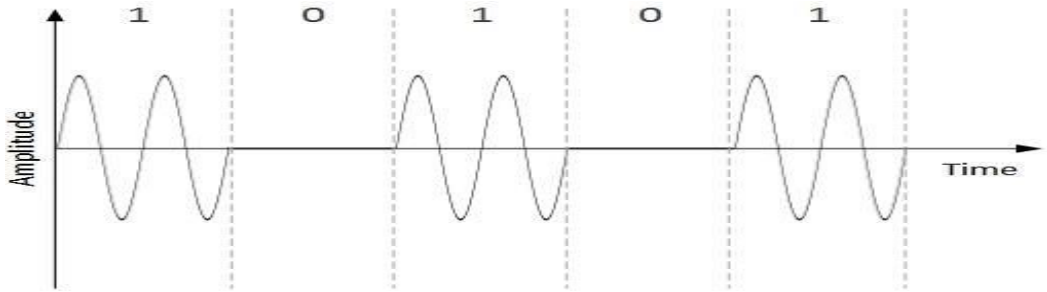
An analog signal is characterized by its amplitude, frequency and phase.

There are three kinds of digital-to-analog conversions possible:

- **Amplitude shift keying**
- **Frequency shift keying**
- **Phase shift keying**

Amplitude shift keying

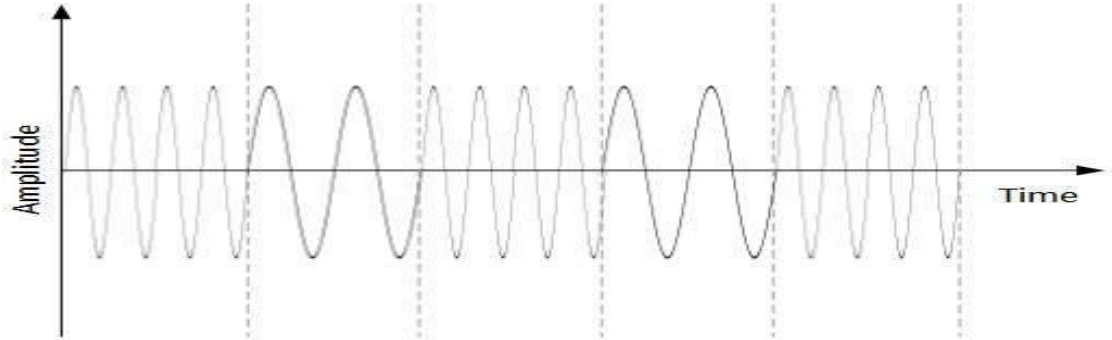
In this conversion technique, the amplitude of analog carrier signal is modified to reflect binary data.



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.

Frequency shift keying

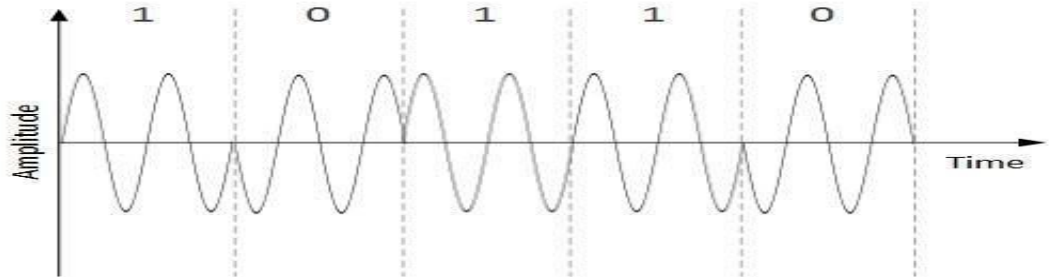
In this conversion technique, the frequency of the analog carrier signal is modified to reflect binary data.



This technique uses two frequencies, f1 and f2. One of them, for example f1, is chosen to represent binary digit 1 and the other one is used to represent binary digit 0. Both amplitude and phase of the carrier wave are kept intact.

Phase shift keying

In this conversion scheme, the phase of the original carrier signal is altered to reflect the binary data.



When a new binary symbol is encountered, the phase of the signal is altered. Amplitude and frequency of the original carrier signal is kept intact.

Quadrature Phase Shift Keying

QPSK alters the phase to reflect 2 binary digits at once.

This is done in two different phases

1. The main stream of binary data is divided equally into two sub-streams
2. The serial data is converted in to parallel in both sub-streams

and then each stream is converted to digital signal using NRZ technique. Later, both the digital signals are merged together

Digital-to-digital conversion

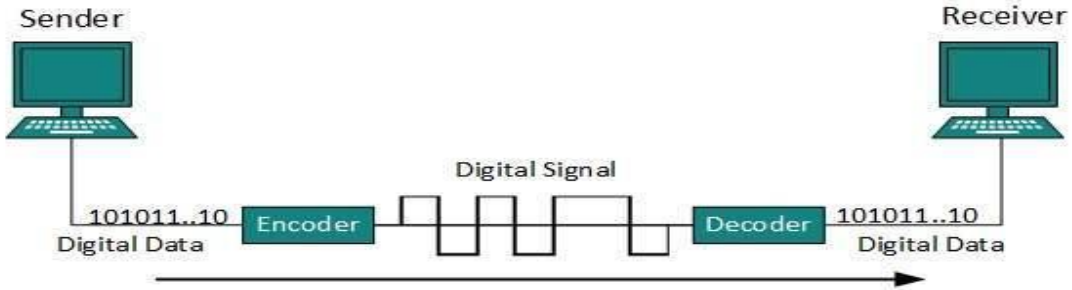
It can be done in two ways,

i. Line coding

ii. Block coding

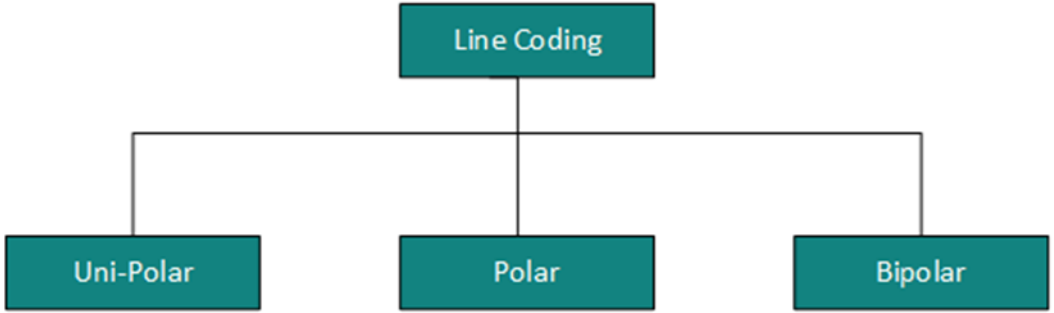
For all communications, line coding is necessary whereas block coding is optional.

i. Line Coding

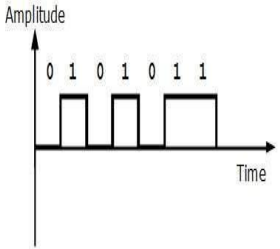


The process for converting digital data into digital signal is said to be Line Coding. Digital data is found in digital format, which is binary bits. It is represented (stored) internally as series of 1s and 0s.

Types of line coding schemes



Uni-Polar Encoding



Unipolar encoding schemes uses single voltage level to represent data.

In this case, to represent binary 1 high voltage is transmitted and to represent 0 no voltage is transmitted.

It is also called Unipolar-Non-return-to-zero, because there's no rest condition i.e. it either represents 1 or 0.

Polar Encoding

Polar encoding schemes multiple voltage levels are used to represent binary values. Polar encodings are available in four types:

- Polar-NRZ (Non-return to zero)

  NRZ scheme has two variants:
  NRZ-L and NRZ-I.

- RZ (Return to zero)

- Manchester

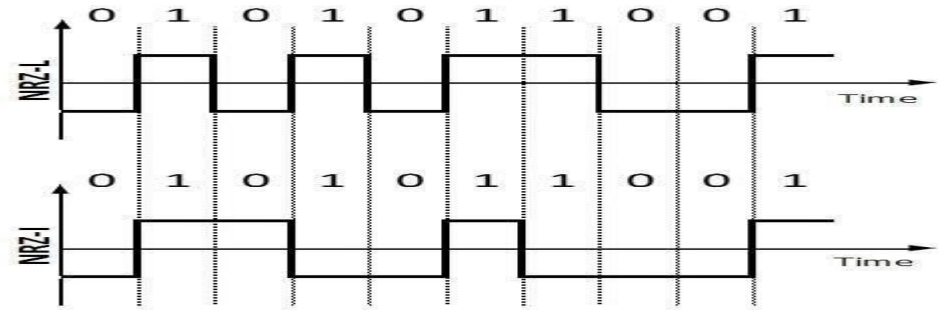
- Differential Manchester

Polar-NRZ (Non-return to zero)

It uses two different voltage levels to represent binary values, generally positive voltage represents 1 and negative value represents 0.

It is also NRZ because there's no rest condition.

NRZ scheme has two variants: NRZ-L and NRZ-I.



NRZ-L changes voltage level at when a different bit is encountered

Whereas NRZ-I changes voltage when a 1 is encountered.

RZ (Return to zero)

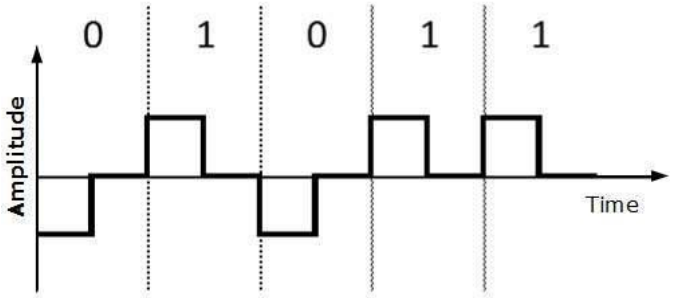
Problem with NRZ was the receiver cannot conclude when a bit ended and when the next bit is started, in case when sender and receiver's clock are not synchronized.

RZ uses three voltage levels,

positive voltage to represent 1,

negative voltage to represent 0 and

zero voltage for none. Signals change during bytes not between bits.



- Manchester

This encoding scheme is a combination of RZ and NRZ-L.

Bit time is divided into two halves.

It transitions at the middle of the bit and changes phase when a *different bit is encountered*.

- Differential Manchester

This encoding scheme is a combination of RZ and NRZ-I.

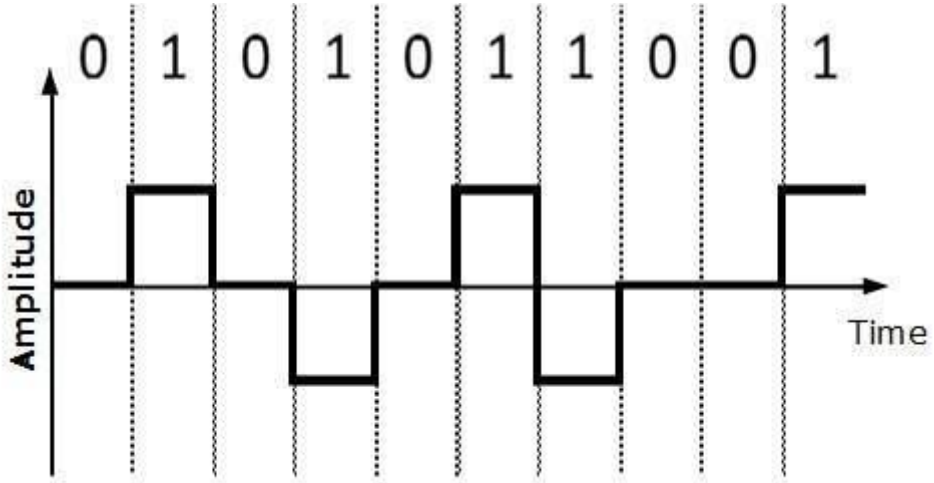
It also transitions at the middle of the bit but changes phase only *when 1 is encountered*.

Bipolar Encoding

Bipolar encoding uses three voltage levels, positive, negative and zero.

Zero voltage represents binary 0 and

bit 1 is represented by altering positive and negative voltages.



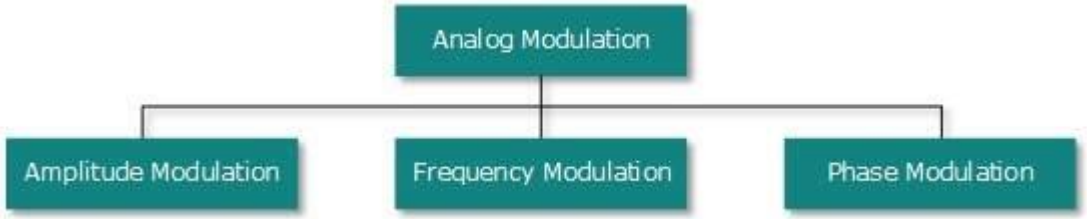
Block Coding

- To ensure accuracy of data frame received, redundant bits are used.
- For example, in even parity one parity bit is added to make the count of 1s in the frame even. This way the original number of bits are increased. It is called Block Coding.
- Block coding is represented by slash notation, mB/nB, that is m-bit block is substituted with n-bit block where n > m. Block coding involves three steps: division, substitution and combination.
- After block coding is done it is line coded for transmission.

Analog-to-analog conversion

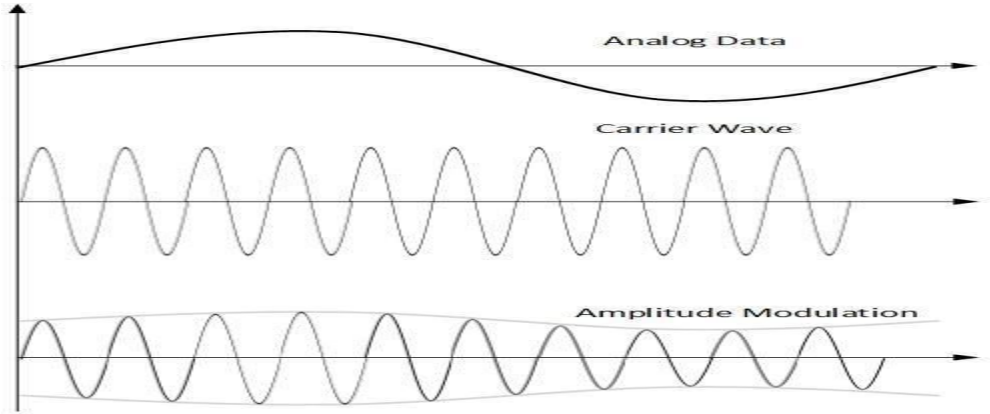
- Analog signals are modified to represent analog data. This conversion is also known as Analog Modulation.
- Analog modulation is required when bandpass is used.

Analog to analog conversion can be done in three ways:



Amplitude Modulation

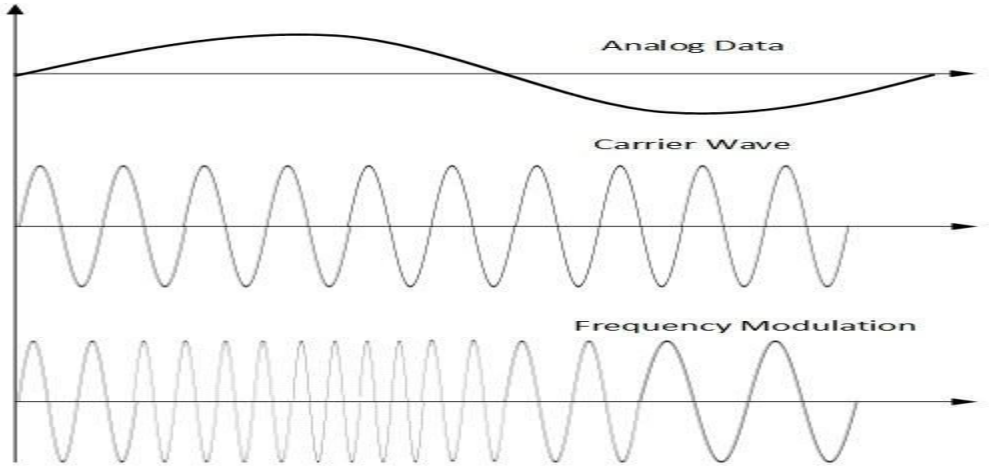
- In this modulation, the amplitude of the carrier signal is modified to reflect



- Amplitude modulation is implemented by means of a multiplier.
- The amplitude of modulating signal (analog data) is multiplied by the amplitude of carrier frequency, which then reflects analog data.
- The frequency and phase of carrier signal remain unchanged.

- **Frequency Modulation**

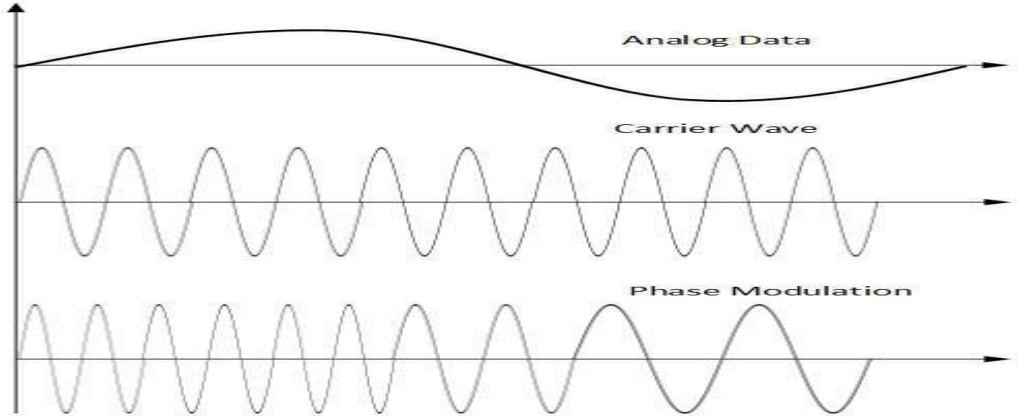
- In this modulation technique, the frequency of the carrier signal is modified to reflect the change in the voltage levels of the modulating signal (analog data).



- The amplitude and phase of the carrier signal are not altered.

- **Phase Modulation**

- In the modulation technique, the phase of carrier signal is modulated in order to reflect the change in voltage (amplitude) of analog data signal.



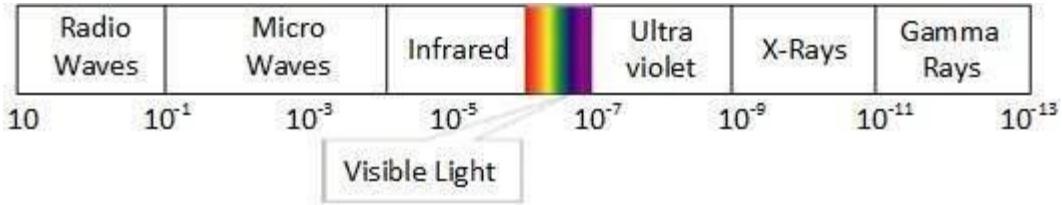
- Phase modulation practically is similar to Frequency Modulation, but in Phase modulation frequency of the carrier signal is not increased.

- Frequency is carrier is signal is changed (made dense and sparse) to reflect voltage change in the amplitude of modulating signal.

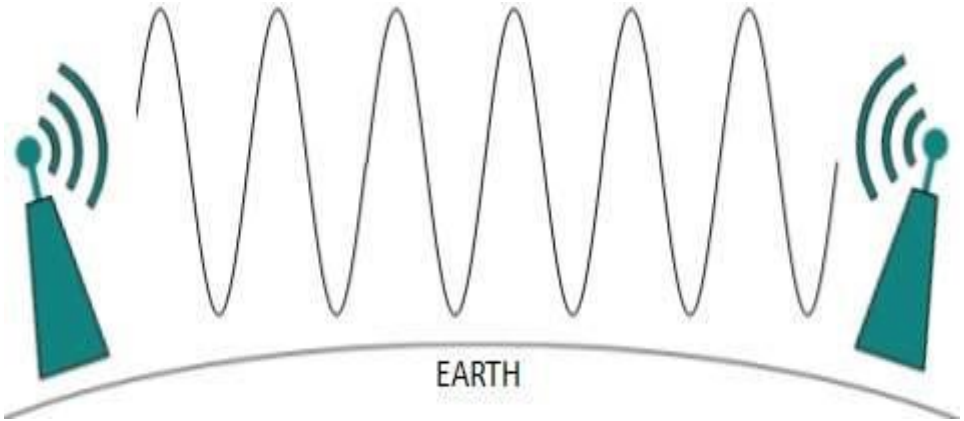
Wireless Transmission

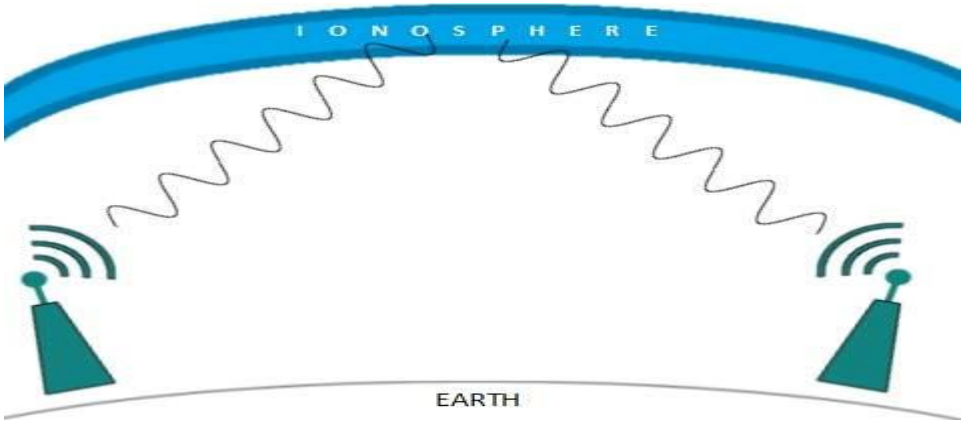
- Wireless transmission is a form of unguided media.
- Wireless communication involves no physical link established between two or more devices, communicating wirelessly.
- Wireless signals are spread over in the air and are received and interpret by appropriate antennas.
- When an antenna is attached to electrical circuit of a computer or wireless device, it converts the digital data into wireless signals and spread all over within its frequency range.
- The receptor on the other end receives these signals and converts them back to digital data.
- A little part of electromagnetic spectrum can be used for wireless transmission.

Radio Transmission



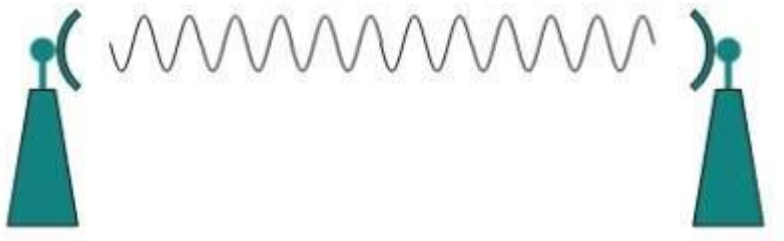
- Radio frequency is easier to generate and because of its large wavelength it can penetrate through walls and alike structures.
- Radio waves can have wavelength from 1 mm – 100,000 km and have frequency ranging from 3 Hz (Extremely Low Frequency) to 300 GHz (Extremely High Frequency).
- Radio frequencies are sub-divided into six bands.
- Radio waves at lower frequencies can travel through walls whereas higher RF travel in straight line and bounces back. The power of low frequency waves decreases sharply as it covers longer distance. High frequency radio waves have more power.
- Lower frequencies like (VLF, LF, MF bands) can travel on the ground up to 1000 kilometers, over the earth's surface.


EARTH


IONOSPHERE
EARTH

Microwave Transmission

- Electromagnetic waves above 100 MHz tend to travel in a straight line and signals over them can be sent by beaming those waves towards one particular station.
- Microwaves travels in straight lines, both sender and receiver must be aligned to be strictly in line-of-sight.
- Microwaves can have wavelength ranging from 1 mm – 1 meter and frequency ranging from 300 MHz to 300 GHz.



- Microwaves are higher frequencies and do not penetrate wall like obstacles

Infrared Transmission

- Infrared waves lies in between visible light spectrum and microwaves. It has wavelength of 700 nm to 1 mm and frequency ranges from 300 GHz to 430 THz.
- Infrared waves are used for very short range communication purposes such as television and it's remote.
- Infrared travels in a straight line so they are directional by nature. Because of high frequency range, Infrared do not cross wall like obstacles.

Light Transmission

- Highest most electromagnetic spectrum which can be used for data transmission is light or optical signaling. This is achieved by means of LASER.
- Because of frequency light uses, it tends to travel strictly in straight line.
- The sender and receiver must be in the line-of-sight.
- laser transmission is unidirectional, at both ends of communication laser and photo-detectors needs to be installed.

Laser beam is generally 1mm wide so it is a work of precision to align two far receptors each pointing to lasers source.

Switching Techniques

There are basically three types of switching methods are made available.

Out of three methods, circuit switching and packet switching are commonly used but the message switching has been opposed out in the general communication procedure but is still used in the networking application.

1) Circuit Switching
2) Packet Switching
3) Message Switching

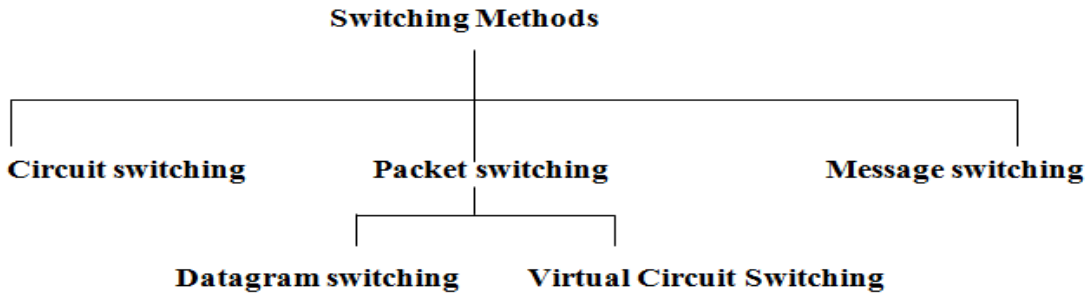


Fig- Types of switching methods

Circuit Switching

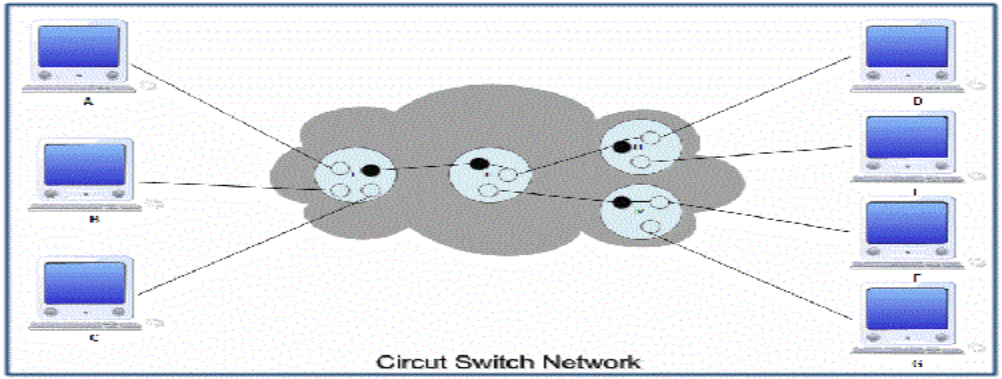


Fig- Circuit Switching

- Circuit Switching is a technique that directly connects the sender and the receiver in an unbroken path.
- For example take telephone switching equipment establishes a path that connects the caller's and reciever's telephone by making a physical connection
    - A complete end to end path must exist before communication can take place.

Message Switching

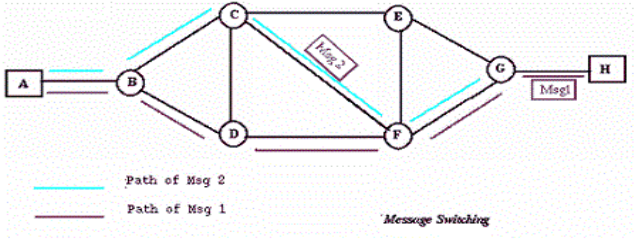


Fig- Message Switching

- In message switching there is no dedicated path required between two communicating devices, because the message switching is the follow the connectionless network.
- With message switching there is no need to establish dedicated path between two stations.
- When a station sends a message, the destination address is appended to the message.
- The message is then transmitted through the network in its entirety, from node to node.
    - Each node receives the entire message, stores it in its entirety on disk and then transmits the message to the next node. This type of network is called a store and forward network.

Packet switching

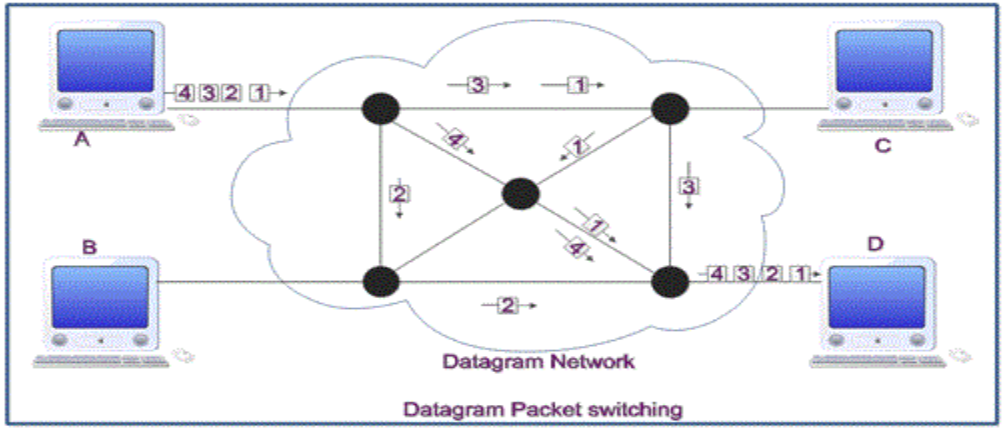


Fig- Packet switching

- Packet switching is cost effective.
- Offers improved delay characteristics.
- Packet can be rerouted if any problem occurs.

Packet switching: Datagram

- Datagram packet switching is a packet switching technology by which each packet is treated as a separate entity and are called as datagram.
- Packets have their own complete addressing information attached.
- Each packet follows different routes to reach the destination.
- So, the packets may arrive at different times, and may be in a disturbed order. In this case reordering is done.

Packet switching: Virtual

- In this type of switching a preplanned route is established before the packets are sent.
- Sender sends a **"call request packet"** to establish a logical connection and receiver sends back an acknowledgement packet **"packet accepted"**.
- It is a cross between circuit switching network and packet switching network.

CONNECTING DEVICES

- **Network** Hub: **Network** Hub is **a networking** device which is used to **connect** multiple **network** hosts
- **Network** Switch: Like **a** hub, **a** switch also works at the layer of LAN (Local Area **Network**) but you can say that **a** switch is more intelligent than **a** hub
- Modem
- **Network** Router
- Bridge
- Repeater