UNIT I: Introduction to Wireless Networks: Applications, History, Simplified Reference Model, Wireless transmission, Frequencies, Signals, Antennas, Signal propagation, Multiplexing, Modulation, Spread spectrum, Cellular Systems: Frequency Management and Channel Assignment, types of hand-off and their characteristics.

Introduction to Wireless Networks:

APPLICATIONS OF WIRELESS NETWORKS:

Wireless networks have numerous applications across different fields, including:

1.Communication: Wireless networks allow for wireless communication between devices such as phones, laptops, and tablets. This communication can be used for text messaging, voice and video calls, and internet browsing.

2.IoT (Internet of Things): Wireless networks enable the connection of different IoT devices such as smart home appliances, medical devices, and industrial sensors, enabling data exchange, automation, and remote control.

3.Transportation: Wireless networks enable real-time communication between vehicles and between vehicles and infrastructure, improving traffic management and reducing accidents.

4.Entertainment: Wireless networks enable streaming of audio and video content over the internet, allowing users to access their favourite movies, TV shows, and music.

5.Education: Wireless networks enable remote learning, video conferencing, and collaboration tools, allowing students and teachers to interact from different locations.

6.Healthcare: Wireless networks allow for real-time monitoring of patient's health status, communication between medical devices, and remote consultations with doctors.

7.Retail: Wireless networks enable mobile payments, inventory management, and customer analytics, enhancing the shopping experience and improving business operations.

8.Agriculture: Wireless networks can be used to monitor soil moisture, temperature, and other environmental factors, enabling farmers to optimize crop yield and reduce water usage.

HISTORY OF WIRELESS NETWORKS:

The history of wireless networks dates back to the late 19th century with the invention of radio communication. Here are some key milestones in the history of wireless networks:

Radio Communication: In 1895, Guglielmo Marconi sent the first wireless telegraph message across the English Channel. This marked the beginning of radio communication, which later evolved into wireless networks.

First Wireless Telephone Call: In 1947, Bell Labs demonstrated the first wireless telephone call using radio technology.

First Cellular Network: In 1979, the first cellular network was launched in Japan by NTT. This enabled mobile phone calls and paved the way for the widespread adoption of wireless communication.

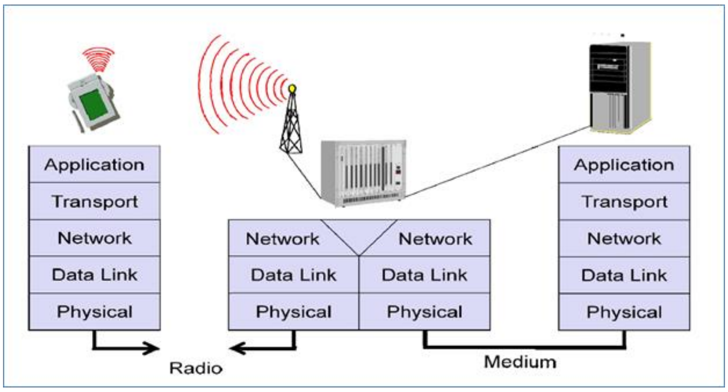
Emergence of Wi-Fi: In 1997, the first Wi-Fi standard (802.11) was introduced, allowing for wireless data transfer between devices.

3G and 4G Networks: In the early 2000s, 3G and 4G networks were introduced, enabling faster data transfer rates and supporting new applications such as video streaming and mobile internet access.

Introduction of 5G Networks: In 2019, 5G networks were introduced, offering even faster data transfer rates, lower latency, and greater capacity, enabling new applications such as autonomous vehicles and virtual reality.

SIMPLIFIED REFERENCE MODEL:

- The Simplified Reference Model (SRM) is a framework that provides a simplified view of the functions and components of a network system. The SRM was developed by the International Organization for Standardization (ISO) and is based on the more complex OSI (Open Systems Interconnection) reference model.
- The SRM consists of Five layers:



Application Layer: This layer includes protocols that provide network services to end-users. It includes protocols such as HTTP (Hypertext Transfer Protocol), FTP (File Transfer Protocol), and SMTP (Simple Mail Transfer Protocol).

Transport Layer: This layer provides end-to-end communication between applications on different hosts, and it ensures reliable data transfer. It includes protocols such as TCP (Transmission Control Protocol) and UDP (User Datagram Protocol).

Network Layer: This layer provides routing and addressing functions to enable communication between hosts on different networks. It includes protocols such as IP (Internet Protocol).

Data Link Layer: This layer governs the wireless transmission of data and includes sub-layers such as the Media Access Control (MAC) layer, which controls access to the wireless medium, and the Logical Link Control (LLC) layer, which provides error control and flow control.

Physical Layer: This layer defines the physical characteristics of the wireless medium, such as the radio frequency band used and the modulation scheme employed.

WIRELESS TRANSMISSION:

- Wireless transmission refers to the transfer of data, voice, or video signals between two or more points without the use of physical cables or wires. This is achieved through the use of wireless communication technologies, which include radio frequency (RF), infrared (IR), and microwave.
- The basic principle of wireless transmission is the conversion of information into a signal that can be transmitted wirelessly. The signal is then transmitted through the air using wireless communication technologies. At the receiving end, the signal is received and decoded back into its original format.

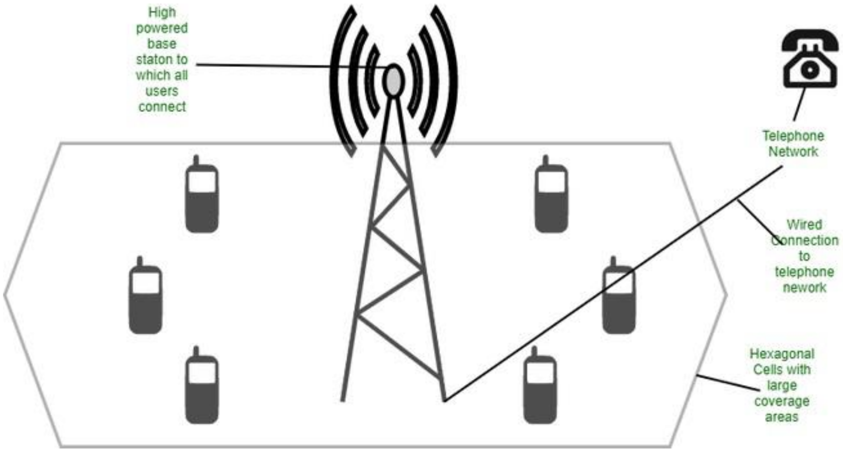
➢ Some common wireless transmission technologies include:

Wi-Fi: A wireless networking technology that uses radio waves to transmit data over short distances.

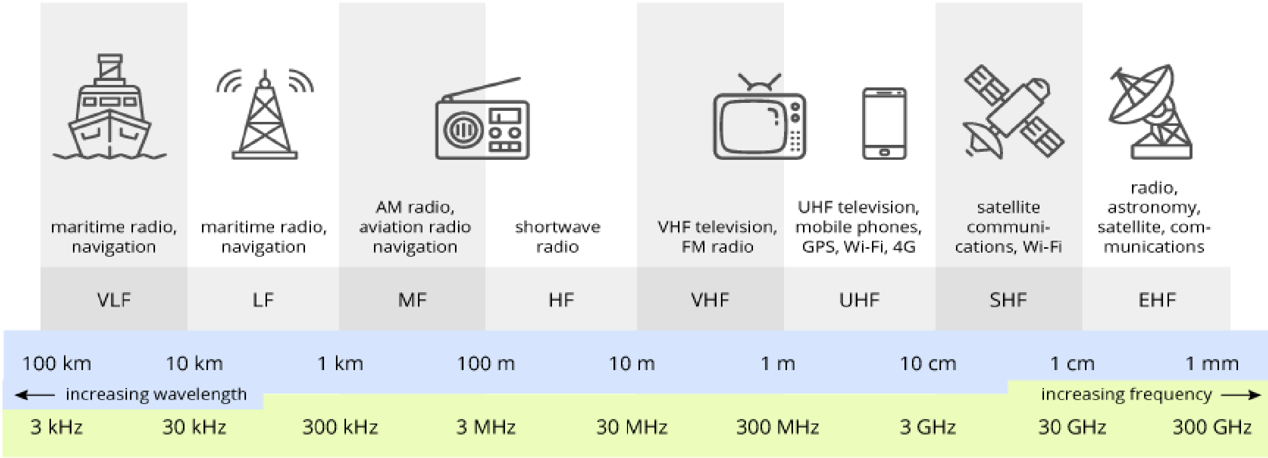
Bluetooth: A wireless technology used for short-range communication between devices, such as smartphones, computers, and smart home devices.

Cellular networks: Mobile communication networks that use radio waves to connect mobile devices to the internet and other communication networks.

Satellite communication: Communication that uses satellites to transmit signals over long distances, often used in areas where terrestrial communication infrastructure is lacking.



FREQUENCIES:



VLF –VLF (Very Low Frequency) has a frequency of 3-30kHz and it have a range of 100km.

➢ As this band of frequency exhibits penetration properties through dirt and rock, it is used for geophysics applications, navigation, wireless heart monitoring, etc.

LF – LF (Low Frequency) has a frequency of 30-300kHz and it have a range of 10km.

➢ In Europe and some parts of Asia, the LF band is used in AM broadcasting. Other LF band applications include RFID, amateur radio, and navigation.

MF – MF (Medium Frequency) has a frequency of 300kHz-3MHz and it have a range of 1km.

- This frequency band covers AM broadcasting, coast-to-sea communication, emergency distress signals, etc.

HF – HF (High frequency) has a frequency of 3-30MHz and it have a range of 100m.

- This band is also called the short-wave band. It is most useful in aviation communication, amateur radio communication, and weather broadcasting applications.

VHF – VHF (Very High Frequency) has a frequency of 30-300MHz and it have a range of 1m.

- This band is used for analog television broadcasting, FM radio broadcasting, medical equipment utilizing magnetic resonance imaging, mobile-land, and marine communication systems.

UHF – UHF (Ultra High Frequency) has a frequency of 300MHz-3GHz and it have a range of 10cm.

- This frequency band is significant in modern wireless communication systems with applications in satellite television, WIFI, GPS, Bluetooth, television broadcasting, mobile communications such as GSM, CDMA, and LTE services.

SHF –SHF (Super High Frequency) has a frequency of 3-30GHz and it have a range of 1cm.

- Modern communications technologies, modern radars, DTH services, 5GHz Wi-Fi channel, radio astronomy, mobile networks, TV broadcasting satellites, microwave devices, broadcasting satellites, and amateur radio are some of the applications of SHF.

EHF – EHF (Extremely High Frequency) has a frequency of 30-300GHz and it have a range of 1mm.

- EHF is used in radio astronomy, amateur radio, remote sensing at microwave frequency, and high-frequency microwave relays.

THF – THF (Terahertz or Tremendously high frequency) has a frequency of 300-3000GHz.

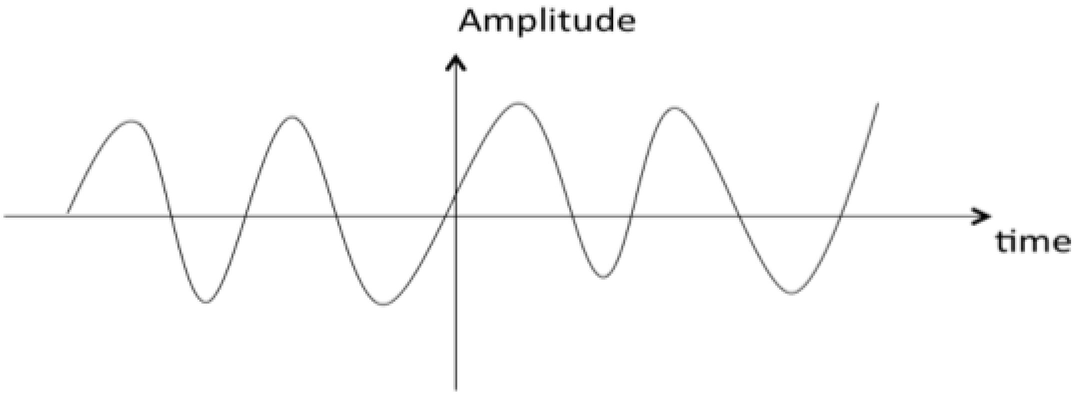
- THF is utilized as an alternative to X-ray and is used in Terahertz frequency imaging. Other applications include terahertz space-time spectroscopy, solid-state physics, and terahertz computability.

SIGNALS: In general, a signal refers to any physical quantity that conveys information. Signals can be electrical, electromagnetic, mechanical, or even biological in nature. Here are some common Types of signals:

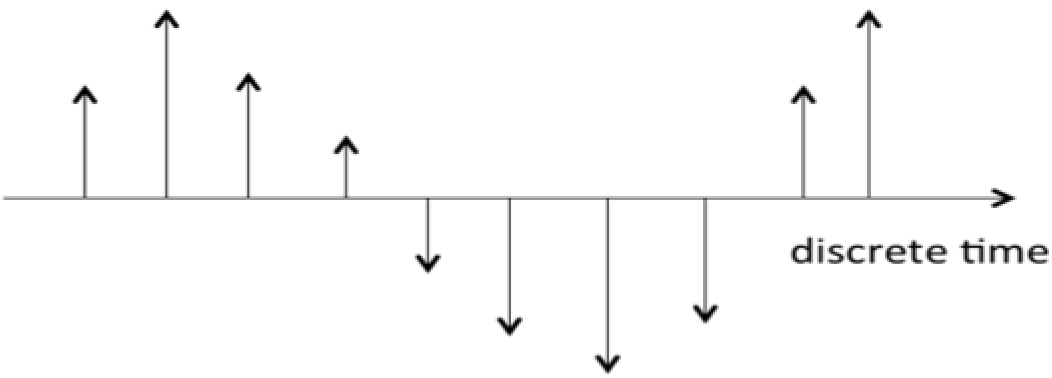
- Continuous Time and Discrete Time Signals
- Deterministic and Non-deterministic Signals
- Analog Signals and Digital Signals

Continuous Time and Discrete Time Signals:

- A signal is said to be continuous when it is defined for all instants of time.

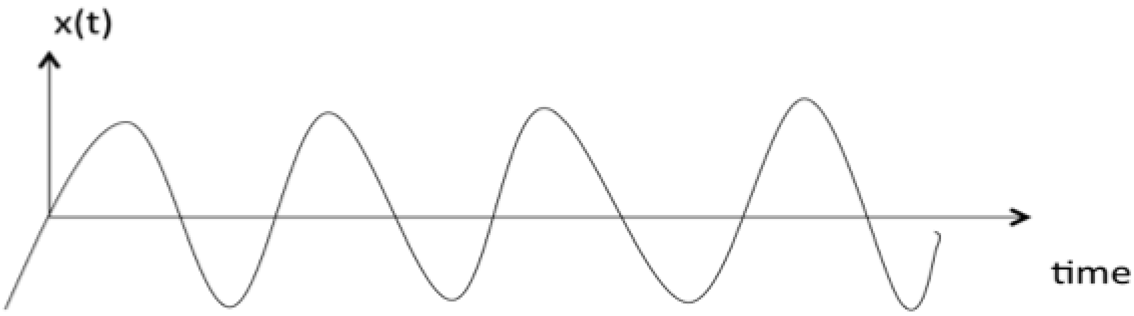


- A signal is said to be discrete when it is defined at only discrete instants of time.

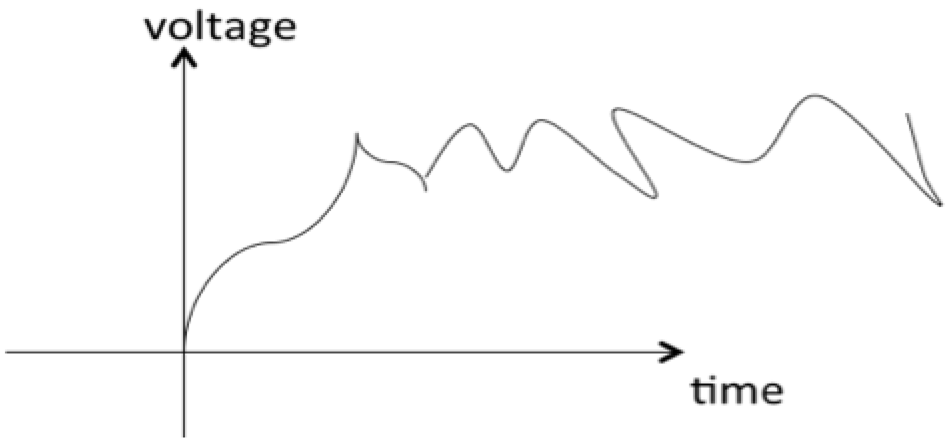


Deterministic and Non-deterministic Signals:

- A signal is said to be deterministic if there is no uncertainty with respect to its value at any instant of time. Or, signals which can be defined exactly by a mathematical formula are known as deterministic signals.

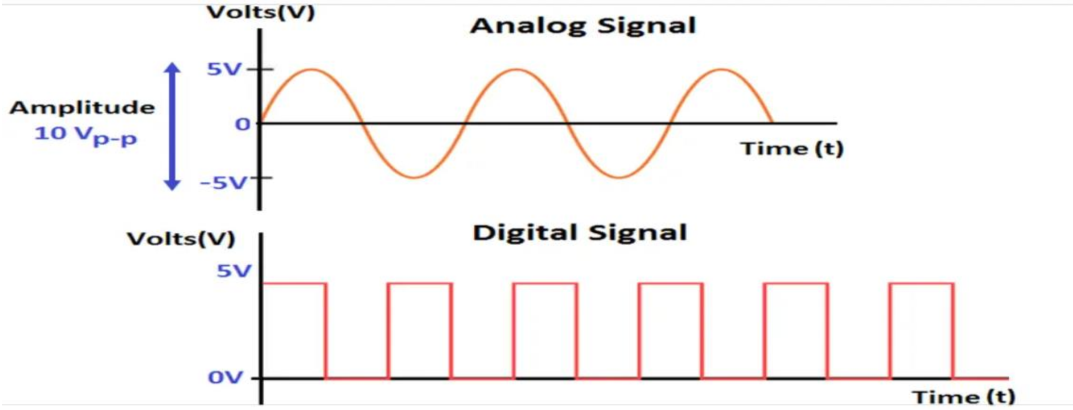


- A signal is said to be non-deterministic if there is uncertainty with respect to its value at some instant of time. Non-deterministic signals are random in nature hence they are called random signals. Random signals cannot be described by a mathematical equation. They are modelled in probabilistic terms.



Analog And Digital Signals:

- A continuous signal that varies in amplitude or frequency over time.



- A discrete signal that consists of a sequence of bits, representing a numerical value.

ANTENNAS: Antennas are devices that are designed to transmit or receive electromagnetic waves, including radio waves, microwaves, and light. They are used in a wide range of applications, including broadcasting, communication, navigation, and scientific research.

- ➢ An antenna works by converting electrical energy into electromagnetic waves, or vice versa.
- ➢ Antennas come in many shapes and sizes, depending on their intended use.
- ➢ Some of the types of Antennas are:
  - Directional Antennas
  - Wired Antennas
  - Aperture Antennas

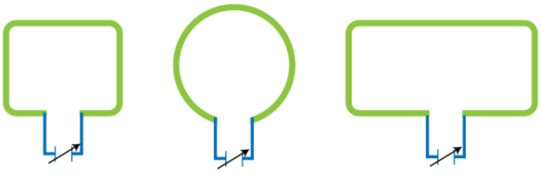
Directional Antennas: The antennas are categorized based on the direction of the radiations emitted by them.

- ➢ The three major types of Antennas based on the direction are:
  - **Omni-directional antenna.**
  - **Semi-directional antenna.**
  - **Directional antenna**.

- **<u>Omni-directional antennas:</u>** The Omni-directional antenna radiations radio power equally in all the directions. The power emitted is perpendicular to the axis. It further declines to zero towards the axis. It is commonly used in applications that require communication with multiple devices.
- **<u>Semi-directional antennas:</u>** Semi-directional antennas also radiate the power in a particular direction providing the radiations across a large area. It is generally a point-to-point communication used for short-to medium distance communications.
- **<u>Directional antennas:</u>** The directional antenna radiations power in a specific direction. The power radiated thus has a strong beam. It prevents the radiations from any interference due to the radiations in a particular direction. It has a narrow beam and double gain as compared to the Omi-directional antenna.
  - The application of directional antenna includes GPS (Global Positioning system), cellular networks, etc.

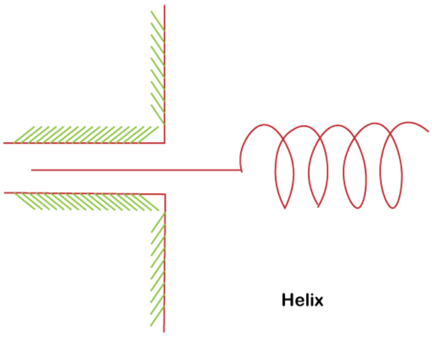
<u>Wired Antennas:</u> Wire Antennas are the type of radio antennas that consists of the long wire suspended over the ground. The wire acts as an antenna by picking up the signals and further radiating them.

- The wire antennas are further categorized as:
  - Loop Antenna.
  - Helical Antenna.
- **<u>Loop Antenna:</u>** The loop antenna consists of turns in a wire. The perimeter of the loop can be large or small, depending on the operating frequency.
  - The loop can be in the shape of a square, rectangle, circle, or any geometrical shape but in the form of a closed loop. It is shown below:


Loop Antennas of Different Shapes

  - The essential requirement of the large loop antennas is the loop's perimeter equal to the 110% of the one-full wavelength.

- **<u>Helical Antenna:</u>**
  - It consists of a wire in the form of a helix. The helical antennas can be directional or omnidirectional. The directional helical antennas are generally mounted on the ground plane.

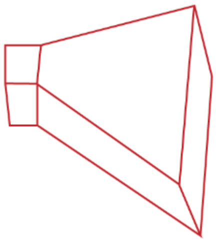


  - The helix antennas can use operators in either **normal mode** or **axial mode**. The antenna's diameter and pitch in the case of the normal mode are smaller than the wavelength. It acts as a monopole antenna in such a case. The helix antenna operating in the normal mode is also called a **broadside helical antenna**.

Aperture Antennas:

A common example of the Aperture Antenna is the Horn Antenna.

- **Horn Antenna:**
    - It is shaped like a horn that directs the radio waves in the form of beam.
    - The horn antennas are used at microwave and Ultra High Frequencies. The frequency range generally lies above 300MHz. The working of a horn antenna is similar to that of a musical instrument trumpet.

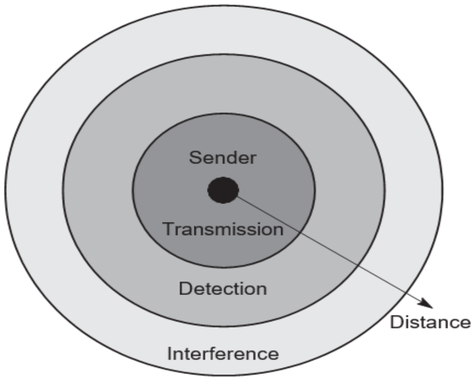


    - The horn antenna allows the radiation of the wave energy with minimum reflection. The other types of horn antenna are ridged horn, exponential horn, conical horn, etc.
    - The wavefronts of the horn antenna are spherical. The phase due to the spherical wavefronts increases smoothly from the edges towards the centre.
    - The increase in the size of the horn increases phase error. It further provides the horn antenna a wider radiation pattern.
    - When the horn antenna is combined with the parabolic reflector, the antenna thus formed is called horn-reflector antenna.

SIGNAL PROPAGATION: Signal propagation refers to the way that electromagnetic waves, such as radio waves, microwaves, and light waves, travel through a medium, such as air or a cable. When a signal is transmitted, it radiates out from the source as an electromagnetic wave, which consists of oscillating electric and magnetic fields.

- The behaviour of the wave as it travels depends on many factors, including the frequency of the wave, the properties of the medium, and the distance between the transmitter and the receiver.

Transmission range: Within a certain radius of the sender transmission is possible, i.e., a receiver receives the signals with an error rate low enough to be able to communicate and can also act as sender.



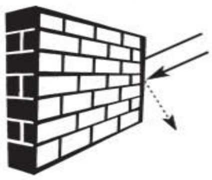
Detection range: Within a second radius, detection of the transmission is possible, i.e., the transmitted power is large enough to differ from background noise. However, the error rate is too high to establish communication.

Interference range: Within a third even larger radius, the sender may inter- fere with other transmission by adding to the background noise. A receiver will not be able to detect the signals, but the signals may disturb other signals.

Signal Propagation Effects:

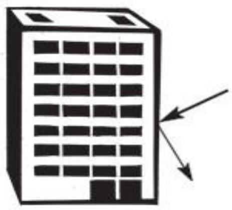
Signal propagation effects refer to the different ways that electromagnetic waves can interact with the medium they travel through, which can affect the quality and reliability of the signal. Some of the main signal propagation effects include:

- **Shadowing:** This occurs when the signal is blocked or attenuated by large objects in its path, such as buildings, hills, or trees. Shadowing can cause significant signal loss and is a common problem in urban environments or hilly terrain.



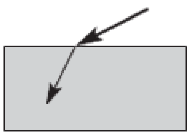
Shadowing

- **Reflection:** This occurs when the signal encounters a surface, such as a building or a mountain, and is reflected back in the opposite direction. Reflection can cause multiple copies of the signal to arrive at the receiver, which can lead to interference and distortion.



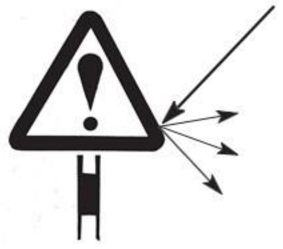
Reflection

- **Refraction:** This occurs when the signal passes through a medium with varying refractive index, such as the atmosphere or water, causing it to bend or change direction. Refraction can cause the signal to be distorted or to arrive at the receiver at a different time than expected.

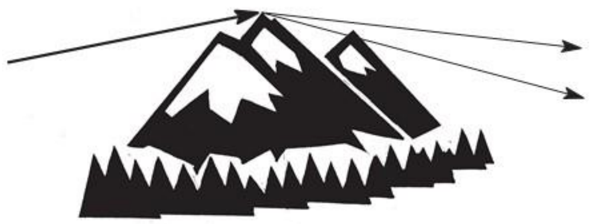


Refraction

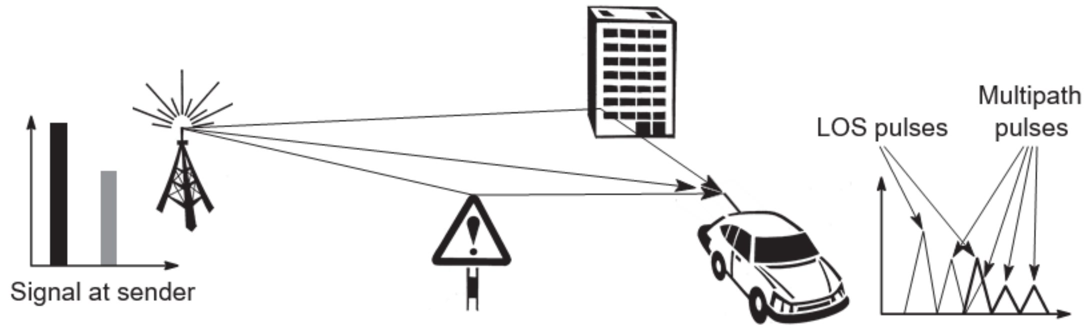
- **Scattering:** This occurs when the signal encounters small objects in its path, such as raindrops or dust particles, and is scattered in many directions. Scattering can cause the signal to become weaker or distorted, which can affect the quality of the received signal.



- **Diffraction:** This occurs when the signal encounters an obstacle, such as a building or a hill, and bends around it. Diffraction can cause the signal to spread out, which can improve coverage but can also lead to interference and distortion.



- **<u>MULTIPATH PROPAGATION:</u>**
  Multipath propagation occurs when the transmitted signal reaches the receiver by two or more paths, with each path having a different length and experiencing different reflections, diffraction, and scattering. The multiple copies of the signal arriving at the receiver can interfere with each other, causing fading, distortion, and errors in the received signal.



<u>MULTIPLEXING:</u> Multiplexing is the sharing of a medium or bandwidth. It is the process in which multiple signals coming from multiple sources are combined and transmitted over a single communication/physical line.

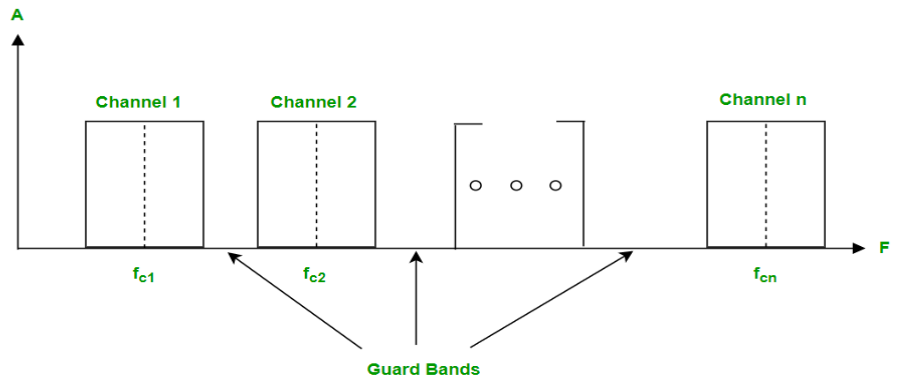
Types of Multiplexing

There are four types of Multiplexing:

1. Frequency Division Multiplexing (FDM)
2. Time-Division Multiplexing (TDM)
3. Code Division Multiplexing (CDM)
4. Wavelength Division Multiplexing (WDM)

FREQUENCY DIVISION MULTIPLEXING(FDM):

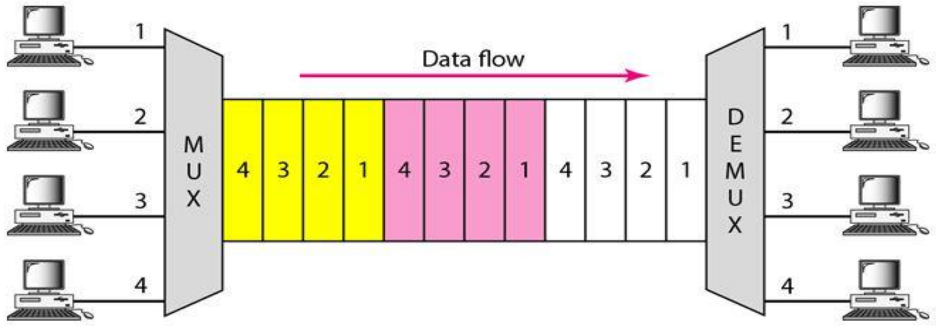
- In FDM, the available bandwidth of the channel is divided into multiple non-overlapping frequency bands.
- Each user is assigned a separate frequency band to transmit their signal.



- The signals are then combined and transmitted over the channel.
- In order to prevent the inter-channel cross talk, unused strips of bandwidth must be placed between each channel. These unused strips between each channel are known as guard bands.
- FDM is commonly used in analog communication systems such as radio and television broadcasting.

TIME DIVISION MULTIPLEXING(TDM):

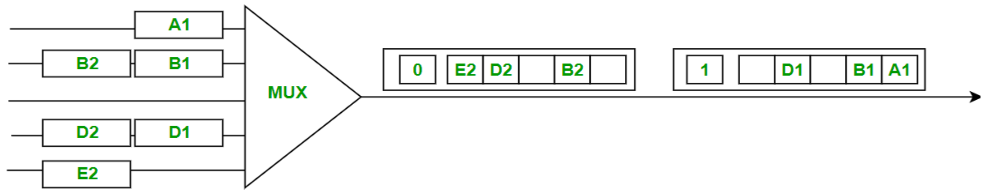
- In TDM, the available time slots of the channel are divided among multiple users.
- Each user is assigned a specific time slot to transmit their signal, the signals are then combined and transmitted over the channel.
- TDM is commonly used in digital communication systems such as telephone networks and Ethernet.



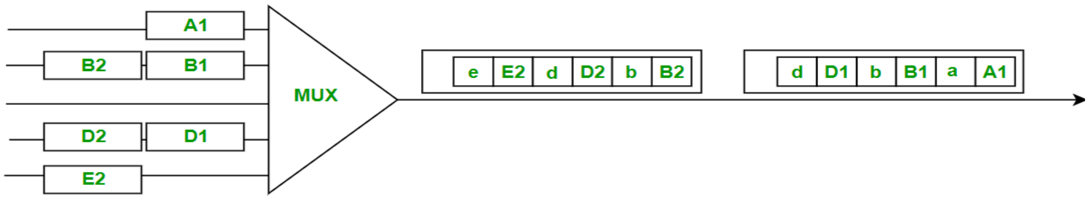
- There are two types of Time Division Multiplexing:

1. Synchronous Time Division Multiplexing
2. Statistical (or Asynchronous) Time Division Multiplexing

- **Synchronous Time Division Multiplexing:**
  - Synchronous TDM is a type of Time Division Multiplexing where the input frame already has a slot in the output frame. Time slots are grouped into frames. One frame consists of one cycle of time slots.
  - Synchronous TDM is not efficient because if the input frame has no data to send, a slot remains empty in the output frame.
  - In synchronous TDM, we need to mention the synchronous bit at the beginning of each frame.



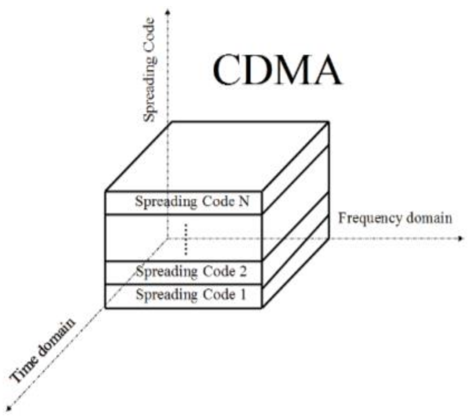
- **Statistical (or Asynchronous) Time Division Multiplexing:**
  - Statistical TDM is a type of Time Division Multiplexing where the output frame collects data from the input frame till it is full, not leaving an empty slot like in Synchronous TDM.
  - In statistical TDM, we need to include the address of each particular data in the slot that is being sent to the output frame.



  - Statistical TDM is a more efficient type of time-division multiplexing as the channel capacity is fully utilized and improves the bandwidth efficiency.

<u>CODE DIVISION MULITIPLEXING:</u>

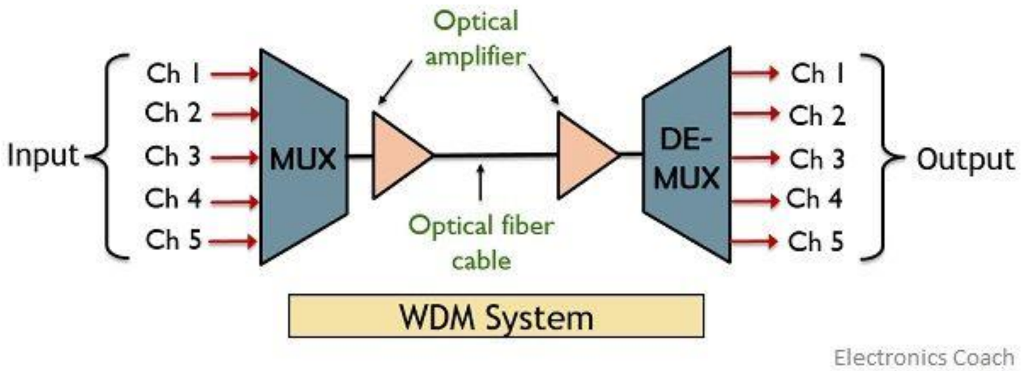
- Code Division Multiplexing (CDM) is a multiplexing technique that allows multiple users to share the same frequency band by using unique code sequences to encode their data.
- Each user is assigned a unique code that is used to spread their signal over the entire frequency band.
- The encoded signals are then transmitted simultaneously over the same channel, and at the receiver, the signals are decoded using the respective code sequences.



- CDM is commonly used in digital communication systems such as CDMA (Code Division Multiple Access) used in cellular networks.

WAVELENGTH DIVISION MULTIPLEXING:

- It is an analog multiplexing technique.
- Wavelength Division Multiplexing is used on fiber optics to increase the capacity of a single fiber.
- In WDM, multiple optical signals with different wavelengths are combined and transmitted over a single optical fiber.



- At the receiving end, the demultiplexer separates the signals to transmit them to their respective destinations.
- WDM is commonly used in high-speed fiber optic communication systems.

MODULATION:

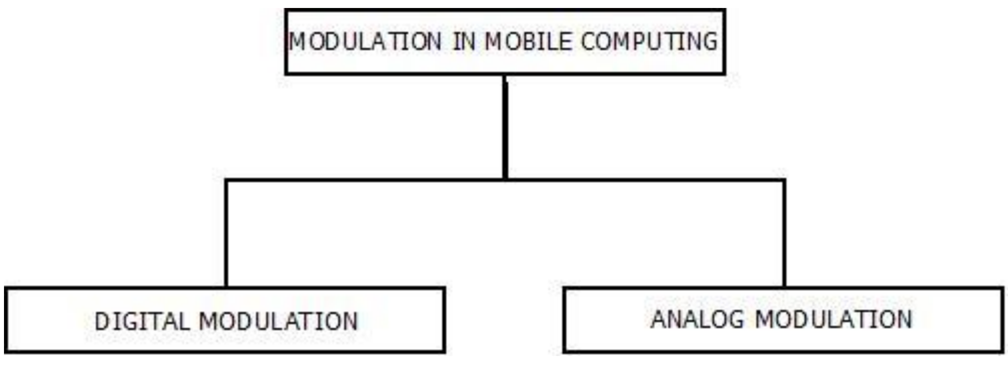
- Modulation is the **process of converting one form of signals into another form of signals**."

  For example, Analog signals to Digital signals or Digital signals to Analog signals.

- Modulation is used to make the message carrying signal strong to be transmitted over a long distance and establish a reliable communication.
- Types of Modulations:

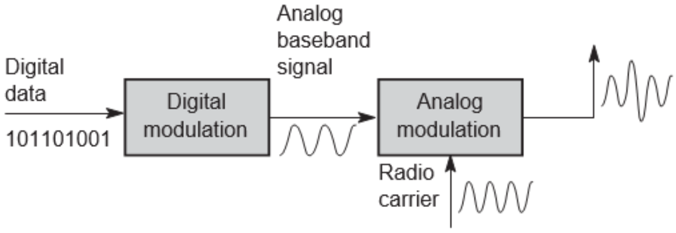
  Primarily Modulation can be classified into two types:

  - Digital Modulation.
  - Analog Modulation.



DIGITAL MODULATION:

Digital Modulation is a technique in which digital signals/data can be converted into analog signals. For example, Base band signals.

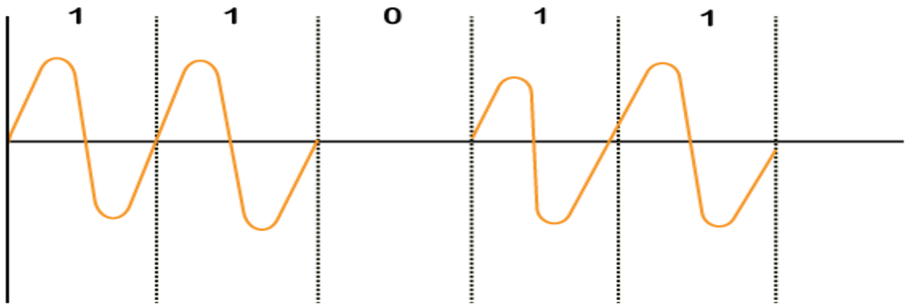


Digital Modulation can further be classified into three types:

- Amplitude Shift Key (ASK) Modulation
- Frequency Shift Key (FSK) Modulation
- Phase Shift Key (PSK) Modulation

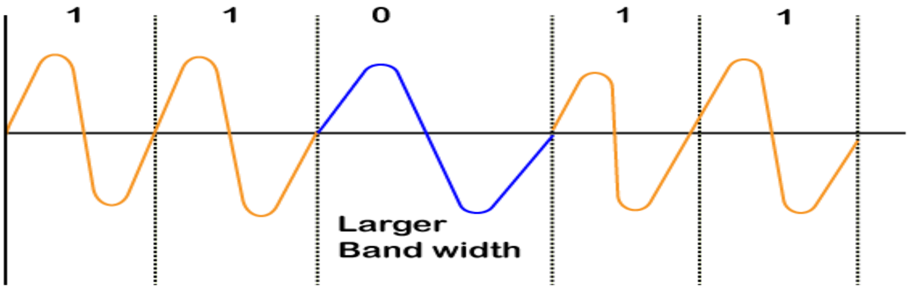
Amplitude Shift Key (ASK) Modulation:

- As the name suggests, in Amplitude Shift Key or ASKS Modulation, the amplitude is represented by "1," and if the amplitude does not exist, it is represented by "0".



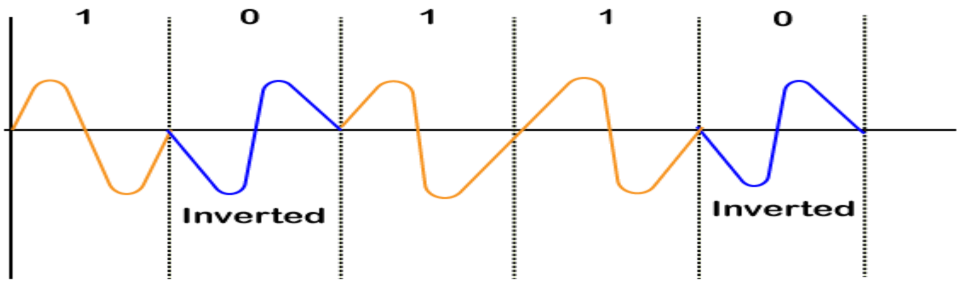
Frequency Shift Key (FSK) Modulation:

- In Frequency Shift Key or FSK Modulation, different notations f1 and f2 are used for different frequencies.
- Here, f1 is used to represent bit "1," and f2 represents bit "0".
- It uses different frequencies for different bits, so the bandwidth requirement becomes high.



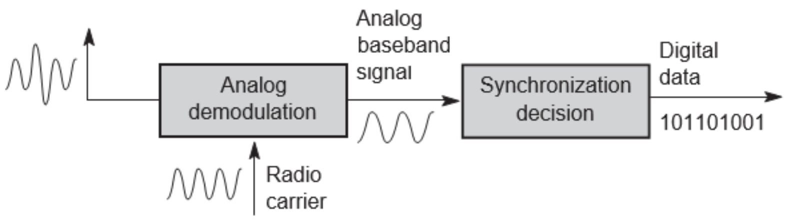
Phase Shift Key (PSK) Modulation:

- In Phase Shift Key or PSK Modulation, the phase difference is used to differentiate between the "1" and "0" bits.
- If the bit is "1", a simple wave is drawn, and if the bit becomes "0", the phase of the wave is shifted by "180 or π".
- PSK Modulation is more complicated than ASK and FSK Modulation, but it is robust too.



ANALOG MODULATION:

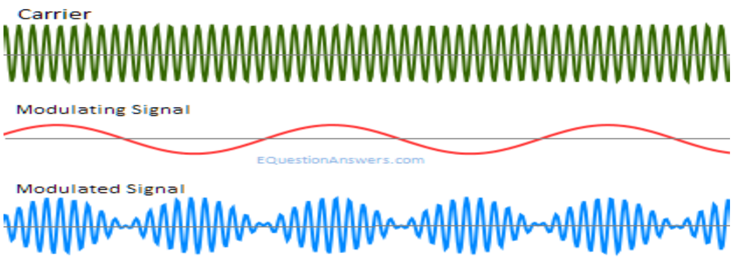
Analog Modulation is a technique which is used in analog data signals transmission into digital signals. An example of Analog Modulation is Broadband Signals.



Analog modulation can further be classified as:

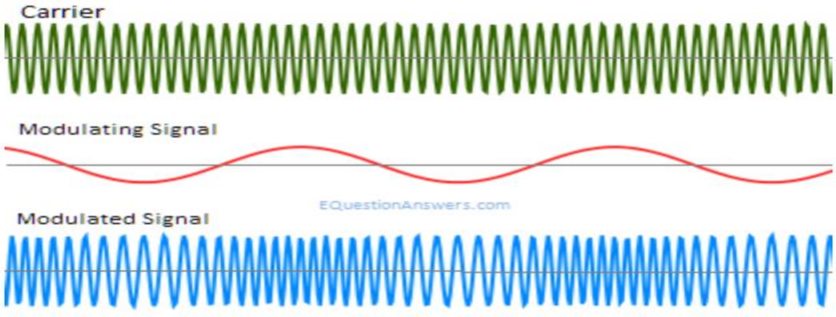
- Amplitude Modulation (AM)
- Frequency Modulation (FM)
- Phase Modulation (PM)

Amplitude Modulation (AM): Amplitude modulation or AM is a modulation technique that is used in electronic communication. It is most commonly used for transmitting messages with a radio carrier wave. It varies the instantaneous amplitude of the carrier signal or waves according to the message signal's instantaneous amplitude.



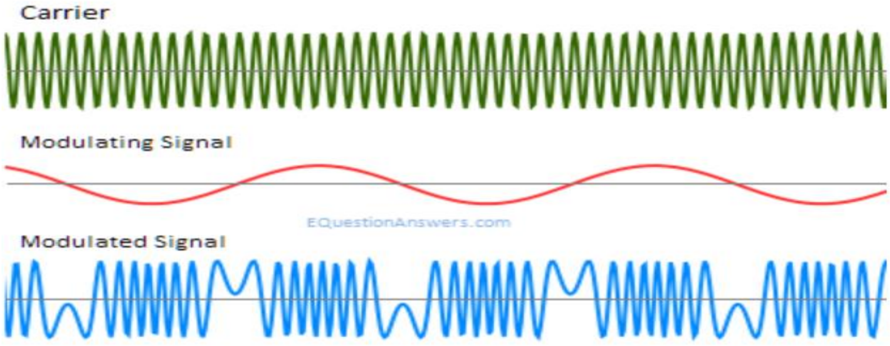
Amplitude Modulation

Frequency Modulation: Frequency Modulation or FM is the process of encoding the information in a carrier wave by varying the instantaneous frequency of the wave. It varies the instantaneous frequency of the carrier signal according to the instantaneous amplitude of the message signal.



Frequency Modulation

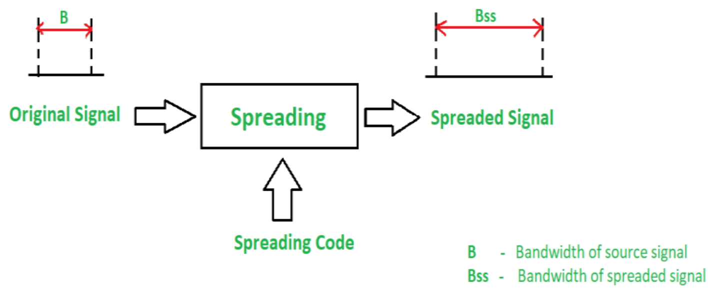
Phase Modulation: Phase modulation or PM is the technique of varying the carrier signal's instantaneous phase according to the instantaneous amplitude of the message signal. It encodes the message signal as changes occurred in the instantaneous phase of a carrier signal.



Phase Modulation

SPREAD SPECTRUM: Spread Spectrum is a technique used in wireless communication systems to spread the bandwidth of the signal over a wider frequency range than is required for the transmission of the data. This is achieved by adding a special code to the transmitted signal, which spreads it out over a wider bandwidth.

The spread spectrum technique provides several benefits, including improved security, higher resistance to interference, and the ability to share the same frequency band with multiple users. In addition, spread spectrum can be used to increase the range of wireless communication systems and improve the accuracy of location tracking.



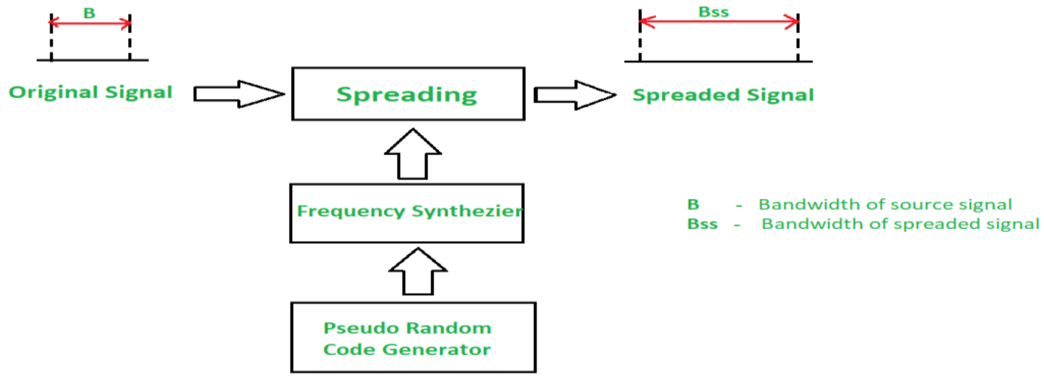
Spread spectrum techniques are commonly used in modern wireless communication systems, including cellular networks, Wi-Fi, Bluetooth, and GPS.

There are two main types of spread spectrum techniques:

- Direct Sequence Spread Spectrum (DSSS)
- Frequency Hopping Spread Spectrum (FHSS)

Frequency Hopping Spread Spectrum (FHSS):

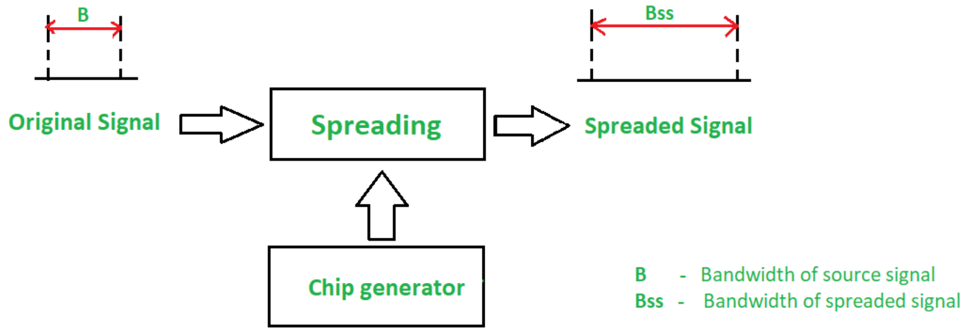
- In Frequency Hopping Spread Spectrum (FHSS), different carrier frequencies are modulated by the source signal i.e., M carrier frequencies are modulated by the signal. At one moment signal modulates one carrier frequency and at the subsequent moments, it modulates other carrier frequencies.



- A pseudorandom code generator generates Pseudo-random Noise of some pattern for each hopping period $\mathbf{T_h}$. The frequency corresponding to the pattern is used for the hopping period and is passed to the frequency synthesizer. The synthesizer generates a carrier signal of that frequency.

Direct Sequence Spread Spectrum (DSSS):

In DSSS, the bandwidth of the original signal is also expanded by a different technique. Here, each data bit is replaced with n bits using a spreading code called **chips,** and the bit rate of the chip is called as **chip-rate**. The chip rate is n times the bit rate of the original signal.



In wireless LAN, the sequence with n = 11 is used. The original data is multiplied by **chips** (spreading code) to get the spread signal. The required bandwidth of the spread signal is 11 times larger than the bandwidth of the original signal.

CELLULAR SYSTEMS:

Early wireless systems had a high-power transmitter, covering the entire service area. This required a very huge amount of power and was not suitable for many practical reasons.

The cellular system replaced a large zone with a number of smaller hexagonal cells with a single BS (base station) covering a fraction of the area. Evolution of such a cellular system is shown in the given figures, with all wireless receivers located in a cell being served by a BS.

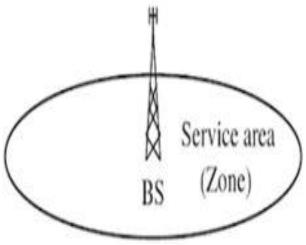


Fig: Early wireless system: large zone

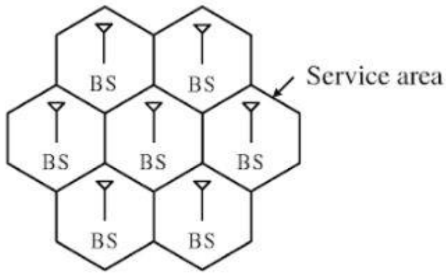


Fig: Cellular system: small zone

Frequency Management and Channel Assignment:

Frequency Management: Frequency management in cellular systems involves dividing the available frequency band into smaller sub-bands or channels, which are then allocated to different cells within the network. This ensures that each cell has its own set of frequencies that do not interfere with adjacent cells.

Channel Assignment: Channel Assignment means to allocate the available channels to the cells in a cellular system. The goal of channel assignment is to maximize the number of users that can be served while minimizing interference between users.

There are four strategies in channel assignment:

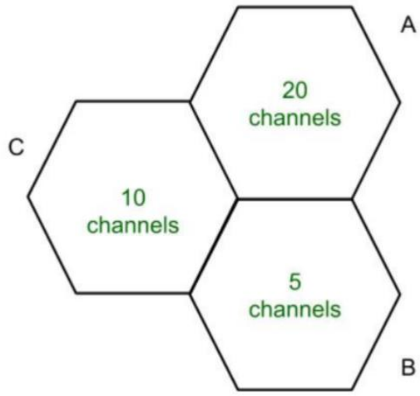
1.Fixed Channel Allocation (FCA)

2.Dynamic Channel Allocation (DCA)

3.Hybrid Channel Allocation (HCA)

4.Channel Borrowing

Fixed Channel Allocation (FCA): Fixed Channel Allocation is a strategy in which fixed number of channels or voice channels are allocated to the cells. Once the channels are allocated to the specific cells then they cannot be changed. In FCA channels are allocated in a manner that maximize Frequency reuse.



In cell A 20 Channels or Voice channels are allocated. If all channels are occupied and user make a call then the call is blocked. Borrowing Channels handles this type of problem. This cell borrow channels from other cells.

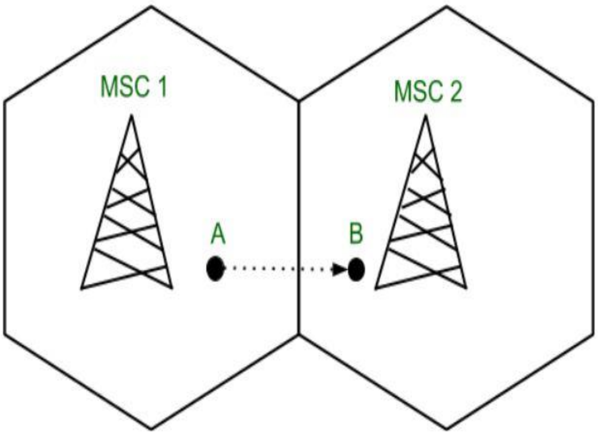
Dynamic Channel Allocation: Dynamic Channel allocation is a strategy in which channels are not permanently allocated to the cells. When a User makes a call request then Base Station (BS) send that request to the Mobile Station Center (MSC) for the allocation of channels or voice channels. This way the likelihood of blocking calls is reduced. As traffic increases more channels are assigned and vice-versa.

Hybrid Channel Allocation: Hybrid Channel Allocation is a combination of both Fixed Channel Allocation (FCA) and Dynamic Channel Allocation (DCA). The total number of channels or voice channels are divided into fixed and dynamic set. When a user makes a call then first fixed set of channels are utilized but if all the fixed sets are busy then dynamic sets are used. The main purpose of HCA is to work efficiently under heavy traffic and to maintain a minimum S/I.

Channel Borrowing: when a cell experiences high traffic demand and all of its channels are occupied, it can borrow channels from neighbouring cells that are not being used at that time. The borrowed channels are assigned to the busy cell and are used to support the additional traffic demand. Once the demand subsides, the borrowed channels are released and returned to their home cell. BCA can be implemented manually or automatically using algorithms or policies but the main disadvantage is that if the borrowed channel is reclaimed by the original cell the call drop may occur.

TYPES OF HAND OFF AND THEIR CHARACTERISTICS

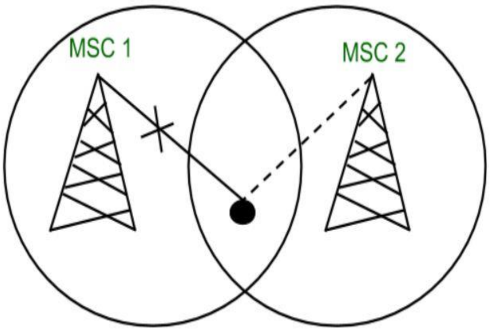
In cellular telecommunications, the terms **handover** or **handoff** refers to the process of transferring ongoing call or data connectivity from one Base Station to other Base Station. When a mobile moves into the different cell while the conversation is in progress then the MSC (Mobile Switching Center) transfer the call to a new channel belonging to the new Base Station.



When a mobile user A moves from one cell to another cell then BSC 1 signal strength loses for the mobile User A and the signal strength of BSC 2 increases and thus ongoing calls or data connectivity for mobile user goes on without interrupting.

Types of Handoff:

1. **Hard Handoff:**
   When there is an actual break in the connectivity while switching from one Base Station to another Base Station. There is no burden on the Base Station and MSC because the switching takes place so quickly that it can hardly be noticed by the users. The connection quality is not that good. Hard Handoff adopted the 'break before make' policy.



2. **Soft Handoff:**
   In Soft Handoff, at least one of the links is kept when radio signals are added or removed to the Base Station. Soft Handoff adopted the 'make before break' policy. Soft Handoff is more costly than Hard Handoff.