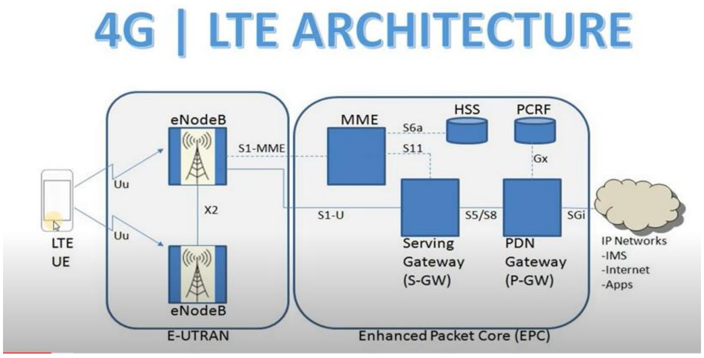
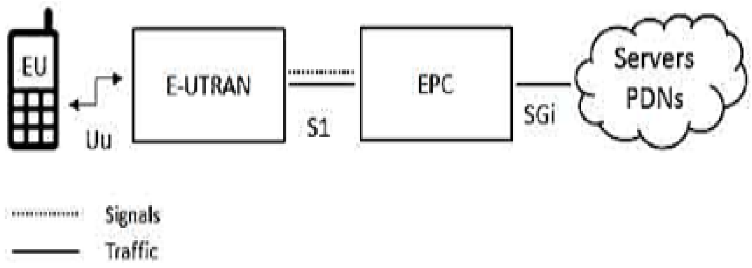
1) ARCHITECTURE OF 4G|LTE ARCHITECTURE





The high-level network architecture of LTE is comprised of following three main components:

- The User Equipment (UE).
- The Evolved UMTS Terrestrial Radio Access Network (E-UTRAN).
- The Evolved Packet Core (EPC).

The evolved packet core (EPC) communicates with packet data networks in the outside world such as the internet, private corporate networks or the IP multimedia subsystem. The interfaces between the different parts of the system are denoted Uu, S1 and SGi .

1. The User Equipment (UE):

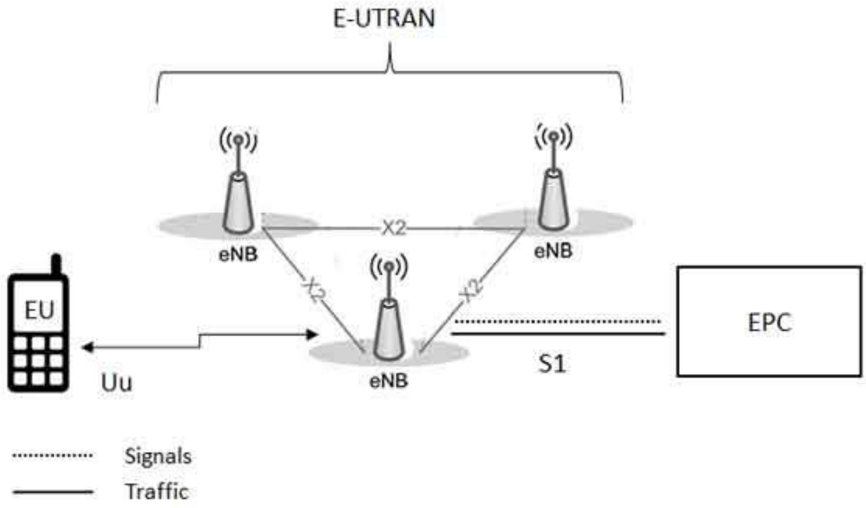
The internal architecture of the user equipment for LTE is identical to the one used by UMTS and GSM which is actually a Mobile Equipment (ME). The mobile equipment comprised of the following important modules:

- **Mobile Termination (MT)**: This handles all the communication functions.
- **Terminal Equipment (TE)**: This terminates the data streams.

- **Universal Integrated Circuit Card (UICC)**: This is also known as the SIM card for LTE equipment's. It runs an application known as the Universal Subscriber Identity Module (USIM).

2. The E-UTRAN (The access network):

The architecture of evolved UMTS Terrestrial Radio Access Network (E-UTRAN) has been illustrated below.



The E-UTRAN handles the radio communications between the mobile and the evolved packet core and just has one component, the evolved base stations, called **eNodeB** or **eNB**. Each eNB is a base station that controls the mobiles in one or more cells. The base station that is communicating with a mobile is known as its serving eNB.

LTE Mobile communicates with just one base station and one cell at a time and there are following two main functions supported by eNB:

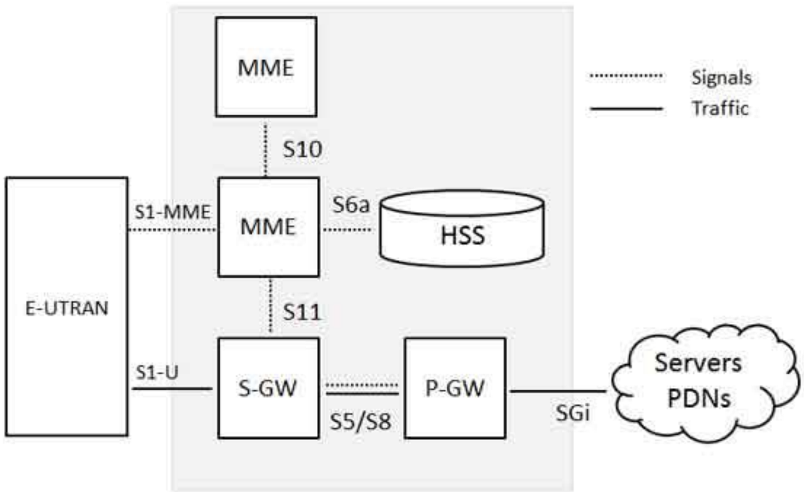
- The eBN sends and receives radio transmissions to all the mobiles using the analogue and digital signal processing functions of the LTE air interface.

- The eNB controls the low-level operation of all its mobiles, by sending them signalling messages such as handover commands.

Each eBN connects with the EPC by means of the S1 interface and it can also be connected to nearby base stations by the X2 interface, which is mainly used for signalling and packet forwarding during handover.

3. The Evolved Packet Core (EPC) (The core network):

The architecture of Evolved Packet Core (EPC) has been illustrated below:



Below is a brief description of each of the components shown in the above architecture:

- The Home Subscriber Server (HSS) component is a central database that contains information about all the network operator's subscribers.
- The packet gateway (P-GW) communicates with the outside world ie. packet data networks PDN, using SGi interface. Each packet data network is identified by an access point name (APN).
- The serving gateway (S-GW) acts as a router, and forwards data between the base station and the PDN gateway.
- The mobility management entity (MME) controls the high-level operation of the mobile by means of signalling messages and Home Subscriber Server (HSS).
- The interface between the serving and PDN gateways is known as S5/S8. This has two slightly different implementations, namely S5 if the two devices are in the same network, and S8 if they are in different networks.

2) EXPLAIN GSM

The full form of GSM is the **Global System for Mobile Communication.** GSM established by the ETSI (European Telecommunication Standards Institute) to define protocols for 2 G networks. It operated as a substitute for the 1 G cellular networks.

GSM is an open and digital cellular technology used for mobile communication. It uses 4 different frequency bands of 850 MHz, 900 MHz, 1800 MHz and 1900 MHz. It uses the combination of FDMA and TDMA.

Features of GSM are:

1. Supports international roaming
2. Clear voice clarity
3. Ability to support multiple handheld devices.
4. Spectral / frequency efficiency
5. Low powered handheld devices.
6. Case of accessing network
7. International ISDN compatibility.

Structure of GSM:

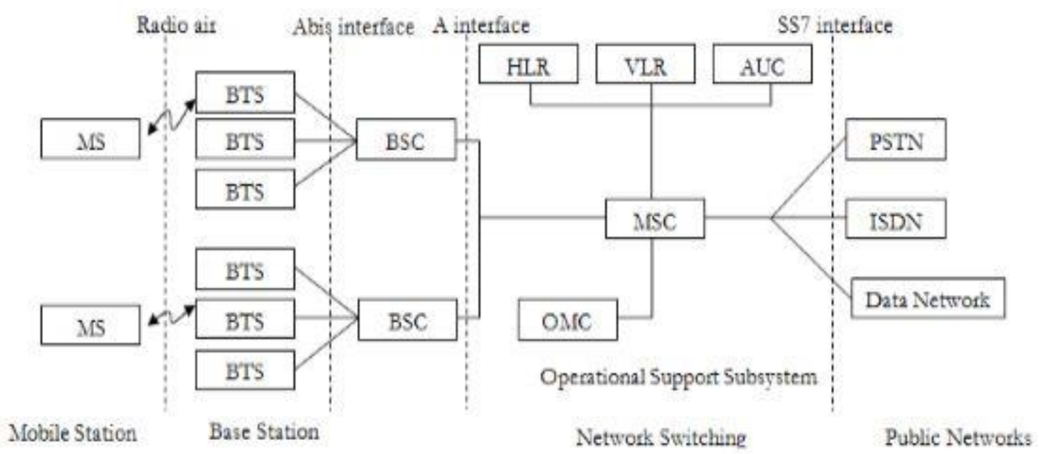


Fig: GSM Architecture

GSM standards divide networks into four distinct parts:

1. Mobile Station

2. Base Station Subsystem (BSS)

3. Network and Switching Subsystem (NSS)

4. Operations Support System (OSS)

1. Mobile Station (MS): Mobile Station is made up of two entities:

(a) Mobile equipment (ME):

- It is a portable, vehicle mounted, hand held device.
- It is uniquely identified by an IMEI number.
- It is used for voice and data transmission. It also monitors power and signal quality of surrounding cells foe optimum handover. 160 characters long SMS can also be sent using Mobile Equipment.

(b) Subscriber Identity module (SIM):

- It is a smart card that contains the International Mobile Subscriber Identity (IMSI) number.
- It allows users to send and receive calls and receive other subscriber services. - It is protected by password or PIN.
- It contains encoded network identification details. it has key information to activate the phone.
- It can be moved from one mobile to another.

2. Base Station Subsystem (BSS): It is also known as radio subsystem, provides and manages radio transmission paths between the mobile station and the Mobile Switching Centre (MSC). BSS also manages interface between the mobile station and all other subsystems of GSM. It consists of two parts.

(a) Base Transceiver Station (BTS):

- It encodes, encrypts, multiplexes, modulates and feeds the RF signal to the antenna.

- It consists of transceiver units.
- It communicates with mobile stations via radio air interface and also communicates with BSC via Abis interface.

(b) Base Station Controller (BSC):

- It manages radio resources for BTS. It assigns frequency and time slots for all mobile stations in its area.
- It handles call set up, transcoding and adaptation functionality handover for each MS radio power control.
- It communicates with MSC via A interface and also with BTS.

3. Network Switching Subsystem (NSS): it manages the switching functions of the system and allows MSCs to communicate with other networks such as PSTN and ISDN. It consists of:

(a) Mobile switching Centre:

- It is a heart of the network. It manages communication between GSM and other networks.
- It manages call set up function, routing and basic switching.
- It performs mobility management including registration, location updating and inter BSS and inter MSC call handoff.
- It provides billing information.
- MSC does gateway function while its customers roam to other network by using HLR/VLR.

(b) Home Location Registers (HLR): - It is a permanent database about mobile subscriber in a large service area. - Its database contains IMSI, IMSISDN, prepaid/post-paid, roaming restrictions, supplementary services.

(c) Visitor Location Registers (VLR): - It is a temporary database which updates whenever new MS enters its area by HLR database. - It controls mobiles roaming in its area. It reduces number of queries to HLR. - Its database contains IMSI, TMSI, IMSISDN, MSRN, location, area authentication key.

(d) Authentication Centre: - It provides protection against intruders in air interface. - It maintains authentication keys and algorithms and provides security triplets (RAND, SRES, Ki).

(e) Equipment Identity Registry (EIR):

- It is a database that is used to track handset using the IMEI number.
- It is made up of three sub classes- the white list, the black list and the gray list.

4. Operational Support Subsystem (OSS): It supports the operation and maintenance of GSM and allows system engineers to monitor, diagnose and troubleshoot all aspects of GSM system. It supports one or more Operation Maintenance Centres (OMC) which are used to monitor the performance of each MS, Bs, BSC and MSC within a GSM system. It has three main functions:

- To maintain all telecommunication hardware and network operations with a particular market.
- To manage all charging and billing procedures
- To manage all mobile equipment in the system.

Interfaces used for GSM :
1)UM Interface –Used to communicate between BTS with MS
2)Abis Interface— Used to communicate BSC TO BTS
3)A Interface-- Used to communicate BSC and MSC
4) Singling protocol (SS 7)- Used to communicate MSC with other network .

3) EXPLAIN DAB & DVB

DAB-Digital Audio Broadcasting:

It is a digital radio technology which broadcasts radio frequency waves to provide digital audio services to the users having DAB receivers. The service is available in more than 30 countries including Europe and Asia Pacific. It is developed for terrestrial mobile reception and hence user can also obtain service in moving cars.

Following are the advantages or features of **DAB** system:

- Uses four frequency bands or modes for its operation worldwide. Mode-I uses Band-III having 174 to 240 MHz, Mode-II and Mode-IV use L Band (1452 to 1492 MHz) and Mode-III uses less than 3 GHz frequencies.

- Most of the DAB stations use 128 Kbps which provides better SNR compare to FM radio.

- It uses OFDM along with advanced modulation schemes such as DQPSK to achieve high data rate and to provide simultaneous transmission of multiple programs. It also helps in interference mitigation.

- It provides more than 9 to 10 services on a single frequency simultaneously as mentioned.

- In addition to music other services such as data, weather maps, traffic information, mobile TV, stock information etc. are also available.

DVB-Digital Video Broadcasting:

It is used as open standard for digital TV broadcast. There are various standards developed to provide the digital TV broadcasting service viz. DVB-T, DVB-S, DVB-C and DVB-H.

Following are the advantages or features of **DVB** system:

• It uses OFDM along with complex modulation schemes such as QPSK, 16-QAM, 64-QAM etc.

• It uses FEC techniques (e.g. LDPC, BCH) to provide better reception quality with good error correction capabilities at the DVB receivers.

• It uses different interleaving techniques (e.g. bit, time, frequency) in order to take care of interference/fading.

4) EXPLAIN ALL TYPES OF SATELLITES

Based on the location of the orbit, satellites can be divided into four categories as follows:

1. **GEO**:

- GEO stands for Geostationary Earth Orbit.
- The communication satellites in this orbit operates at a distance of about 36000 km above the earth's surface and their orbital time period is about 24 hours.
- Geostationary Orbit Satellites are used for radio broadcasting.
- To ensure constant communication, the satellite must move at the same speed as the earth, so that it seems to remain fixed above a certain spot. So such satellites are called geostationary.
- One geostationary satellite cannot cover the whole earth. One satellite in orbit has line-of-sight contact with vast number of stations, but the curvature of the Earth still keeps much of the planet out of sight. It takes minimum of three satellites equidistant from each other in geostationary Earth Orbit(GEO) to provide full global transmission.

2. **MEO**:

- MEO stands for Medium Earth Orbit.
- The communication satellites in this orbit operates at a distance of about 5000 to 12000 km above the earth's surface.
- These satellites are positioned between the two Van Allen belts. A satellite at this orbit takes approximately 6 to 8 hours to circle the Earth.
- One Example of a MEO satellite system is Global Positioning System(GPS), constructed and operated by US Department of Defense, orbiting at an altitude about 18,000 km above the earth.
- The system consists of 24 satellites and is used for land, sea, and air navigation to provide time and locations for vehicle and ships.
- The orbits and the locations of the satellites in each orbit are designed in such a way that, at any time, four satellites are visible from any point on the Earth. A GPS receiver has a almanac that tells the current position of each satellite.
- GPS is based on a principle called Trilateration(also sometimes called Triangulation). Principle states that "On a plane, if we know our distance from three points, we know exactly where we are."

3. **LEO:**

- LEO stands for Low Earth Orbit.
- The communication satellites in this orbit operates at a distance of about 500 to 1200 km above the earth's surface and their orbital time period generally ranges between 95 to 120 minutes. The Satellite has a speed of 20,000 to 25,000 km/h. Low Orbit Satellites makes global radio coverage possible.
- An LEO system is made of a constellation of satellites that work together as a network, each satellite acts as a switch. Satellites that are close to each other are connected through inter-satellite links

(ISLs). A mobile system communicates with the satellite through a user mobile link(UML). A satellite can also communicate with an Earth station(gateway) through a gateway link(GWL).

- LEO satellites can be divided into three categories: Little LEOs, Big LEOs, and Broad Band LEOs.
- Little LEOs operate under 1GHz. They are mostly used for low-data-rate messaging.
- Big LEOs operate between 1 and 3GHz. Globalstar and Iridium system are examples of Big LEOs.
- Broad Band LEOs provide communication similar to fiber-optic networks. The first broadband LEO system was Teledesic.

4. HEO (High Earth Orbit):

- The High Earth orbit satellite is the only non-circular orbit of the four types.
- HEO satellite operates with an elliptical orbit, with a maximum altitude (apogee) similar to GEO, and a minimum altitude (perigee) similar to the LEO.
- The HEO satellites used for the special applications where coverage of high latitude locations is required.

5) WHAT IS MULTIPLEXING. EXPLAIN

Multiplexing is a method that can be used to combine multiple analog or digital signals into one signal over a shared medium. The main aim of using this method is to share a scarce resource.

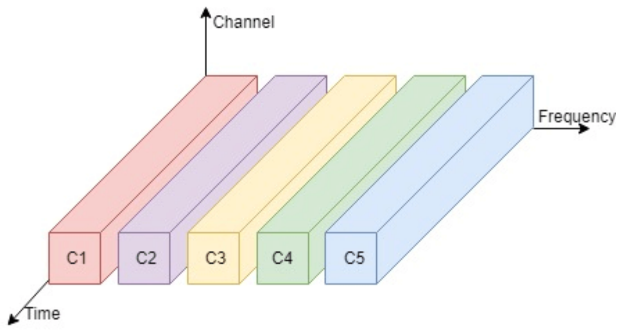
Example: You can see a real-life example of Multiplexing in the telecommunication field where several telephone calls may be carried using one wire. Multiplexing is also called as **muxing**.

Multiplexing can be classified into the following four types:

1. Frequency Division Multiplexing (FDM):

As the name specifies, in Frequency Division Multiplexing, the frequency dimension spectrum is split into smaller frequency bands. It combines several smaller distinct frequency ranges signals into one medium and sends them over a single medium. In FDM, the signals are electrical signals.

In FDM, several frequency bands can work simultaneously without any time constraint.



Advantages of FDM

- The concept of frequency division multiplexing (FDM) applies to both analog signals and digital signals.
- It facilitates you to send multiple signals simultaneously within a single connection.

Disadvantages of FDM

- It is less flexible.
- In FDM, the bandwidth wastage may be high.

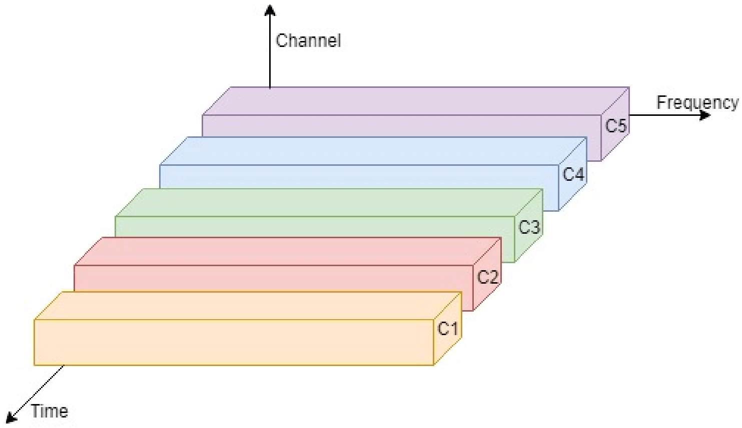
Usage

It is used in Radio and television broadcasting stations, Cable TV etc.

2. Time Division Multiplexing (TDM):

The Time Division Multiplexing or (TDM) is a digital or analog technology (in rare cases) that uses time, instead of space or frequency, to separate the different data streams. It is used for a specific amount of time in which the whole spectrum is used.

The Time frames of the same intervals are divided so that you can access the entire frequency spectrum at that time frame.



Advantages of TDM

- It facilitates a single user at a time.
- It is less complicated and has a more flexible architecture.

Disadvantages of TDM

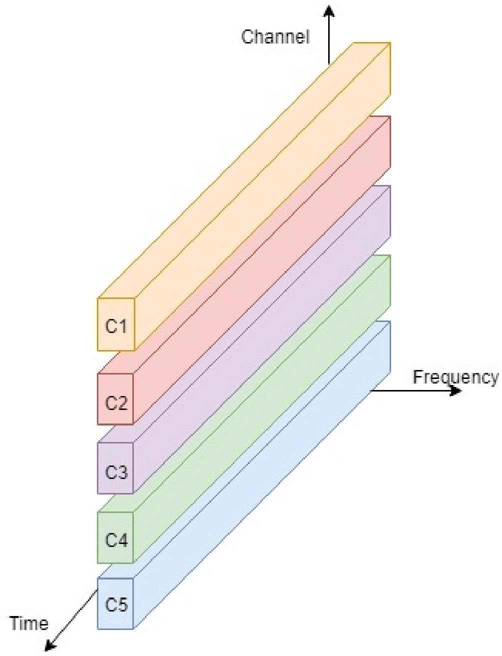
- It isn't easy to implement.

Usage

- It is mainly used in telephonic services.

3. <u>Code Division Multiplexing (CDM):</u>

The Code Division Multiplexing or (CDM) allots a unique code to every channel so that each of these channels can use the same spectrum simultaneously at the same time.



Advantages of CDM

- It is highly efficient.
- It faces fewer Inferences.

Disadvantages of CDM

- The data transmission rate is low.
- It is complex.

Usage

- It is mainly used in Cell Phone Spectrum Technology (2G, 3G etc.).

4. <u>Space Division Multiplexing (SDM):</u>

The Space Division Multiplexing or (SDM) is called a combination of Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM).

It passes messages or data-parallel with the use of specific frequency at a specific. It means a particular channel will be used against a specific frequency band for some amount of time.

Advantages of SDM

- In SDM, the data transmission rate is high.
- It uses Time and Frequency bands at its maximum potential.

Disadvantages of SDM

- An inference may occur.
- It faces high inference losses.

Usage

- It is used in GSM (Global Service for Mobile) Technology.

6) EXPLAIN MODULATION TECHNIQUES

"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 also called **signal modulation**.

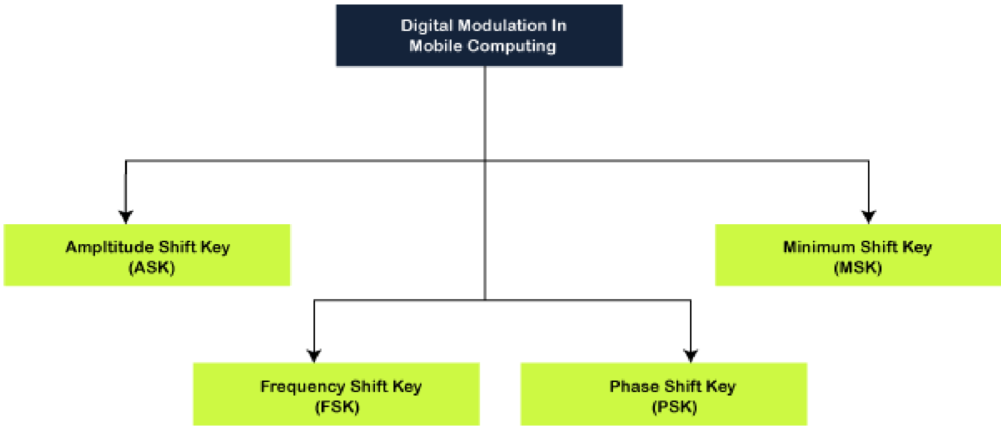
Types of Modulation: Primarily Modulation can be classified into two types:

- Digital Modulation
- Analog Modulation

1. Digital Modulation:

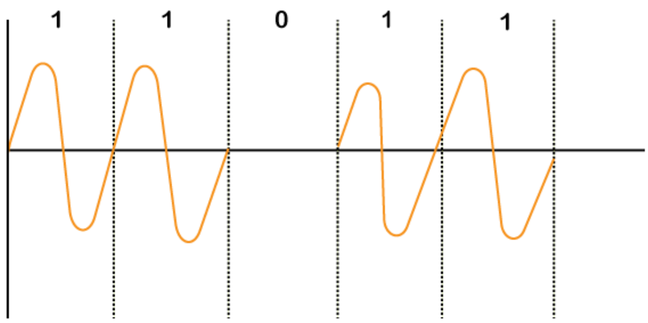
Digital Modulation is a technique in which digital signals/data can be converted into analog signals. For example, Base band signals.

Digital Modulation can further be classified into four types:



(a) Amplitude Shift Key (ASK) Modulation

- As the name suggests, in Amplitude Shift Key or ASK Modulation, the amplitude is represented by "1," and if the amplitude does not exist, it is represented by "0".
- Using Amplitude Shift Key Modulation is very simple, and it requires a very low bandwidth.
- Amplitude Shift Key Modulation is vulnerable to inference or deduction.

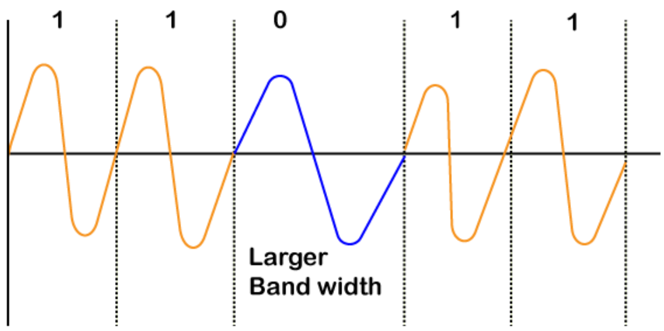


(b) Minimum Shift Key (MSK) Modulation

- The Minimum Shift Key or MSK Modulation is the most effective technique of Modulation and can be implemented for almost every stream of bits. It is easy and effective than Amplitude Shift Key, Frequency Shift Key and Phase Shift Key.
- MSK is mostly used because of its ability and flexibility to handle "One(1)" and "Zero(0)" transition of binary bits.

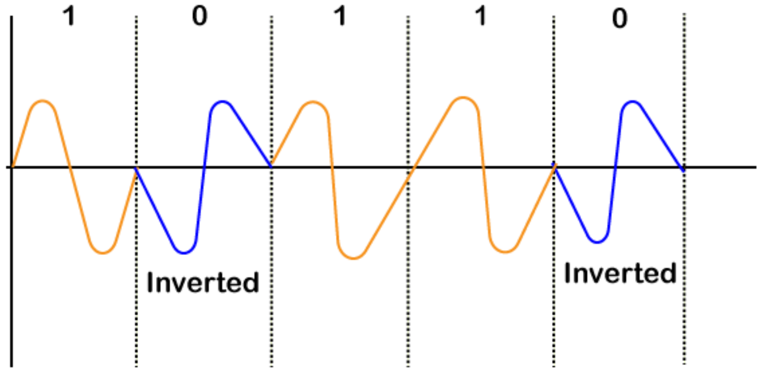
(c) Frequency Shift Key (FSK) Modulation

- 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 is also a simple modulation technique but uses different frequencies for different bits; bandwidth requirement becomes high.



(d) 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.



2. 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.

There are three properties of a carrier signal in analog modulation i.e., amplitude, frequency and phase. So, the analog modulation can further be classified as:

(a) Amplitude Modulation

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.

- Amplitude Modulation is easy to implement. It is the simplest type of modulation.

- AM radio broadcast is an example of Amplitude Modulation.

(b) 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.

- Frequency Modulation is widely used for FM radio broadcasting.

- The main advantage of using frequency modulation in radio transmission is that it has a larger signal-to-noise ratio.

(c) Phase Modulation

It encodes the message signal as changes occurred in the instantaneous phase of a carrier signal.

- Phase Modulation is mainly used for transmitting radio waves.
- Phase Modulation is mainly used in Wi-Fi, GSM and satellite television.

7) EXPLAIN CELLULAR NETWORKS

A **Cellular network or Mobile network** is a radio network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station.

In a cellular network, each cell uses a different set of frequencies from neighboring cells, to avoid interference and provide guaranteed bandwidth within each cell.

Features of Cellular Networks:

Wireless Cellular Networks solves the problem of spectral congestion and increases user capacity. The features of cellular networks are as follows −

- Offer very high capacity in a limited spectrum.
- Reuse of radio channel in different cells.
- Enable a fixed number of channels to serve an arbitrarily large number of users by reusing the channel throughout the coverage region.
- Communication is always between mobile and base station (not directly between mobiles).
- Each cellular base station is allocated a group of radio channels within a small geographic area called a cell.
- Neighboring cells are assigned different channel groups.
- By limiting the coverage area to within the boundary of the cell, the channel groups may be reused to cover different cells.
- Keep interference levels within tolerable limits.
- Frequency reuse or frequency planning.
- Organization of Wireless Cellular Network.

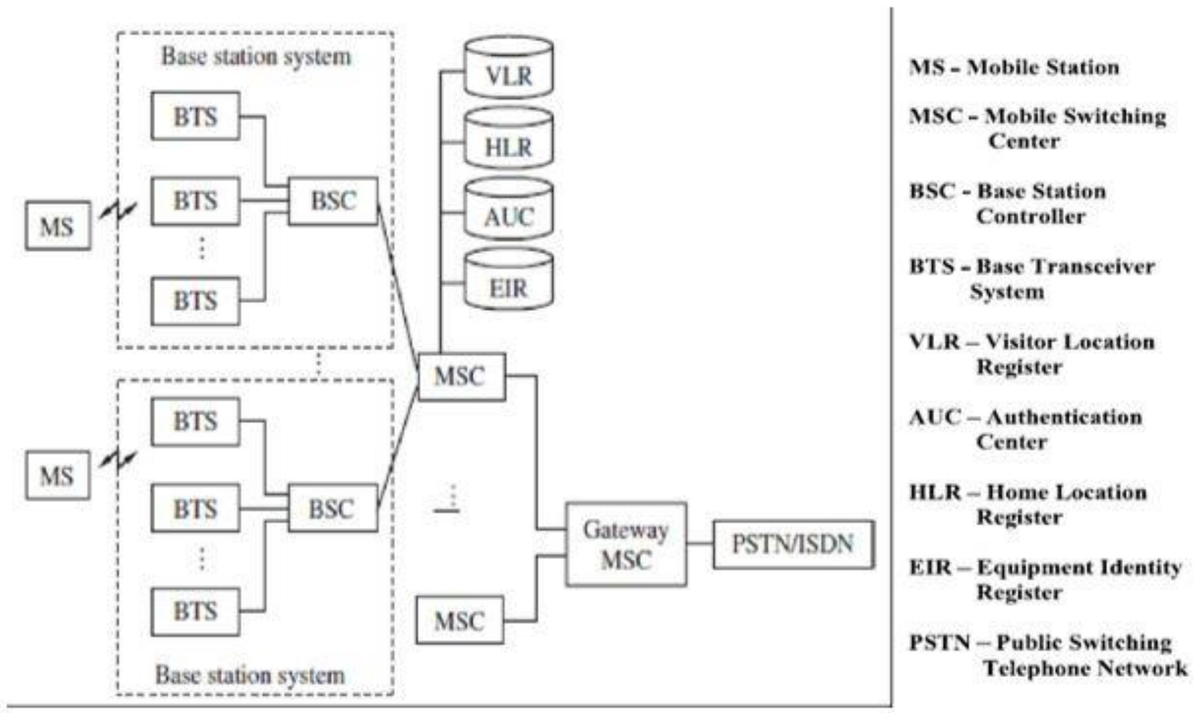
BASIC STRUCTURE OF CELLULAR NETWORK:

In a cellular structure, a MS (mobile station) needs to communicate with the BS of the cell where the MS is currently located and the BS acts as a gateway to the rest of the world.

Several base stations are connected through hard-wires and are controlled by a BS controller (BSC), which in turn is connected to a mobile switching center (MSC).

Several mobile switching centers are interconnected to a PSTN (public switched telephone network) and the ATM (asynchronous transfer mode) backbone.

A cellular system requires a fairly complex infrastructure. A generic block diagram in shown in the figure:



A BS consists of a base transceiver system (BTS) and a BSC. Both tower and antenna are a part of the BTS, while all associated electronics are contained in the BSC.

The HLR (home location register) and VLR (visitor location register) are two sets of pointers that support mobility and enable the use of the same telephone numbers worldwide.

The AUC (authentication center) unit provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each cell.

The EIR (equipment identity register) is a database that information about identity of mobile equipment. Both AUC and EIR can be implemented as individual stand-alone units or as a combined AUC/EIR unit.

The HLR is located at the MSC where MS is initially registered and is the initial home location for billing and access information.

In simple words, any incoming call, based on the calling number, is directed to the HLR of the home MS where the MS is registered. The HLR then points to the VLR of the MSC where the MS is currently located.

EXTRA :

1) CHALLENGES OF MOBILE COMPUTING/COMMUNICATION:

Mobile Computing is defined as a computing environment which is mobile and moves along with the user. Some of the major technical challenges faced by mobile computing are:

1. Mobility:

It is the most important aspect of mobile computing, but it has to face the certain challenges which are :

- Auto configuration of the system, as the environment of the system is developing continuously
- Location management is also a big objection in mobility.

2. Wireless Medium:

The transmission medium in mobile computing is wireless, therefore the following points are considered:

- Various interferences occurs in the mobile computing by the different elements in the environment.
- Accuracy and quantity of bandwidth should be sufficient.
- Network cost is feasible.

3. Portability:

This means that the communication device moves, for eg. mobile phones. The following mobile constraints are to be considered as the devices are also mobile:

- Minimum number of resources are used.
- Security is very less, as security risks include the processing of fake transactions, unauthorized access of data and program files, and the physical theft or damage of the device.
- Restrictions of the battery.

2) LIMITATIONS OF MOBILE COMPUTING