Unit 1

❖ Introduction:

Different frequency range for communication system as follows :

SL.NO	Frequency Band	Range	Wave length(λ)=c/f(Mtrs)
1	VLF	3 kHZ to 30 kHZ	100K to 10K
2	L.F.	30 kHZ to 300 kHZ	10K to 1 K
3	MF	300 k to 3 MHz	1 K to 100
4	HF	3 MHz to 30 MHz	100 to10
5	VHF	30 MHz to 300 MHz	10 to 1
6	UHF	300 MHz to 3 GHz	1 to 0.1
7	SHF	3 GHz to 30 GHz	0.1 to 0.01
8	EHF	30 GHz to 300 GHz	0.01 to 0.001

Table - 1 Frequency allocation for different type of communication system

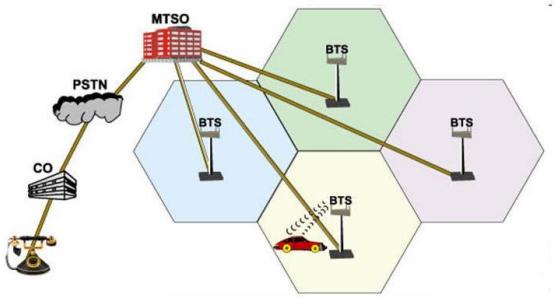
❖ Cellular concept:

1) The aim of the early mobile radio system was to provide coverage to a large area with the help of a single high power transmitter having an antenna mounted on a tall towe
2) This approach had the following disadvantages:
   i. Frequency reuse was not possible.
   ii. Proper spectrum allocation in proportion with increasing demand was not possible.
3) Hence it became necessary to restructure to radio telephone system so as to achieve the following objectives:
   i. High capacity.
   ii. To utilize the available radio spectrum effectively.
   iii. Coverage of large areas.
4) The major breakthrough in this field was the introduction of the cellular concept.

❖ Advantages of cellular concept:

The cellular concept offered the following advantages:
1. Improved user capacity.
2. No spectral congestion.
3. No major technological changes.
4. Efficient utilization of the available spectrum.

In the cellular systems, a single high power transmitter is (large cell) is replaced by many low power transmitter (small cells) as shown in Fig. ⟶



❖ Basic Concept:

1) Cellular phone is wireless communication just like cordless phone.

2) In cell phone distance is not restricted to within home but one can travel in the city or even outside the city without interruption in communication.

3) The demand for cellular mobile phone is increasing at alarming level and is likely that wired communication will be replaced by wireless technology.

4) In the cellular system city is divided into small areas called 'cells'. Each cell is around 10 square kilometre (depends upon power of base station).

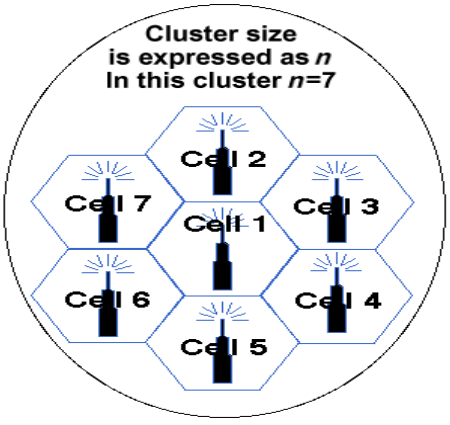
MTSO or MSC:

1) The cells are normally thought of hexagons. Because cell phones and base stations use low power transmitters, the same frequencies can be reused in non-adjacent cell.

2) Each cell is (The cellular network is as shown in Fig. A.2.1) linked to central location called the Mobile Telephone Switching Office (MTSO).
3) It is also called as Mobile Switching Center (MSC).
4) MTSO coordinates all mobile calls between an area which consists of several cell sites and the central office. Time and billing information for each mobile unit is accounted for by MTSO.
5) At the cell site base station is provided to transmit, receive, and switch calls to and from any mobile unit within the cell to the MTSO.
6) A cell covers only few square kilometre area, thus reducing the power requirement necessary communicate with cellular telephones.

Cell:

1) The basic geographic unit of a cellular communication system is called as a cell.
2) Its shape is hexagonal as shown in Fig. Cells have the base stations transmitting over small geographic areas.
3) The size of a cell is not fixed. Practically the shape of the cell may not be a perfect hexagon.
4) The hexagonal shape has been adopted universally because it allows easy and manageable analysis of a cellular system.



Cluster:

1) A group of cells is called as a cluster.
2) Fig. shows the cluster of seven cells or a seven cell cluster. (n = 7)
3) The cluster size (n) is not fixed. It depends on the requirements of a particular area.

❖ Advantages of Cellular Concept:

1. Only a fixed number of channels (frequency slots) are required to be used. This is because the same frequencies can be used for multiple cells due to the principle of frequency re-use.
2. Large area can be covered.
3. Low power transmitters can be used as the cell area is small.

4. Every piece of subscriber equipment (e.g. mobile handset) within a country or continent can be manufactured with the same set of channels so any mobile can be used anywhere.

❖ Mobile Wireless Systems:

We are familiar with a large number of mobile radio systems such as:

1. Cordless telephone
2. Pagers
3. Walky-Talky
4. Cellular phones

1) Each one of them are called as the mobile radio system but they are different as far as their cost, complexity, performance and type of service provided are concerned.
2) The term **mobile** is used to indicate any radio terminal that can move during the operation at a rapid speed.
3) The term **portable** is used for a radio terminal which can be handheld and used by a person who is walking i.e not moving too fast.
4) **Subscriber** is the term used to define a mobile or portable user and the communication device of each subscriber is called as subscriber unit.
5) **Users or mobiles** are the terms used for describing a group of users in a wireless system.

❖ Important Definitions:

Following are some of the important definitions of terms used in wireless communication system.

1. Base station :

It is defined as a fixed (non-moving) station in a mobile radio system, which communicates with the mobile stations as shown in Fig.
Base stations are located at the center or on the edge of a region being covered. It consists of transmitter antenna, receiver antenna and radio channels mounted on a tower.

2. Control channel:

It is defined as the radio channel used for transmitting the control signals such as call set up, call request, call initiation as well as the control information.

3. Forward channel:

It is defined as the radio channel used for transmitting the information from the base station to the mobile i.e. in the forward direction.

4. Reverse channel:

It is defined as the radio channel used for transmitting the information from a mobile to base station i.e. in the reverse direction.

5. Mobile station :

It is defined as a station in the cellular radio service which is used when in motion at an unspecified location.
Mobile stations can be portable hand held personal units or they can be the ones installed in vehicles.

6. Hand-off:

It is the process of transferring the connection with a mobile station from one base station to the other when the mobile station moves from the service area of one base station into that of the other.

7. Mobile switching center (MSC or MTSO):

It is defined as the center which is set up for coordinating the routing of calls. An MSC is also called as MTSO Le. mobile telephone switching office.

8. Transceiver :

It is a unit containing transmitter as well as receiver. It can simultaneously transmit as well as receive.

9. Half duplex system:

These systems are bidirectional, i.e. they can transmit as well as receive but not simultaneously. At a time these systems can either transmit or receive, for example a transreceiver or walky talky set.

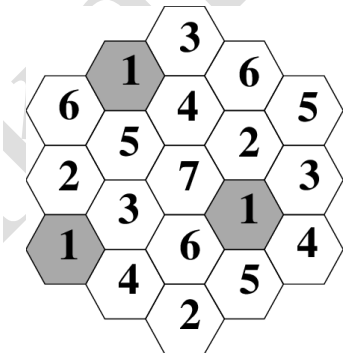
The direction of communication will keep changing itself. The radio communications such as those used in military, fire fighting, citizen band (CB) and amateur radio are half duplex system.

10. Full duplex systems:

These are truly bidirectional systems as they allow the communication to take place in both the directions simultaneously.

These systems can transmit as well as receive simultaneously, for example the telephone systems.

❖ Frequency Reuse



1) In frequency reuse concept the radio channels use the same frequency to cover different areas that are physically separate from each other.

2) In frequency reuse it is necessary to see that the co channel interference is not objectionable.

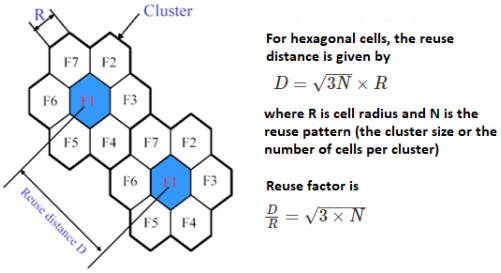
3) Frequency reuse is an important concept because in this a single transmitter of higher power need not be used to cover the entire area.

4) Instead many transmitters of small output power operating at the same frequency can be used.

5) This technique also reduces the minimum height of the transmitting antenna, because now each antenna has to cover a small area.

6) Frequency reuse is a very important concept of the cellular mobile radio system.

7) The users located in different geographical areas i.e. different cells can use the same frequency simultaneously.



8) The advantage of frequency reuse is that it drastically increases the spectrum efficiency but the disadvantage is that if the system is not designed properly then co-channel interference may take place.

❖ Advantages of frequency reuse:

1. A single transmitter of high power need not be used to cover the entire area.

2. Many transmitters of small power working at the same frequency can be used.

3. This technique reduces the minimum height of the antenna.

4. The users located in different geographical areas i.e. different cells can simultaneously. use the same frequency

5. It drastically increases the spectrum efficiency.

❖ Cell Splitting:

Definition:

1) Cell splitting is the technique of dividing a larger cell into smaller cells to increase capacity in congested areas.
2) Separate antennas are placed in smaller cells which transmit low power compared to larger cells.

Concept:

In order to improve the spectrum efficiency of a cellular mobile systems, we can take the following two steps:

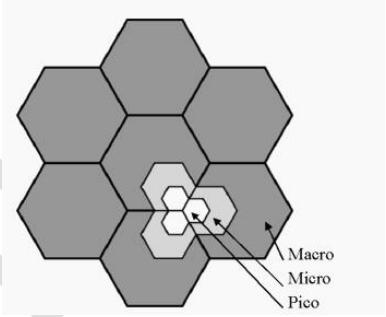
1 Implement some frequency reuse technique.

2. Use the cell splitting technique.

Every cell is supposed to handle a particular value of maximum traffic.

But sometimes the demand (traffic) is higher than this maximum permissible traffic which can be handled by a cell.

Under such circumstances, a technique called cell splitting is used for handling the increased traffic within that cell.



In cell splitting, the cell boundaries are changed in such a way that the local area which was earlier considered as one single cell will now contain a number of smaller calls.

These new cells which are smaller than the original cells are called microcells.

Thus in cell splitting the original cell is split into smaller cells.

❖ Cell Sectoring :

Definition :

1) Sectoring is another method of increasing the number of channels per unit area. But the technique is different from that used for cell splitting.
2) Sectoring is a technique in which an omni directional antenna at the base station is replaced by several directional antennas.
3) In sectoring, the cell radius R is kept constant and the D/R ratio is decreased.

Concept:

1) The sectoring technique is used for increasing the signal to interference ratio (SIR) so as to reduce the cluster size N.
2) In the sectoring approach, the SIR improves due to the use of directional antennas and the system capacity increases as the number of cells are reduced in a cluster and the frequency reuse is increased.
3) However all this can be achieved only if we reduce the interference by keeping the transmitter unchanged.
4) The co-channel interference is reduced by replacing the omni-directional antenna at the base station by several directional antennas.
5) Each directional antenna is allowed to radiate within a specific sector, so that the transmitters in adjacent cells will not interfere with each other.
6) The amount of reduction in the co-channel interference depends on the amount of sectoring.

Types of sectoring :

There are two types of sectoring as shown in Fig. 120° sectoring and 60^0 sectoring.

In the 120° sectoring, a cell is divided into three sectors, with each sector occupying 120° whereas in 60° sectoring a cell is split into six sectors with each sector occupying 60°.

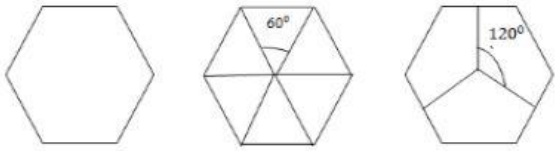


Fig: omni-directional 60^0 sectoring 120^0 sectoring

While carrying out the sectoring, the channels used in a cell are divided into sectored groups (3 or 6) and used only within a particular sector (1, 2, 3 or 1, 2, ..., 6) as shown in Fig.

Advantages:
1 It improves the signal to interference ratio (SIR).

2. It increases the system capacity.

3. It reduces the interference.

4. It reduces the cluster size and provides freedom to assign channels.

Disadvantages :
1. It increases the number of directional antennas at each base station.

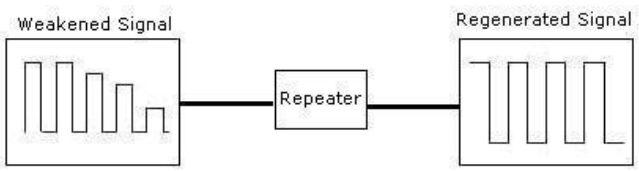
2. The coverage area is reduced which results in increase in number of handoffs.

3. There is a reduction in trunk traffic

❖ Repeaters for Range Extension :

Definition:

1) A repeater is a connecting device. All transmission media weaken the electromagnetic waves that travel through them.
2) Attenuation of signals limits the distance any medium can carry data. Devices that amplify signals to ensure data transmission are called repeaters.
3) Function of a Repeater:
4) A repeater receives a signal and before it gets attenuated or corrupted, regenerates the original signal. Thus we can use a repeater to extend the range of communication.



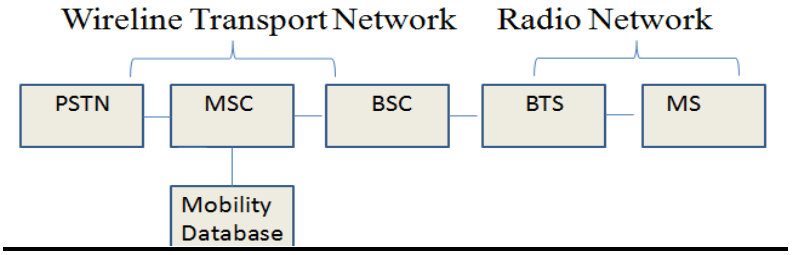
5) Repeater is not an amplifier because amplifiers simply amplify the entire incoming signal along with noise.
6) Signal regenerating repeaters create an exact - duplicate of incoming data by identifying it amidst the noise, reconstructing it and retransmitting only the desired information.
7) The original signal is duplicated, boosted to its original strength and sent as shown in Fig.

❖ What is Personal Communication?

1) A PCS provides people with wireless access to information service e.g. Cordless, cellular, mobile data networks etc.
2) Mobility* is the heart of PCS (the ability to move or be moved freely and easily.)
3) Personal Communication Services(PCS) refers to wide variety of a wireless access and personal mobility services provided through a small terminal, with the goal of enabling the communication at any time, at any place, and in any form.
4) PCS provides the user with an all-in-one wireless phone, paging, messaging, and data service.

❖ PCS Architecture

- Basic Architecture Consist of Two Parts:



- **Radio Network**

1. PCS use Mobile Station (MS) to communicate with the Base Station (BS) in a PCS Network.
2. n a PCS network, PCS users carry MSs (Mobile Stations) to communicate with the BSC (base station)
3. MS can be a handset, subscriber unit or mobile phone
4. A cell is the radio coverage of a base station Through the dedicated microwave links or land links, the base station will reach the wireline transport network.
5. In GSM network, through base station, BSC (Base Station Controller) controls every cell that is connected to mobile station.

BSCs are connected to MSC with the help of landlines

Wireline transport network:

1) In a PCS network MSC (Mobile Station Controller) acts as a special switch which is connected to the base station.
2) The MSC is connected to the PSTN to provide the services between the PCS users and wireline users. MSCs are connected to the mobility database to keep the track of location of mobile station.
3) The mobility databases are HLR (Home Location Register) and VLR (Visitor Location Register).
4) HLR includes the authentication information such as IMSI (International Mobile Subscriber Identity), identification information such as address, name of the subscriber, operator selection, billing information, denial of service to a subscribe etc.
5) VLR includes data about the location area of subscriber in case of power off status of the handset or in roaming.
6) PCS architecture divides into to 3 subsystem i.e.Base Station Subsystem(BSS),Network Switching Subsystem (NSS) and Operation and Support Subsystem (OSS)

❖ **Mobile station**

1) PCS use mobile stations (MSs) to communicate with the base stations (BSs) in a PCS network.

2) MS is also referred to as handset, mobile phone, subscriber unit, or portable.

3) Mobile stations (MS), mobile equipment (ME) or as they are most widely known, cell or mobile phones are the section of a GSM cellular network.

4) In recent years their size has fallen dramatically while the level of functionality has greatly increased.

5) There are a number of elements to the cell phone, although the two main elements are the main hardware and the SIM.

6) It contains a number known as the International Mobile Equipment Identity (IMEI). This is installed in the phone at manufacture and "cannot" be changed. It is accessed by the network during registration to check whether the equipment has been reported as stolen.

7) The SIM or Subscriber Identity Module contains the information that provides the identity of the user to the network. It contains variety of information including a number known as the International Mobile Subscriber Identity (IMSI).

❖ **Base Station Subsystem (BSS)**

❖ The Base Station Subsystem (BSS) section of the GSM network architecture that is fundamentally associated with communicating with the mobiles on the network. It consists of two elements:

❖ ***Base Transceiver Station (BTS):*** The BTS comprises the radio transmitter receivers, and their associated antennas that transmit and receive to directly communicate with the mobiles. The BTS is the defining element for each cell. The BTS communicates with the mobiles and the interface between the two is known as the Um interface.

❖ ***Base Station Controller (BSC):*** The BSC forms the next stage back into the GSM network. It controls a group of BTSs, and is often co-located with one of the BTSs in its group. It manages the radio resources

❖ **Global System for Mobile Communications(GSM)**

1) GSM is the world's first cellular system to specify the digital Modulation.
2) Global Systems for Mobile(GSM) is a second generation (2G) cellular standard developed in Europe in order to solve the fragmentation problems of the first generation cellular systems.
3) It is developed to cater voice services and data delivery using digital modulation.
4) GSM uses TDMA technique for multiple access.

❖ **GSM Services are of Two types:**

i. Teleservices
ii. Data Services

Teleservices are the services corresponding to the standard mobile telephony and the traffic originated from either teleservices or data services.
Data services are the GSM services corresponding to the communication between computers and packet switched traffic.

- The user services are of the following three categories:

1. Telephone services
2. Bearer services or data services
3. Supplementary ISDN services.

1. Telephone services:
The following services are called as telephone services:
1. Emergency calling
2. FAX
3. Videotext
4. Teletext

2. Bearer or data services:

- These services correspond to the transfer of data between computers and packet switched traffic.

3. Supplementary ISDN services:
The following services, that are digital in nature are known as supplementary ISDN services:
1. Call diversion
2. Closed user group
3. Caller Identification
4. SMS (upto 160 words)

3.Teleservices:
Basically the standard mobile telephony and the mobile originated or base originated traffic comes under the teleservices.
The teleservices are as follows:
1. Digital telephony.
2. Emergency number.
3. SMS.
4. EMS.
5. MMS.

1. Digital telephony:
   - The main service of GSM is to provide a high quality digital voice transmission, with a minimum bandwidth of 3.1 kHz.
   - Special codecs (combination of coder and decoder) are used for transmission of voice digitally.
2. Emergency number:
   - With this GSM service the same emergency number can be used throughout a country. This is a mandatory but free service with the highest connection priority.
   - If this number is dialled, then the call with the nearest emergency center is set up automatically.
3. Short Message Service (SMS):
   - With this service the user can send messages upto 160 characters. SMS messages are not transmitted over the standard data channels of GSM.
   - Instead they are sent over the unused capacity of signaling channels.
   - Hence SMS sending and receiving is possible even when the voice or data is being transmitted.

- SMS can transfer logos, ring tones, horoscopes alongwith the text messages. It is also possible to update the software of a mobile phone via SMS.

4. Enhanced Message Service (EMS):
   - EMS is the successor of SMS which offers a message size of upto 760 characters.
5. Multimedia Message Service (MMS):
   - With this service, it is possible to transmit large pictures (GIF, JPEG) and short video clips. MSS is integral part of mobile phones with an inbuilt camera.

4. Supplementary Services: Call related services

1. Conference Call: This service allows a mobile subscriber to start a conference call i.e. a simultaneous conversation takes place between three or more mobile subscribers.
2. **Call Waiting:** During a conversation this service informs a mobile subscriber about an incoming call. The user can answer, reject, or ignore the incoming call while conversing.
3. Call Hold: This service allows a user to put an incoming call on hold and after a while call can be resumed.
4. Call Forwarding: To divert calls from the original recipient to another number call forwarding service is used. The user himself can set up this service on his/her mobile.
5. **Call Barring:** To restrict some type of calls such as outgoing calls like ISD or incoming calls from unwanted numbers call barring service is useful.
6. Caller Identification: On your mobile screen, this service displays the telephone number of the person who is calling. It displays telephone number of a person to whom you are connected.
7. Suggestion of Charge: This service informs the user about the cost of the services used by them
8. Closed User Groups: This service is intended for the group of subscribers who want to call only each other in the group.

❖ Features of GSM

1. GSM can support more subscribers in the given spectrum.
2. The short messaging service (SMS) is provided by the GSM standard, that allows its subscribers to transmit and receive character text messages.
3. GSM has a subscriber identity module (SIM), which is a memory device that stores all the important information like subscriber's identification number.
4. Each subscriber is allotted a four digit personal ID number the activates service from any GSM phone. The SIMs are smart cards or plug-in modules. Each subscriber needs to insert his SIMs into a mobile phone, to receive GSM calls to the number irrespective of the location.
5. The GSM system provides the on-the-air privacy by encrypting the digital bit stream sent by the GSM transmitter.
6.The same GSM phone can be used in different networks.
7. The data transmission and reception rate supported across GSM networks is 9600 bps.
8. GSM also supports FAX transmission and reception at 9.6 kbps.
9. The size of GSM handsets is much smaller.
10. GSM supports the facilities like call forwarding, call on hold, conferencing, Calling Number Identification Presentation (CLIP) and international roaming
11. GSM is compatible with ISDN for supplementary services.

- **Following are the two most important GSM feature**

1. Subscriber Identity Module (SIM)
2. On air privacy.

1. Subscriber Identity Module (SIM):

- The SIM card of a GSM phone is nothing but a memory device that stores some very important information like, identification number of the subscriber, the type of network and the countries in which the services can be provided to the subscriber.
- In addition it also stores the unique privacy key for the subscriber for decrypting the encrypted received messages and other important information. A SIM is required to activate service for any GSM phone.
- Without a SIM all GSM mobile phone cannot operate.

2. On air privacy:
   - On-air privacy is the second important feature of GSM. On-air privacy indicates that the GSM system ensures some kind of privacy of the transmitted signal. The analog FM cellular system calls can be easily monitored because no on air privacy is provided. However the GSM transmitters use encryption to encode the signals before transmitting them which makes them a lot safer and hard to monitor.

❖ GSM System Architecture

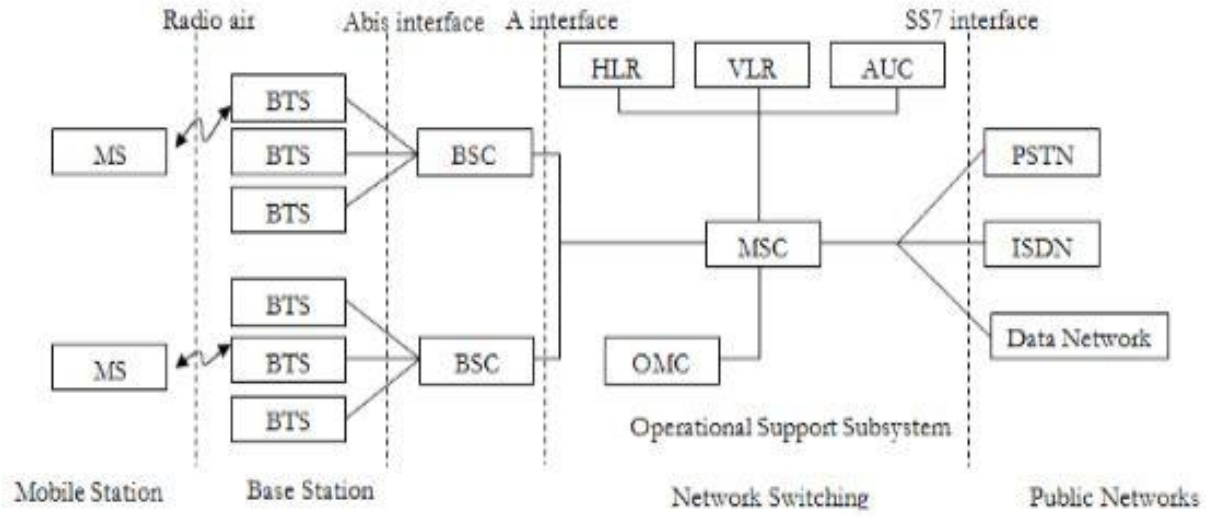


Fig: GSM Architecture

1) The BTS and BSC both are part of the Base Station Subsystem (BSS).
2) Each BSS is made of many BSCs (Base Station Controllers) and all BSCs are connected to a single MSC.
   Each BSC has hundreds of BTSs. (Bus Transceiver Stations) connected to it. These BTSS are controlled by the corresponding BSCs.
3) The BTSS are connected to BSCs either physically or via microwave links or dedicated leased lines.
4) The interface between BTS to BSC is called as Abis interface. This interface is expected to carry the voice data (traffic) and maintenance data.
5) The BSCs are physically connected to MSC (Mobile Switching Center) via dedicated / leased lines or microwave link. This interface is known as the A interface.
6) The NSS contains three different databases, called Home Location Register (HLR), Visitor Location Register (VLR) and Authentication Center (AUC).
7) The HLR is a database containing the subscriber information and location information of each user, who is staying in the same city as MSC.
8) Each subscriber is assigned a unique International Mobile Subscriber Identity (IMSI) and this number will identify each user.
9) VLR database is used to temporarily store the IMSI and customer information for each roaming subscriber.

10) AUC is the strongly protected database which takes care of authentication and handles the encryption keys for all the subscribers in HLR and VLR.
11) The OSS supports one or more Operation Maintenance Centers (OMC). The OMC is used for monitoring and maintaining the performance of each MS, BS, BSC and MSC used in a GSM system.

❖ GSM Interfaces

- ***Um interface*** The "air" or radio interface standard that is used for exchanges between a mobile (ME) and a base station (BTS / BSC). For signaling, a modified version of the ISDN LAPD, known as LAPDm is used.
- ***Abis interface*** This is a BSS internal interface linking the BSC and a BTS, and it has not been totally standardized. The Abis interface allows control of the radio equipment and radio frequency allocation in the BTS.
- ***A interface*** The A interface is used to provide communication between the BSS and the MSC. The interface carries information to enable the channels, timeslots and the like to be allocated to the mobile equipment being serviced by the BSSs. The messaging required within the network to enable handover etc. to be undertaken is carried over the interface.

Base Transceiver Station (BTS)
- Encodes, encrypts, multiplexes, modulates and feeds RF signals to antenna.
- Communicates with Mobile station and BSC(Base station controller)
- Consists of Transceivers(TRX) units

Base Station Controller (BSC)
- Manages Radio resources for BTS(Base Transceiver Station).
- Assigns frequency and time slots for all MS's in its area.
- Handles call setup
- Handover for each MS
- It communicates with MSC and BTS

MOBILE SWITCHING CENTER (MSC):

- Heart of the network
- Manages communication between GSM and other networks
- Billing information and collection
- Mobility management
  - Registration
  - Location Updating
  - Inter BSS and inter MSC call handoff

VISITOR LOCATION REGISTER (VLR):

- Temporary database which updates whenever new MS enters its area, by HLR database
- Assigns a TMSI to each MS entering the VLR area which keeps on changing.
- Controls those mobiles roaming in its area
- Database contains IMSI, MSISDN, Location Area, authentication key.

OPERATION AND MAINTENANCE CENTRE (OMC):

- The centralized operation of the various units in the system and functions needed to maintain the subsystems.
- Dynamic monitoring and controlling of the network.
- Functions :
  - configuration management
  - fault report and alarm handling
  - performance supervision/management
  - storage of system software and data

HOME LOCATION REGISTER (HLR):

- Stores information about each subscriber that belongs to it MSC in permanent and temporary fashion.
- As soon as mobile subscriber leaves its current local area, the information in the HLR is updated.
- Database contains IMSI, MSISDN, prepaid/postpaid, roaming restrictions, supplementary services.

AUTHENTICATION CENTER (AUC):

- Contains the algorithms for authentication as well as the keys for encryption.
- Protects network operators from fraud.
- Situated in special protected part of the HLR.

❖ GSM Specifications

❖

- **frequency band**—The frequency range specified for GSM is 1,850 to 1,990 MHz (mobile station to base station).
- **duplex distance**—The duplex distance is 80 MHz. Duplex distance is the distance between the uplink and downlink frequencies. A channel has two frequencies, 80 MHz apart.
- **channel separation**—The separation between adjacent carrier frequencies. In GSM, this is 200 kHz.
- **modulation**—Modulation is the process of sending a signal by changing the characteristics of a carrier frequency. This is done in GSM via Gaussian minimum shift keying (GMSK).
- **transmission rate**—GSM is a digital system with an over-the-air bit rate of 270 kbps.
- **access method**—GSM utilizes the time division multiple access (TDMA) concept. TDMA is a technique in which several different calls may share the same carrier. Each call is assigned a particular time slot.
- **speech coder**—GSM uses linear predictive coding (LPC). The purpose of LPC is to reduce the bit rate. The LPC provides parameters for a filter that mimics the vocal tract. The signal passes through this filter, leaving behind a residual signal. Speech is encoded at 13 kbps.

❖ GSM frequency

GSM Originally used two 25MHz cellular bands but now it is used in many bands. Two 25MHz bands are as follows.

i. GSM 900:

890-915 MHz UPLINK or reverse link from subscriber to base transmission.
935-960MHz DOWNLINK or forward link

ii. GSM 1900:

1850-1910 MHz UPLINK
1930-1990 MHz DOWNLINK

iii. GSM 1800:

1710-1785 MHz UPLINK
1805-1880 MHz DOWNLINK

❖ Frame Structure of GSM System

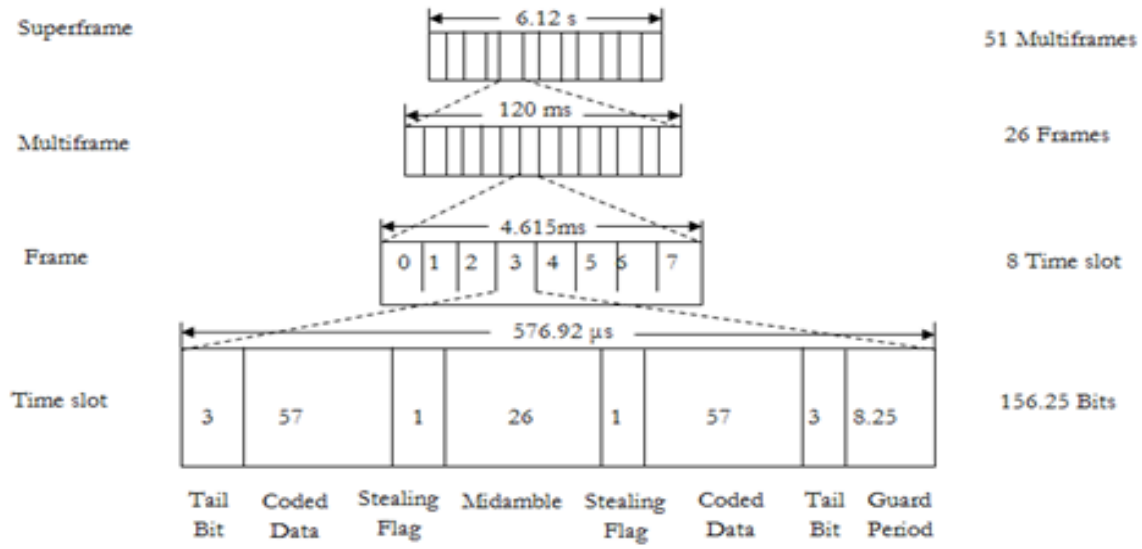
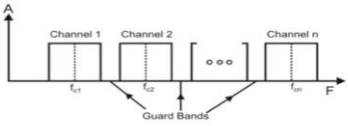


Fig: Frame Hierarchy

Why Guard Band?

- When channels are very close to one other, it leads to inter-channel cross talk
- Channels must be separated by strips of unused bandwidth to prevent inter-channel cross talk
- These unused channels between each successive channel are known as **guard bands**
- The range of frequencies have to be non-overlapping



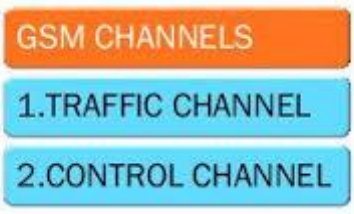
❖ GSM channel types

❖

- GSM channels are of two types:

1. **Physical Channel**
2. **Logical Channel**

Logical Channel

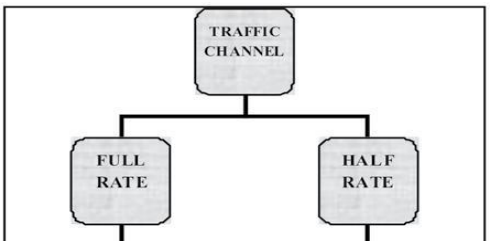


1. GSM traffic channels (TCHS).
2. Control channels (CCHs).

- The traffic channels (TCHs) are supposed to carry speech or data signals that are encoded into digital form.
- Their functions and formats on forward as well as reverse links are the same.
- The base station uses the control channels to communicate the signaling and synchronization commands to the mobile station.

The control channels (CCH) defined for the forward links and those defined for the reverse links are entirely differen

Traffic Channels



- GSM has two types of traffic channels

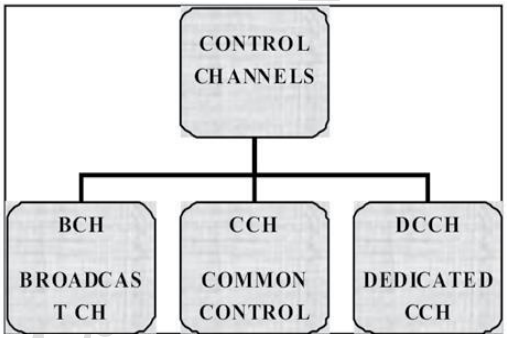
TCH/FS stands for traffic channel at Full rate speech
TCH/HS stands for traffic channel at half rate speech

- It is used both in the uplink and downlink after mobile has established connection with the GSM cell (BTS).
- It uses 26 frame multi frame structure.

Control channel

1. Control Channels

Control Channels further consists of three Groups namely Broadcast Channel, Common Control Channel and Dedicated Control Channel.



1. **Broadcast Control Channel**

- **Broadcast Control Channel (BCCH)**
- The Broadcast Control Channels are downlink only (BSS to MS) . It also sends control information to MS (Mobile Station). The information carried on the BCCH is monitored by the MS periodically (at least every 30 sec), when it is switched on and not in a call.

- **Synchronization Channel (SCH)**

The Synchronizing Channel (SCH) helps to synchronise TDMA Frame. The MS will monitor BCCH information from surrounding cells and stores the information.

- **Frequency Correction Channel (FCH)**

Frequency Correction Channel (FCCH) allows the mobile to synchronize its own frequency to that of the transmitting base site. It acts as a flag to the mobile to identify Timeslot 0 because it may only sent during time slot 0 on BCCH carrier frequency.

2. **Common Control Channel**

- The Common Control Channel (CCCH) is responsible for transferring control information between all mobiles and the BTS
- **Random Access Control Channel (RACH)**

Random Access Channel (RACH) helps MS to assign with network and used by the mobile when it requires to gain access to the system . This occurs when the mobile initiates a call or responds to a page.

- **Paging Control Channel (PCH)**

Paging Control Channel (PCH) helps network to assign with MS and also used by BTS (Base transceiver station) to page MS.

- **Access Grant Control Channel (AGCH)**

Access Grant Control Channel (AGCH) is used by network to assign signalling upon successful decodation of Burst.

- **Cell Broadcast Control Channel (CBCH)**

Cell Broadcast Control Channel (CBCH) tells from which BTS (Base Transceiver Station) we are getting coverage

3. **Dedicated Control Channels**

- Dedicated Control Channels are both Uplink and Downlink and has further categories: SDCCH, SACCH, and FACCH

- **Stand Alone Dedicated Control Channel (SACH)**

Stand Alone Dedicated Control Channel (SDCCH) is used by MS for Location Updation, SMS, and Authentication.

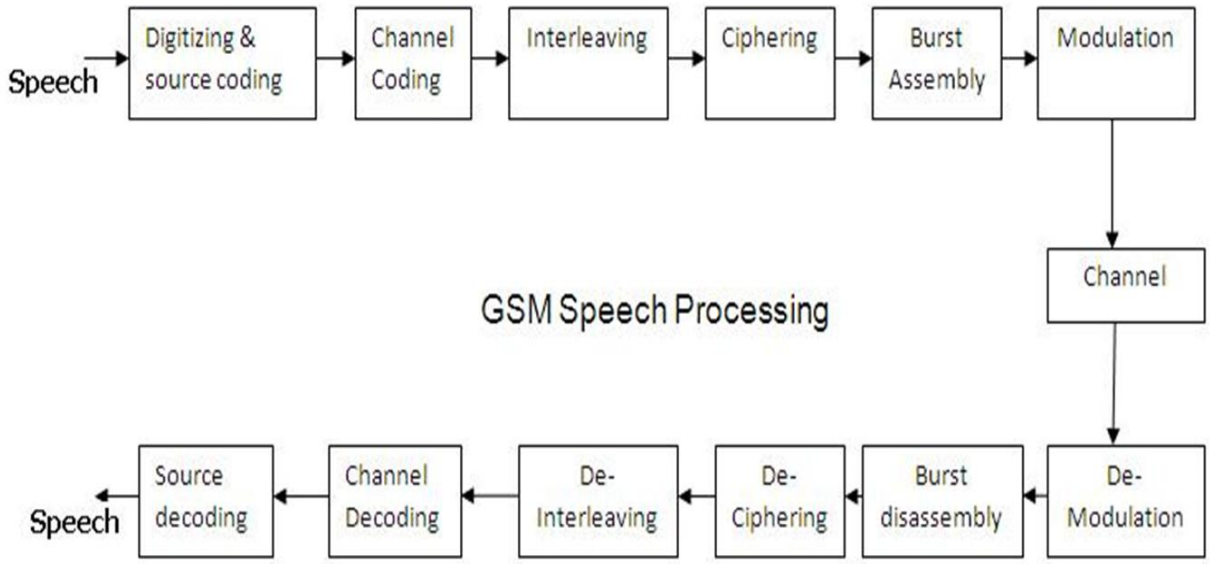
- **Slow Associated Control Channel (SACCH)**

Slow Associated Control Channel (SACCH) sends control information (Power Control) in downlink and measurement reports (Link Quality Reports) in uplink.

- **Fast Associated Control Channel (FACCH)**

Fast Associated Control Channel is transmitted instead of a TCH. The FACCH ‘‘steals” the TCH (Traffic Control Channel) burst and inserts its own information. The FACCH is used to carry out user authentication, handovers and immediate assignmentrol Channel

❖ Signal Processing in GSM



1. The MS (Handset) plays an important role in transmission process. The function of MS is transmission (uplink) and reception (Downlink) of voice or data through air interface. Main aim of transmission process is how to make Burst or Time slot in TDMA Frame.

Stage - I: Analog to Digital (A/D) conversion

The primary function of an MS is to convert the analog signal (speech) information in digital form for transmission using a digital signal. The analog to Digital (A/D) conversion Process outputs collection of bits, binary ones and zero which represent the speech input.

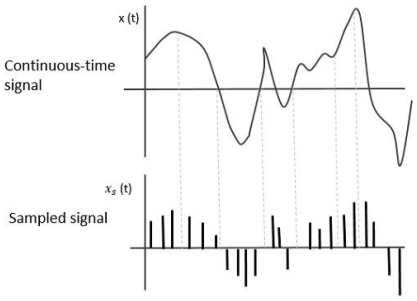
The A/D conversion is performed by using a process called pulse code modulation (PCM)

The PCM involves three main steps:

• Sampling

• Quantization

• Coding

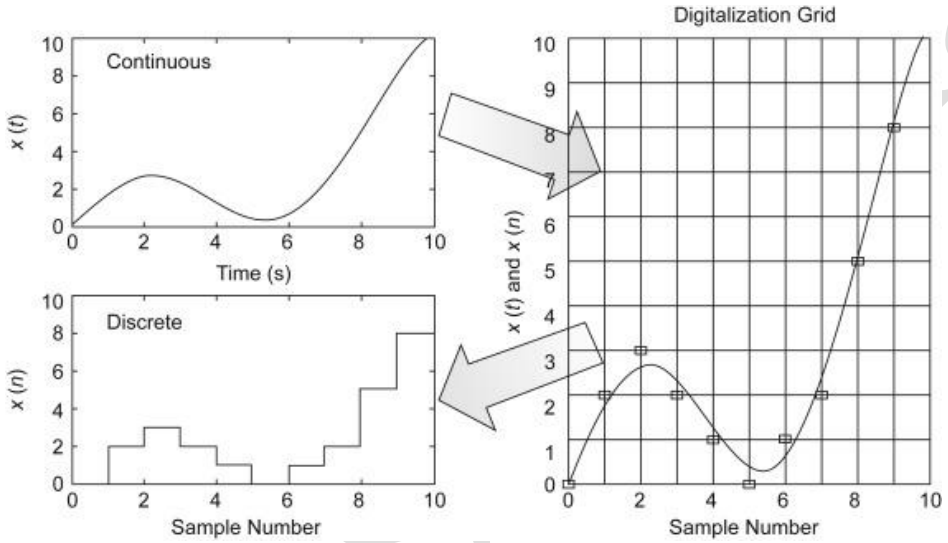


Step - I: Sampling :

It is the process of measuring the input (Analog) signal at specific time intervals.

Step II: Quantization

It is the process of measuring amplitude of sampled signal. This is a step to give each sample a particular value. For this reason, the amplitude of the signal at the time of sampling is measured and approximated to one of a finite set of values.



Step III: Coding the measured amplitude into a series of binary values, which are transmitted by modulation of a pulsed, or intermittent, carrier.

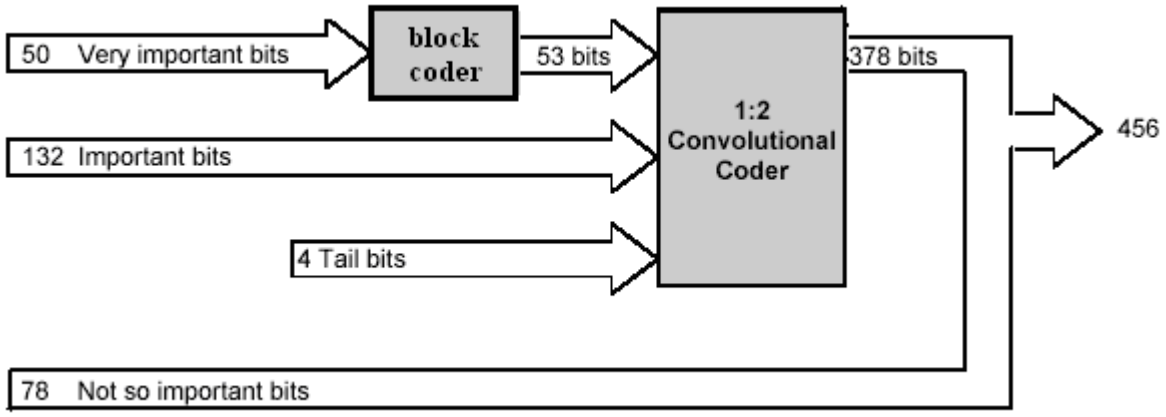
Stage - II: Channel Coding

Channel coding in GSM uses the 260 bit from speech coding as input to channel coding and outputs 456 encoded bits. The 260 bits are split into three categories:

Block-1 50 bit - very important bit

Block-2: 132 bit- Important bit

Block-3: 78 bit - Not so important



Mathematically:

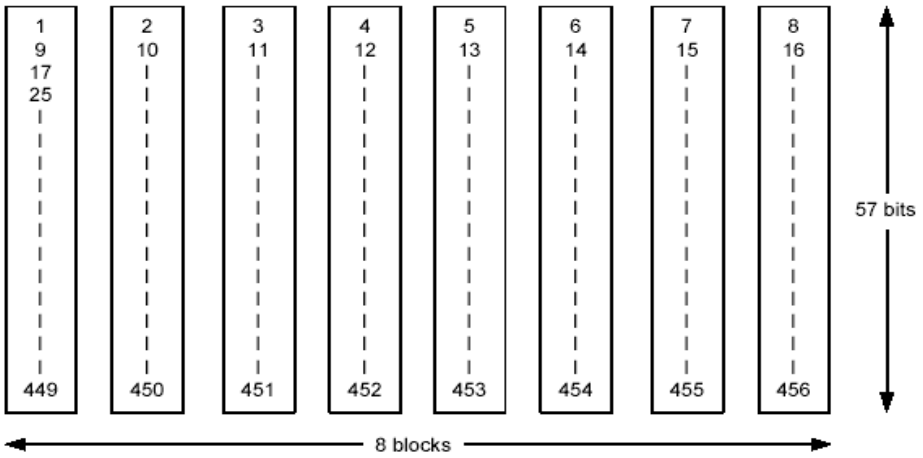
Convolution coder input = 53 + 132+4=189 bits

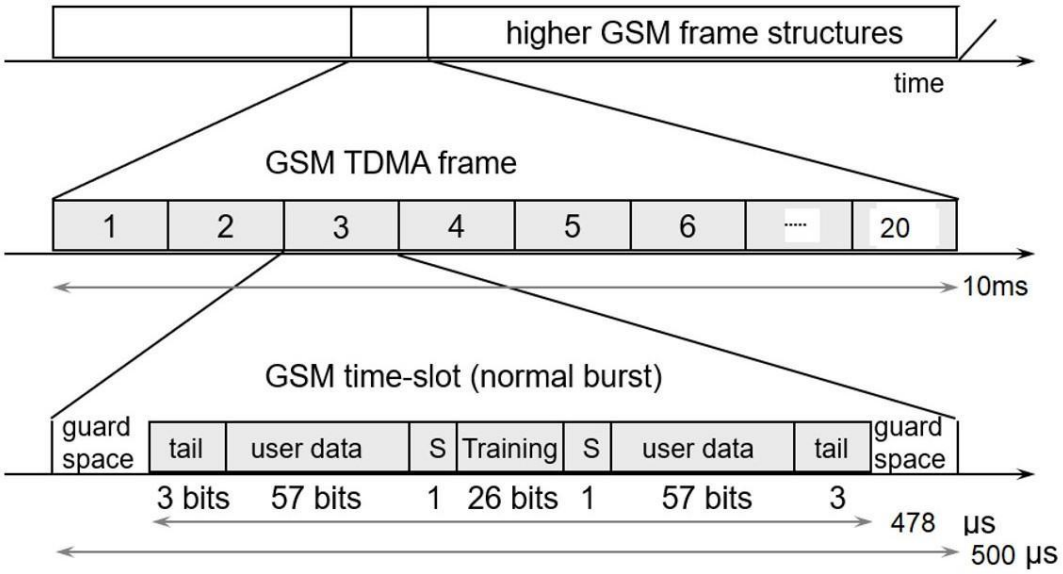
coder output = 189 x2=378 bits

Hence Total output = (378+78) = 456 bits

Stage -V: Interleaving:

The channel coder provides 456 bit for every 20 msec of speech. These are interleaved, forming eight block of 57 bits (456/8) each, as shown in following figure-





57 bits: Data Bits
26 bits: Training Sequence
1bit: Stealing flag
3 bit: Tail bit
8.25: Guard period

Stage- VI: Ciphering/Encryption

The purpose of ciphering is to include the burst so that it cannot be interpreted by any other device than the intended receiver. The ciphering algorithm in GSM is called the **A5 algorithm.**

Stage- VII: Burst formatting:

Combines the various burst signals into one format and generates the signal for transmission.

Stage- VIII: Modulation and Transmission: The bits must be sent over the air using a carrier frequency.GSM uses GMSK Modulation technique. The bits are modulated into a carrier frequency and transmitted.

❖ Mobility Management ❖

- Mobility management is one of the major functions of a GSM that allows mobile phones to work.
- The aim of mobility management is

1. to track the location of the subscribers
2. To allow calls, SMS and other mobile phone services to be delivered to them.

Functions of MM

- **Registration-**
  - Informs network which device is used and that it is ready to receive request
  - Normally combined with authentication
- **Paging**
  - In power saving mode only the area a device is located in is known by the network

- Paging is used to find the cell a device is located in.

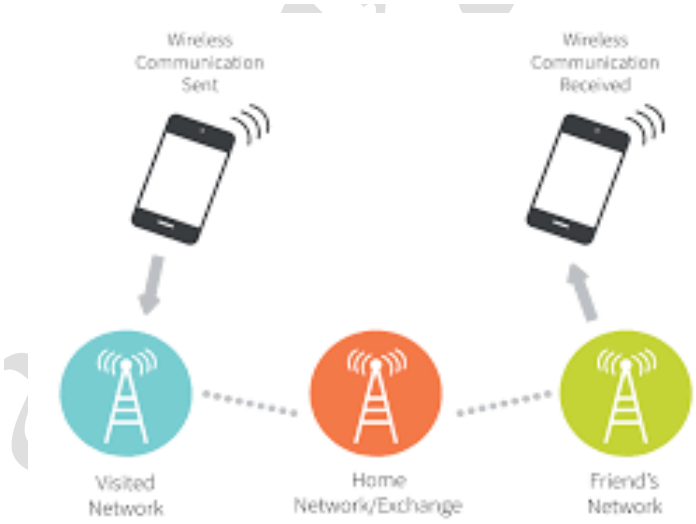
- **Location Update**
  - Informs the network of new location of the device
- **Handover**
  - Keeps the link while moving by switching the link from one access point to another.
- **Rerouting**
  - Optimizes the traffic path by redefining routes after handover

❖ Roaming

Roaming is the ability for a customer of mobile communications to automatically make and receive telephone calls, send and receive data, or access other services while travelling outside the geographical coverage area of the home network, by means of using a network of another operator

Concept of Roaming :

1) Roaming is one of the basic mobility management processes in all cellular networks.
2) Roaming is defined as the capability of a cellular customer to make and receive voice calls automatically, send and receive data, or to access other services containing home data services, while travelling outside the geographical coverage area of the home network, by means of using a visited network.
3) Roaming can be done by using a communication terminal or by using the subscriber identity in the visited network.



4) Technically Roaming is supported by mobility management, authorization, authentication and billing procedures.

❖ Roaming Services

5 Most common domains of roaming services are:

1) **Calling:** Roaming service allows one to make calls and receive calls from anywhere. This includes the home country, the present country or any other country.
2) **Messaging:** Similar to voice, SMS roaming services include sending and receiving text messages to and from the home country, the present country and any third country.
3) **Emails:** Roaming services include receiving and replying or forwarding any email while abroad.
4) **Mobile Data:** Roaming services enable data accessing through mobile devices or any other device. The service includes downloading files, uploading files when travelling abroad.
5) **Mobile Applications:** Global roaming services extend to mobile applications or apps that utilize mobile data for operating. Many mobile applications are useful while travelling internationally.
6)

❖ Identifiers used in GSM:

Following are the identifiers used in GSM.

MSISDN (Mobile Station ISDN Number):

It is an authentic telephone number of the Subscriber Identity Module (SIM) card displayed on mobile or cellular phones.

A MSISDN is a subscription in the Global System for Mobile Communications (GSM) or Universal Mobile Telecommunications System (UMTS) networks.

Based on the SIM card, a mobile station can have many MSISDNS. Each subscriber is assigned with a separate MSISDN to their SIM.

IMEI (International Mobile Equipment Identity) :

IMEI is a 15 or 17-digit code that uniquely identifies mobile handsets.

The International Mobile Station Equipment Identity (IMEI) is similar to a serial number which distinctively identifies a mobile station internationally.

This is allocated by the device manufacturer and registered by the network operator.By using IMEI number one can recognize outdated, stolen, or non-functional equipment.

IMSI (International Mobile Subscriber Identity) :

It uniquely identifies the MS. It is used as the key to search any data in the databases from VLR, HLR and GSN.

IMSI is usually fifteen digit unique number. Every registered user has an original International Mobile Subscriber Identity IMSI with a valid IMEI

MSIN (Mobile Subscriber Identification Number):

It is an identification number of the subscriber in the home network.

MSRN (Mobile Station Roaming Number):

Mobile Station Roaming Number MSRN is an temporary location dependent ISDN number, assigned to a mobile station by a regionally responsible Visitor Location Register VLR. Using MSRN, the incoming calls are channeled to the MS.

LAI (Location Area Identity) :

Within a PLMN, a Location Area identifies its own authentic Location Area Identity LAI. The LAI hierarchy is based on international standard.

❖ Call Processing in GSM / Typical Call Flow Sequences in GSM:

In this section we will discuss the following call flow sequences related to GSM:

1. Registration / Location updating

2. Mobile terminated call

3. Mobile originated call

1.Location Updating :

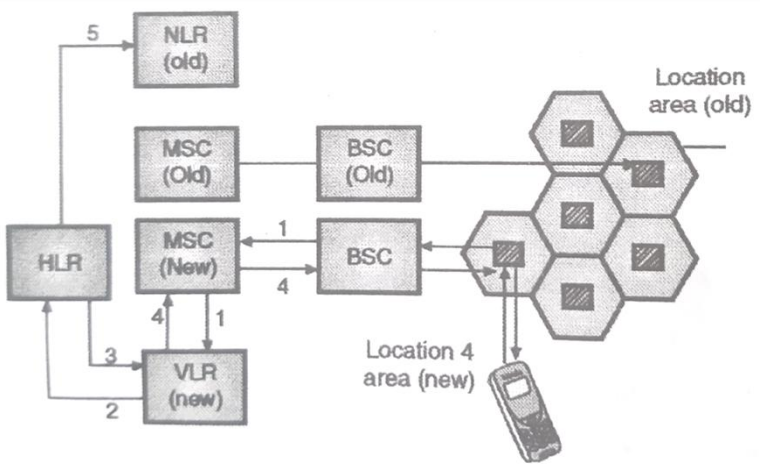
In order to receive the incoming calls from a mobile station that moves within and outside the service area, the home network should somehow keep a track of the location of all the active mobile stations.

The location updating feature is activated when a mobile station either moves to another MSC or tries to access the network and is not registered in the VLR of that location.

Each service area consists of many adjacent cells recognized by location area identities (LAI).

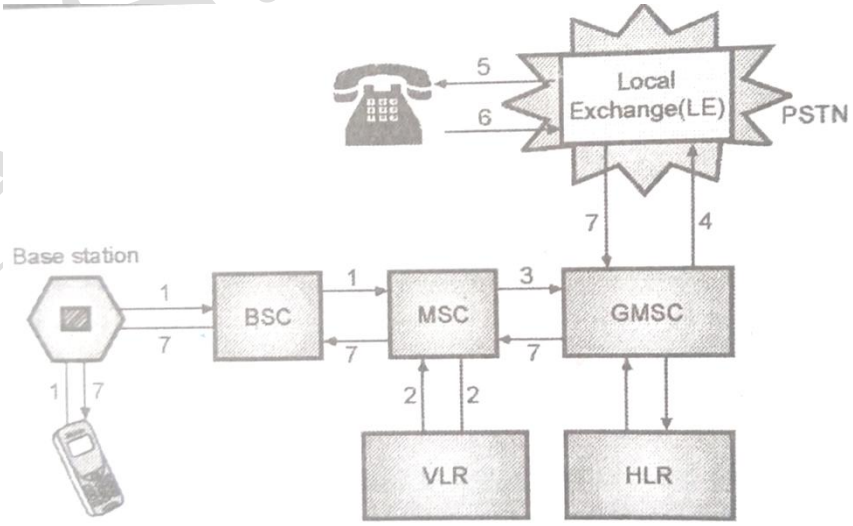
The mobile station (MS) generally has the information from the neighbouring base stations and if it sees that a subscriber has moved to a new location then it initiates the sequence as shown in Fig.

Location Updating Procedure:



Step 1: When a new location is identified, the mobile station (MS) sends a request for location update to the new VLR via the BSC and MSC.
Step 2: The location update message is sent to the HLR from the VLR. This message consists of the address of the VLR (new) and the IMSI of the MS.
Step 3: The security and service related information for the MS is transferred to the new VLR.
Step 4: An acknowledgement message is sent to the mobile station as soon as the location update is done successfully.
Step 5: The HLR instructs the old VLR to delete all the information related to the relocated MS

Mobile Originated Call:



This type of call is originated by a mobile subscriber and it is meant for a landline user.

First the calling mobile subscriber enters the phone number to be called on the mobile and presses the send key.

Then the mobile station connects the correct signalling links to the BSC.

After that the call is processed by following the steps shown in Fig

Step 1: The mobile station passes on the dialled number to the MSC via BSC to indicate that it needs service.
Step 2: The VLR tells the MSC if the mobile station can access the requested service or not. If the MS can access the requested service, then the MSC instructs the BSC to assign the resources required for the call.
Step 3: The allowed call is then routed to GMSC via MSC.
Step 4: The GMSC then routes the call to the Local
Step 5: Exchange (LE) of called landline subscriber. The LE then gives a ring on the called landline terminal.
Step 6: The landline terminal returns an answer back tone to the LE.
Step 7:The answer back tone is sent back to the Mobile Station thus completing the call.

❖ Hand Off (Hand Over) in GSM:

1) Assume that there is a call going on between two parties over a voice channel.

2) When the mobile unit moves out of the coverage area of a particular cell site, the reception becomes weak. Then the present cell site will request a handover.

3) The system will switch the call to a new cell site without interrupting the call. This procedure is called the handover procedure or handover procedure.

4) The user can continue talking without even noticing that the handover procedure has taken place.

The advantage of handover procedure is increase in the effectiveness of the mobile system.

Refer Fig to understand the handover procedure clearly. Fig. BELOW shows two co-channel cells separated by a distance D and using the frequency f_1.

Other cells such as C_1, C_2, C3, C4, C5 etc. exist in-between the two co-channel using frequency f_1.

The cells C_1, C_2, C3 and C4 use different frequencies f_1, fz f3, f4, etc. as shown in Fig.

Suppose a mobile unit initiates a call in cell C, and then moves to cell C_2. Then as it starts going away from C_1, the call is dropped and reinitiated in the frequency channel from f_1 to f_2 when the mobile unit (such as car) moves form C_1 to C_2

Similarly when the mobile unit moves from cell C_2 to C_2 the frequency is changed automatically from f_2 to f3 as shown in Fig.

The process of changing the frequency is done automatically by the system and the user does not even notice it.

It is important to process handovers in any cellular system. In many handover strategies, higher priority is given to the handover request than the call initiation request.

Handovers should be performed successfully and they should not be repeated frequently.

So as to satisfy these requirements, system designers should decide and specify an optimum signal level at which the handover should be initiated.

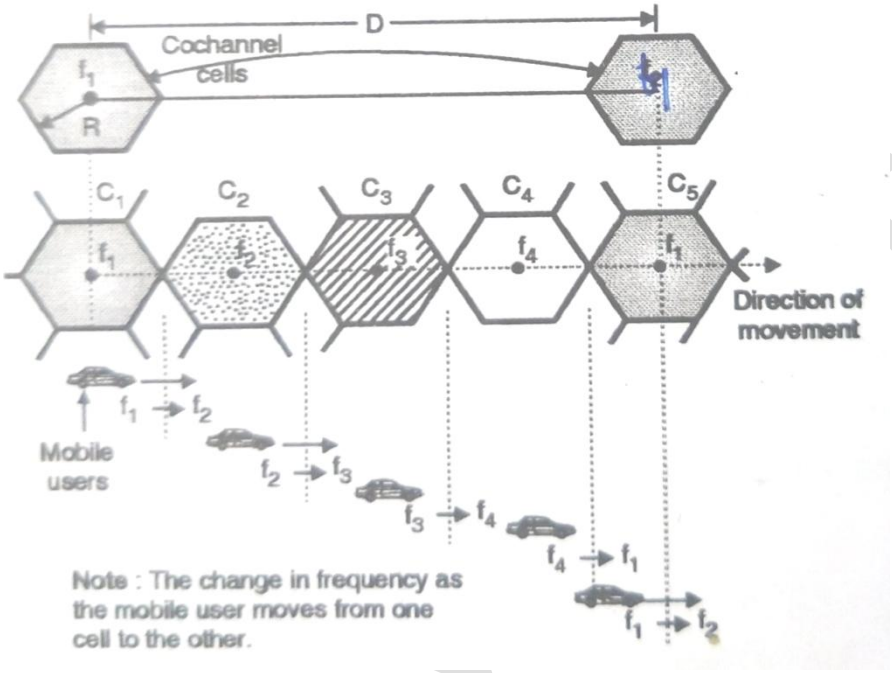


Fig. below illustrates handover diagrammatically. First a minimum signal level for maintaining the call is decided. Then a slightly stronger signal level is used as the handover threshold. The handover will be made at this signal level.

The margin between these two levels is denoted by A and given by,
A = Pr handover - Pr minimum usable

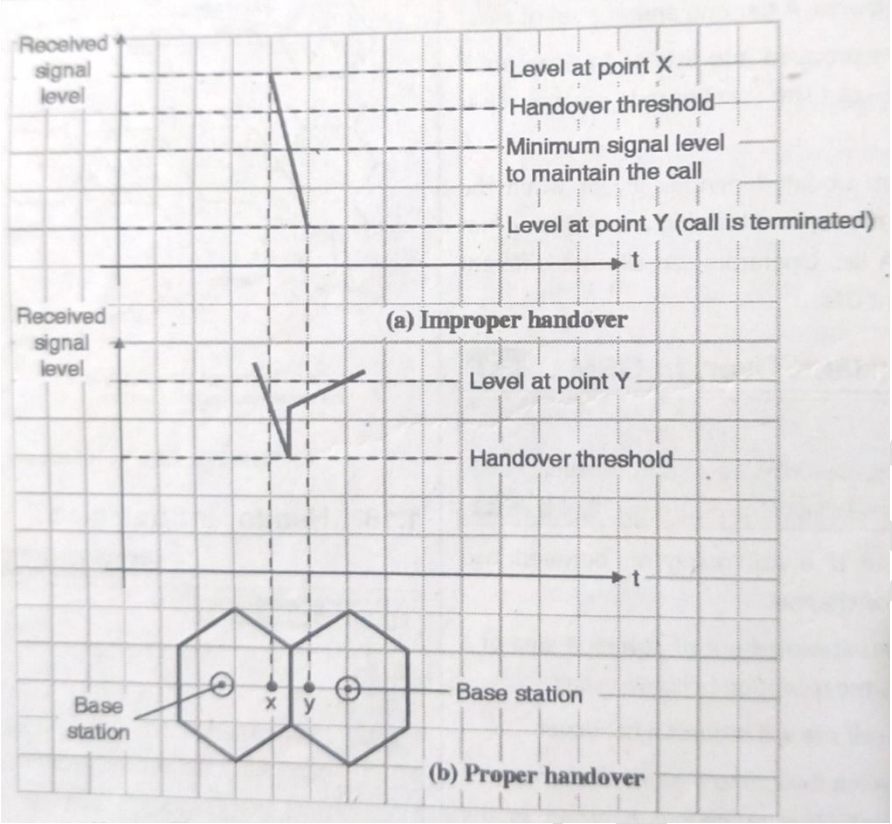
Note the choice of the value of A is critical. A cannot be too small and it cannot be too large as well.

If A is too large, then unnecessary handovers will take place and if A is too small, there won't be sufficient time to complete the handover and the call may lost due to weak signal
Improper Handover:

Refer Fig (a) which illustrates the improper handover situation i.e. handover is not made and signal drops below the minimum signal level. The call is terminated.

In Fig. (b), the handover has taken place as soon as the received signal level drops to the handover threshold. Note the increase in the signal level at point Y after handover

Before initiating the handover, it is necessary to ensure that the reduction in the measured signal level is not due to the momentary signal fading and that the drop in signal level is due to the actual movement of the mobile station.



❖ **Different Types of Handover :**

Following are various types of handovers

1. Hard handover

2.Soft handover

3. Queued handover

4. Delayed handover

5. Forced handover

1. Hard handover :

The handover is known as hard handover if a mobile station transmits between two base stations operating on different frequencies.

2. Soft handover :

The handover is known as soft handover if the MS starts communication with a new base station without stopping the communication with the older base station.

In a soft handover the operating frequencies of the old and new base stations are identical.

Soft handover enhances the signal by providing different-site selection diversity.

If the handover takes place within the same cell then it is known as softer handover.

3. Delayed handover:

In many situations, instead of one level, a two level handover procedure is followed, in order to ensure a higher possibility of a successful handover. A handover can be delayed if no available cell could accept the call.

Fig. shows a graph of signal strength with two handover levels.

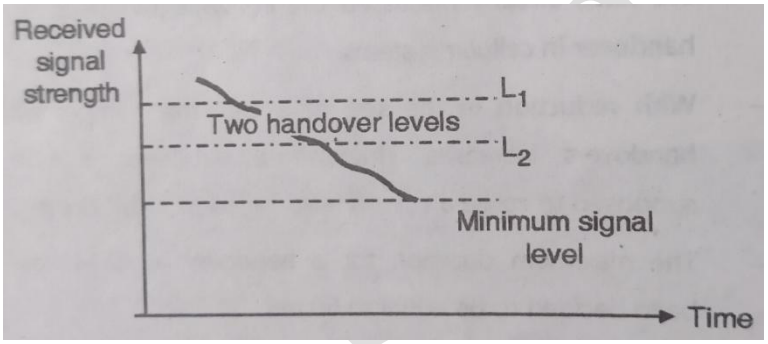
When the signal level drops below the first handover level, the MS initiates a handover request. If due to some reason the mobile unit is in a hole (Place in a cell with low signal level) or neighbouring cell is busy then the MS will repeat the handover request after every 5 seconds.

Received signal strength

Two handover levels L_2 Minimum signal level Time (G-1415) Fig. A two level handover scheme

But if the signal strength drops down further and reaches the second handover level (L_2) then the handover will take place without any condition, immediately.

This process is called as delayed handover.



3. Forced handover:

A forced handover is defined as the handover which would normally occur but is not allowed to happen by force or a handover that should not occur but is forced to take place.
Queued handover:

In the queued handover process, the MTSO arranges the handover requests in a queue instead of rejecting them, if it finds that new cell sites are too busy to makes the handover possible.

These handover requests are then acted upon in a sequential manner. Queuing of handovers is more effective than the two threshold handover. Also, a queuing scheme is effective only when the handover requests arrive at the MTSO in the form of batches or bundles

----------******END*******----------

FIRST GENERATION (1G)

1G (or 1-G) is short for first-generation wireless telephone technology, cellphones. These are the analog cell phones standards that were introduced in the 1980s and continued until being replaced by 2G digital cell phones. The main difference between two succeeding mobile telephone systems 1G and 2G is that, the radio signals that IG networks use are analog, while 2G networks are digital. Although both systems use digital signaling to connect the radio towers (which listen to the handsets) to the rest of the telephone system, the call itself is encoded to digital signals in 2G whereas IG is only modulated to higher frequency, typically 150MHz and up.

SECOND GENERATION (2G)

2G is short for second generation wireless telephone technology. The main differentiator to previous mobile telephone systems, retrospectively dubbed 1G networks use are analog, while 2G networks are digital Note that both systems used digital signaling to connect the radio towers(which listen to the handset) the rest of the telephone systems.

Channels:

An important factor in determining the capacity of a mobile system is the channel. A channel is a frequency or a set of frequencies which can be allocated for the transmission and reception of information. Communication channels of any form can be one of the following types.
One way only
Two way,
Simplex
Half Duplex one once at time
Full Duplex Two way both at the same time

Abbreviations

MSC : Mobile switching center
BSC : Base station controller Base transceiver station
BTS :TRX : Transceiver.
MS :Mobile station
OMC : Operations and Maintenance centre.
PSTN: Public switched telephone network.
BSS : Base station sub-system.
HLR : Home location register
VLR : Visitor location register
AUC :Authentication centre
EIR: Equipment Identity Register

1. What is Mobile communication?
   a) Allows to communicate from different locations without the use of physical medium
   b) Allows to communicate from different locations with the use of physical medium
   c) Allows to communicate from same locations without the use of physical medium
   d) Allows to communicate from same locations with the use of physical medium
2. What is wireless communication?
   a) Sending data from one location to with the use of physical medium
   b) Sending data from one location to another without the use of physical medium
   c) Sending data from one location to another without the use of virtual medium
   d) None of the mentioned
3. 3. Which of the following is a type of wireless communication?
   a) LAN
   b) WAN
   c) PAN
   d) All of the mentioned
4. 4. Which of the following is not an example of wireless communication?
   a) Wi-Fi
   b) Mobiles
   c) Landline
   d) Wireless Computer Parts
5. Why wireless communication is used?
   a) It enables billions of people to connect to the Internet
   b) Lowers the cost of network infrastructure
   c) Makes services more inexpensive
   d) All of the mentioned
6. Which of the following is the drawback for cordless telephones?
   a) Security
   b) Wireless technology
   c) Limited coverage area
   d) Mobile
7. Which of the following is not a TDMA standard of 2.5G network?
   a) GPRS
   b) GSM
   c) HSCSD
   d) EDGE
8. **Mobile communication network is also called as _____ network.**

   Cellular network

   Mobile network

   2G network

   Both a and b
9. **. _____ technology is used for communicating over large distances wirelessly.**

- Mobile communication
- Land communication
- Communication
- All the above

Which of the following are not used in mobile communication?

- Wires
- Cables
- Wired antenna
- All the above

A mobile phone uses _____ type of duplex communication.

- Half
- Full
- Zero
- Both a and b

A full-duplex communication is _____ way communication.

- Single
- Two
- Multiple
- All the above

Which of the following are the features of mobile communication?

- High load balancing capacity
- Highly scalable
- Good network management system
- All the above

Which of the following are the examples of mobile communication systems?

- Cellular phones
- Cordless phones
- Wired phones
- Both a and b

Do mobile telephones permit communication at a time?

- Yes
- No
- Maybe