WIRELESS & MOBILE COMMUNICATION

(Unit-3)

Introduction to GSM:

GSM stands for Global System for Mobile Communication. It is a digital cellular technology used for transmitting mobile voice and data services. Important facts about the GSM are given below −

- The concept of GSM emerged from a cell-based mobile radio system at Bell Laboratories in the early 1970s.
- GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard.
- GSM is the most widely accepted standard in telecommunications and it is implemented globally.
- GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time-slots. GSM operates on the mobile communication bands 900 MHz and 1800 MHz in most parts of the world. In the US, GSM operates in the bands 850 MHz and 1900 MHz.
- GSM owns a market share of more than 70 percent of the world's digital cellular subscribers.
- GSM makes use of narrowband Time Division Multiple Access (TDMA) technique for transmitting signals.
- GSM was developed using digital technology. It has an ability to carry 64 kbps to 120 Mbps of data rates.
- Presently GSM supports more than one billion mobile subscribers in more than 210 countries throughout the world.
- GSM provides basic to advanced voice and data services including roaming service. Roaming is the ability to use your GSM phone number in another GSM network.

GSM digitizes and compresses data, then sends it down through a channel with two other streams of user data, each in its own timeslot.

Why GSM?

Listed below are the features of GSM that account for its popularity and wide acceptance.

- Improved spectrum efficiency
- International roaming
- Low-cost mobile sets and base stations (BSs)
- High-quality speech
- Compatibility with Integrated Services Digital Network (ISDN) and other telephone company services
- Support for new services

GSM - Architecture

A GSM network comprises of many functional units. These functions and interfaces are explained in this chapter. The GSM network can be broadly divided into −

- The Mobile Station (MS)
- The Base Station Subsystem (BSS)
- The Network Switching Subsystem (NSS)
- The Operation Support Subsystem (OSS)

GSM - The Mobile Station

The MS consists of the physical equipment, such as the radio transceiver, display and digital signal processors, and the SIM card. It provides the air interface to the user in GSM networks. As such, other services are also provided, which include −

- Voice teleservices
- Data bearer services
- The features' supplementary services

The MS Functions

The MS also provides the receptor for SMS messages, enabling the user to toggle between the voice and data use. Moreover, the mobile facilitates access to voice messaging systems. The MS also provides access to the various data services available in a GSM network. These data services include −

- X.25 packet switching through a synchronous or asynchronous dial-up connection to the PAD at speeds typically at 9.6 Kbps.
- General Packet Radio Services (GPRSs) using either an X.25 or IP based data transfer method at the speed up to 115 Kbps.
- High speed, circuit switched data at speeds up to 64 Kbps.

What is SIM?

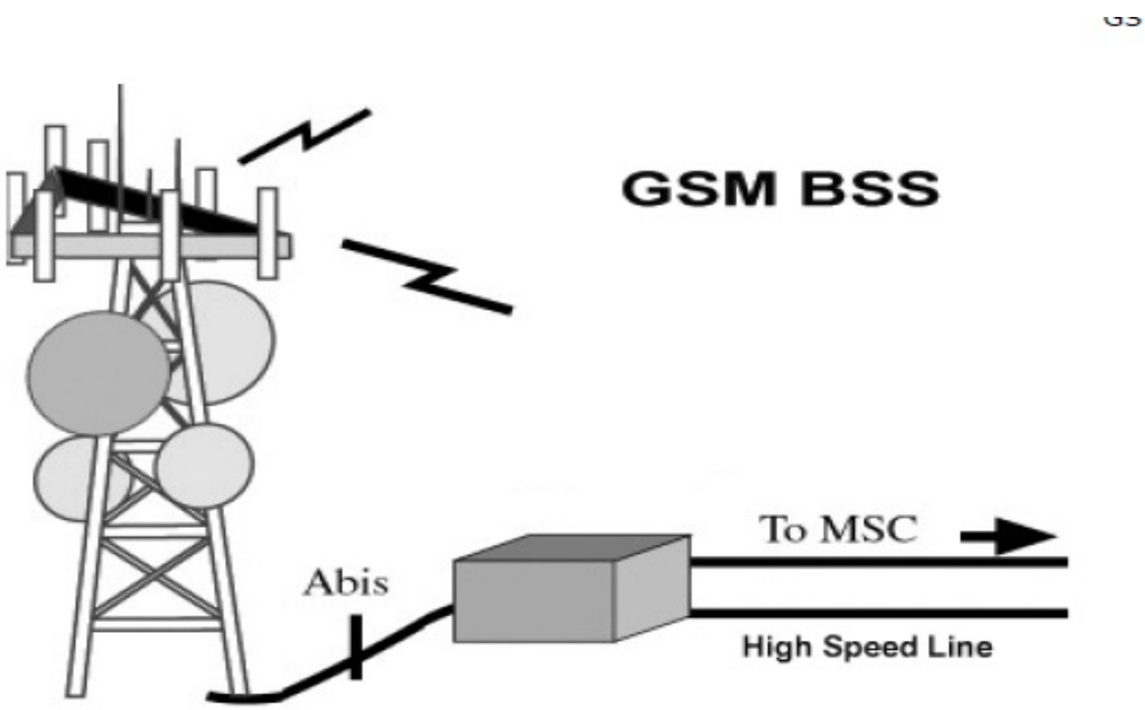
The SIM provides personal mobility so that the user can have access to all subscribed services irrespective of both the location of the terminal and the use of a specific terminal. You need to insert the SIM card into another GSM cellular phone to receive calls at that phone, make calls from that phone, or receive other subscribed services.

GSM - The Base Station Subsystem (BSS)

The BSS is composed of two parts −

- The Base Transceiver Station (BTS)
- The Base Station Controller (BSC)

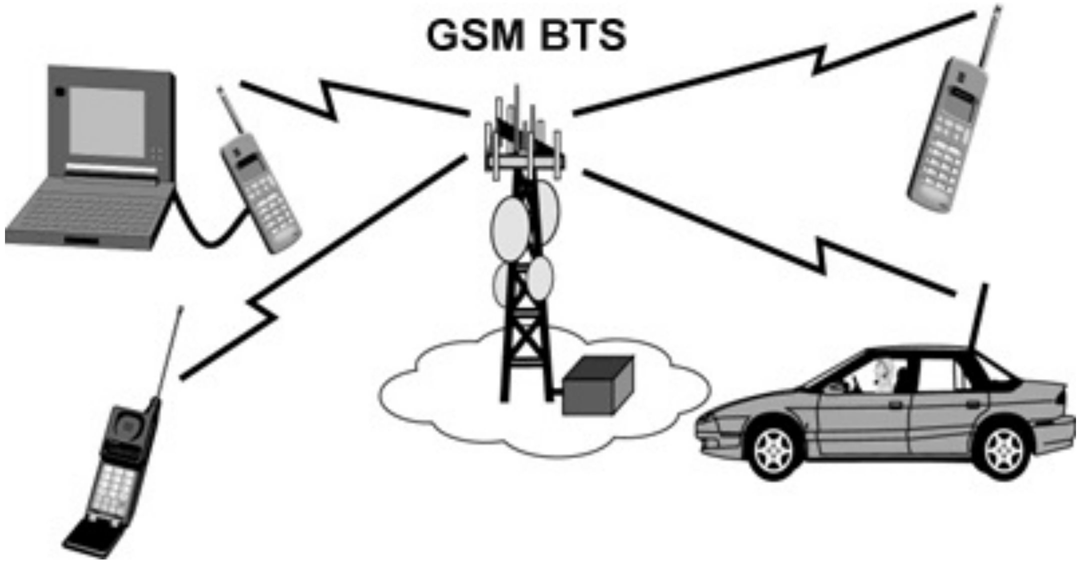
The BTS and the BSC communicate across the specified Abis interface, enabling operations between components that are made by different suppliers. The radio components of a BSS may consist of four to seven or nine cells. A BSS may have one or more base stations. The BSS uses the Abis interface between the BTS and the BSC. A separate high-speed line (T1 or E1) is then connected from the BSS to the Mobile MSC.



The Base Transceiver Station (BTS)

The BTS houses the radio transceivers that define a cell and handles the radio link protocols with the MS. In a large urban area, a large number of BTSs may be deployed.

The BTS corresponds to the transceivers and antennas used in each cell of the network. A BTS is usually placed in the center of a cell. Its transmitting power defines the size of a cell. Each BTS has between 1 and 16 transceivers, depending on the density of users in the cell. Each BTS serves as a single cell.



It also includes the following functions −

- Encoding, encrypting, multiplexing, modulating, and feeding the RF signals to the antenna
- Transcoding and rate adaptation
- Time and frequency synchronizing
- Voice through full- or half-rate services
- Decoding, decrypting, and equalizing received signals
- Random access detection
- Timing advances
- Uplink channel measurements

The Base Station Controller (BSC)

The BSC manages the radio resources for one or more BTSs. It handles radio channel setup, frequency hopping, and handovers. The BSC is the connection between the mobile and the MSC. The BSC also translates the 13 Kbps voice channel used over the radio link to the standard 64 Kbps channel used by the Public Switched Telephone Network (PSDN) or ISDN.

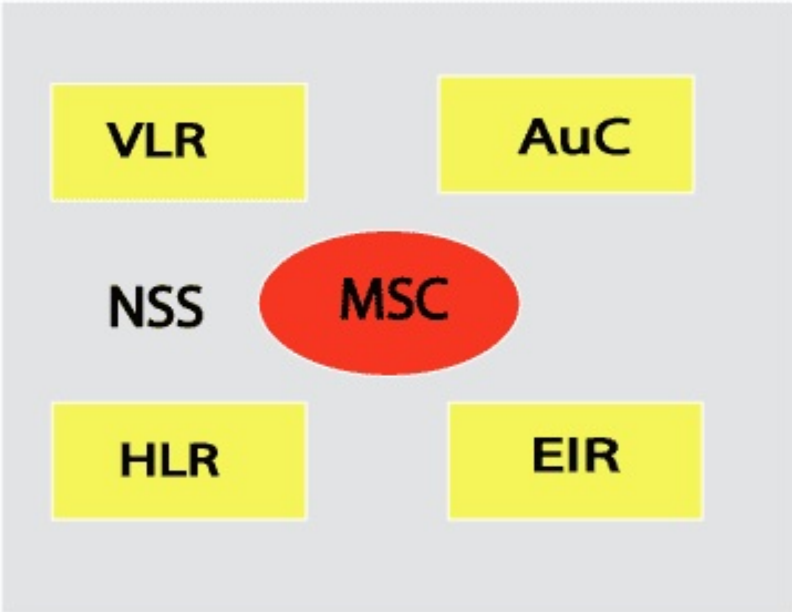
It assigns and releases frequencies and time slots for the MS. The BSC also handles intercell handover. It controls the power transmission of the BSS and MS in its area. The function of the BSC is to allocate the necessary time slots between the BTS and the MSC. It is a switching device that handles the radio resources.

The additional functions include−

- Control of frequency hopping
- Performing traffic concentration to reduce the number of lines from the MSC
- Providing an interface to the Operations and Maintenance Center for the BSS
- Reallocation of frequencies among BTSs
- Time and frequency synchronization
- Power management
- Time-delay measurements of received signals from the MS

GSM - The Network Switching Subsystem (NSS)

The Network switching system (NSS), the main part of which is the Mobile Switching Center (MSC), performs the switching of calls between the mobile and other fixed or mobile network users, as well as the management of mobile services such as authentication.



The switching system includes the following functional elements −

Home Location Register (HLR)

The HLR is a database used for storage and management of subscriptions. The HLR is considered the most important database, as it stores permanent data about subscribers, including a subscriber's service profile, location information, and activity status. When an individual buys a subscription in the form of SIM, then all the information about this subscription is registered in the HLR of that operator.

Mobile Services Switching Center (MSC)

The central component of the Network Subsystem is the MSC. The MSC performs the switching of calls between the mobile and other fixed or mobile network users, as well as the management of mobile services such as registration, authentication, location updating, handovers, and call routing to a roaming subscriber. It also performs such functions as toll ticketing, network interfacing, common channel signaling, and others. Every MSC is identified by a unique ID.

Visitor Location Register (VLR)

The VLR is a database that contains temporary information about subscribers that is needed by the MSC in order to service visiting subscribers. The VLR is always integrated with the MSC. When a mobile station roams into a new MSC area, the VLR connected to that MSC will request data about the mobile station from the HLR. Later, if the mobile station makes a call, the VLR will have the information needed for call setup without having to interrogate the HLR each time.

Authentication Center (AUC)

The Authentication Center is a protected database that stores a copy of the secret key stored in each subscriber's SIM card, which is used for authentication and ciphering of the radio channel. The AUC protects network operators from different types of fraud found in today's cellular world.

Equipment Identity Register (EIR)

The Equipment Identity Register (EIR) is a database that contains a list of all valid mobile equipment on the network, where its International Mobile Equipment Identity (IMEI) identifies each MS. An IMEI is marked as invalid if it has been reported stolen or is not type approved.

GSM - The Operation Support Subsystem (OSS)

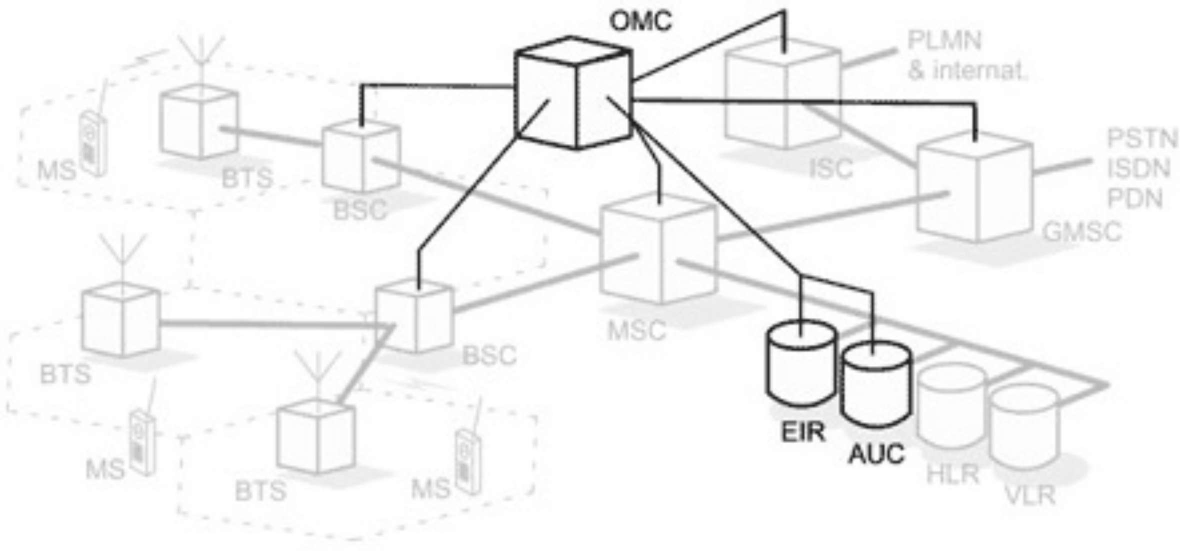
The operations and maintenance center (OMC) is connected to all equipment in the switching system and to the BSC. The implementation of OMC is called the operation and support system (OSS).

Here are some of the OMC functions−

- Administration and commercial operation (subscription, end terminals, charging, and statistics).
- Security Management.
- Network configuration, Operation, and Performance Management.
- Maintenance Tasks.

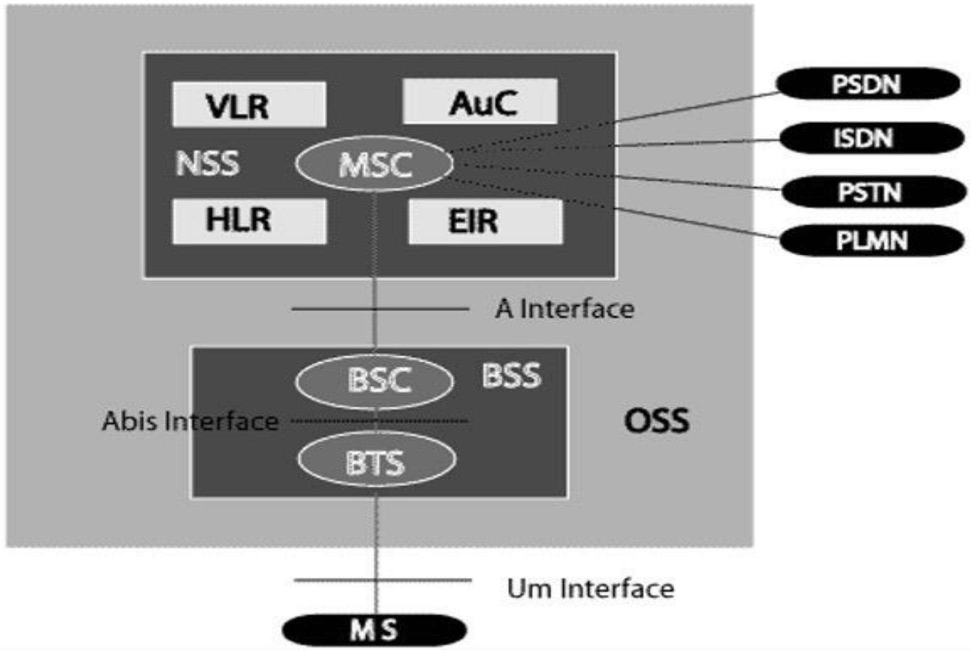
The operation and Maintenance functions are based on the concepts of the Telecommunication Management Network (TMN), which is standardized in the ITU-T series M.30.

Following is the figure, which shows how OMC system covers all the GSM elements.



The OSS is the functional entity from which the network operator monitors and controls the system. The purpose of OSS is to offer the customer cost-effective support for centralized, regional, and local operational and maintenance activities that are required for a GSM network. An important function of OSS is to provide a network overview and support the maintenance activities of different operation and maintenance organizations.

A simple pictorial view of the GSM architecture is given below −



The additional components of the GSM architecture comprise of databases and messaging systems functions −

- Home Location Register (HLR)
- Visitor Location Register (VLR)
- Equipment Identity Register (EIR)
- Authentication Center (AuC)
- SMS Serving Center (SMS SC)
- Gateway MSC (GMSC)
- Chargeback Center (CBC)
- Transcoder and Adaptation Unit (TRAU)

The MS and the BSS communicate across the Um interface. It is also known as the air interface or the radio link. The BSS communicates with the Network Service Switching (NSS) center across the A interface.

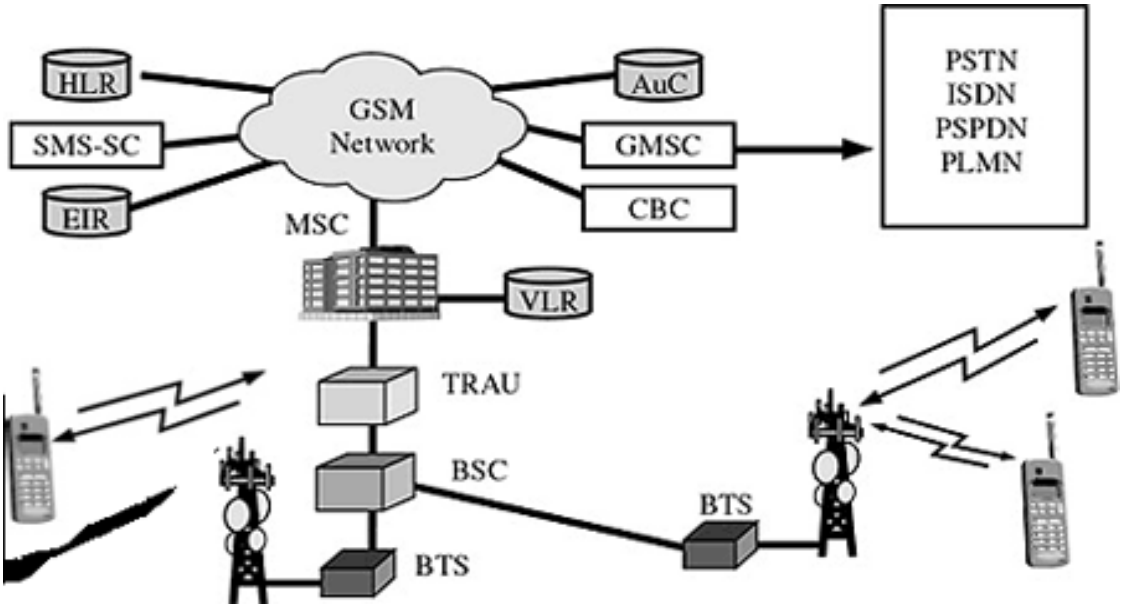
GSM network areas

In a GSM network, the following areas are defined −

- Cell − Cell is the basic service area; one BTS covers one cell. Each cell is given a Cell Global Identity (CGI), a number that uniquely identifies the cell.
- Location Area − A group of cells form a Location Area (LA). This is the area that is paged when a subscriber gets an incoming call. Each LA is assigned a Location Area Identity (LAI). Each LA is served by one or more BSCs.

- MSC/VLR Service Area − The area covered by one MSC is called the MSC/VLR service area.
- PLMN − The area covered by one network operator is called the Public Land Mobile Network (PLMN). A PLMN can contain one or more MSCs.

The following diagram shows the GSM network along with the added elements −



Frequency Bands and Channels:

Modulation

Modulation is the process of transforming the input data into a suitable format for the transmission medium. The transmitted data is demodulated back to its original form at the receiving end. The GSM uses Gaussian Minimum Shift Keying (GMSK) modulation method.

Access Methods

Radio spectrum being a limited resource that is consumed and divided among all the users, GSM devised a combination of TDMA/FDMA as the method to divide the bandwidth among the users. In this process, the FDMA part divides the frequency of the total 25 MHz bandwidth into 124 carrier frequencies of 200 kHz bandwidth.

Each BS is assigned with one or multiple frequencies, and each of this frequency is divided into eight timeslots using a TDMA scheme. Each of these slots are used for both transmission as well as reception of data. These slots are separated by time so that a mobile unit doesn’t transmit and receive data at the same time.

Transmission Rate

The total symbol rate for GSM at 1 bit per symbol in GMSK produces 270.833 K symbols/second. The gross transmission rate of a timeslot is 22.8 Kbps.

GSM is a digital system with an over-the-air bit rate of 270 kbps.

Frequency Band

The uplink frequency range specified for GSM is 933 - 960 MHz (basic 900 MHz band only). The downlink frequency band 890 - 915 MHz (basic 900 MHz band only).

Channel Spacing

Channel spacing indicates the spacing between adjacent carrier frequencies. For GSM, it is 200 kHz.

Speech Coding

For speech coding or processing, GSM uses Linear Predictive Coding (LPC). This tool compresses the bit rate and gives an estimate of the speech parameters. When the audio signal passes through a filter, it mimics the vocal tract. Here, the speech is encoded at 13 kbps.

Duplex Distance

Duplex distance is the space between the uplink and downlink frequencies. The duplex distance for GSM is 80 MHz, where each channel has two frequencies that are 80 MHz apart.

Misc

- Frame duration − 4.615 mS
- Duplex Technique − Frequency Division Duplexing (FDD) access mode previously known as WCDMA.
- Speech channels per RF channel − 8.

Frames in GSM:

The basic element in the GSM frame structure is the frame itself. This comprises the eight slots, each used for different users within the TDMA system. As mentioned in another page of the tutorial, the slots for transmission and reception for a given mobile are offset in time so that the mobile does not transmit and receive at the same time.

The basic GSM frame defines the structure upon which all the timing and structure of the GSM messaging and signalling is based. The fundamental unit of time is called a burst period and it lasts for approximately 0.577 ms (15/26 ms). Eight of these burst periods are grouped into what is known as a TDMA frame. This lasts for approximately 4.615 ms (i.e.120/26 ms) and it forms the basic unit for the definition of logical channels. One physical channel is one burst period allocated in each TDMA frame.

In simplified terms the base station transmits two types of channel, namely traffic and control. Accordingly the channel structure is organised into two different types of frame, one for the traffic on the main traffic carrier frequency, and the other for the control on the beacon frequency.

GSM multiframe

The GSM frames are grouped together to form multiframes and in this way it is possible to establish a time schedule for their operation and the network can be synchronised.

GSM Frame Structure showing the relationship between slots, frames, multiframes, superframes & hyperframes

There are several GSM multiframe structures:

- Traffic multiframe: The Traffic Channel frames are organised into multiframes consisting of 26 bursts and taking 120 ms. In a traffic multiframe, 24 bursts are used for traffic. These are numbered 0 to 11 and 13 to 24. One of the remaining bursts is then used to accommodate the SACCH, the remaining frame remaining free. The actual position used alternates between position 12 and 25.
- Control multiframe: the Control Channel multiframe that comprises 51 bursts and occupies 235.4 ms. This always occurs on the beacon frequency in time slot zero and it may also occur within slots 2, 4 and 6 of the beacon frequency as well. This multiframe is subdivided into logical channels which are time-scheduled. These logical channels and functions include the following:
    - Frequency correction burst
    - Synchronisation burst
    - Broadcast channel (BCH)
    - Paging and Access Grant Channel (PACCH)
    - Stand Alone Dedicated Control Channel (SDCCH)

GSM Superframe

Multiframes are then constructed into superframes taking 6.12 seconds. These consist of 51 traffic multiframes or 26 control multiframes. As the traffic multiframes are 26 bursts long and the control multiframes are 51 bursts long, the different number of traffic and control multiframes within the superframe, brings them back into line again taking exactly the same interval.

GSM Hyperframe

Above this 2048 superframes (i.e. 2 to the power 11) are grouped to form one hyperframe which repeats every 3 hours 28 minutes 53.76 seconds. It is the largest time interval within the GSM frame structure.

Within the GSM hyperframe there is a counter and every time slot has a unique sequential number comprising the frame number and time slot number. This is used to maintain synchronisation of the different scheduled operations with the GSM frame structure. These include functions such as:

- Frequency hopping: Frequency hopping is a feature that is optional within the GSM system. It can help reduce interference and fading issues, but for it to work, the transmitter and receiver must be synchronised so they hop to the same frequencies at the same time.

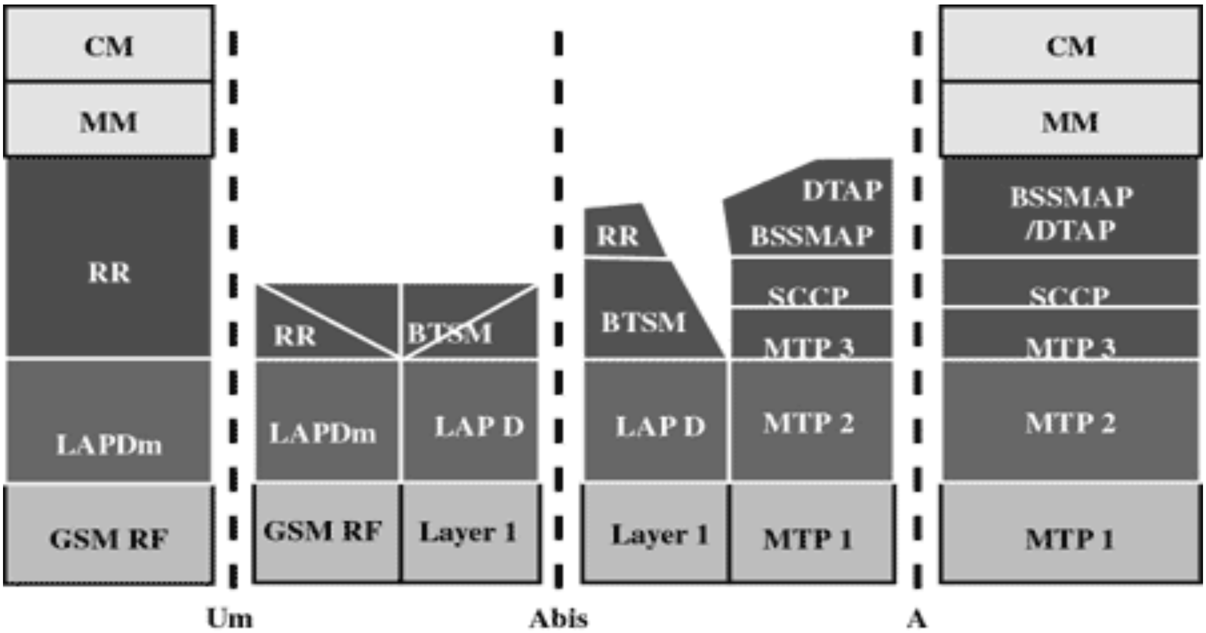
- Encryption: The encryption process is synchronised over the GSM hyperframe period where a counter is used and the encryption process will repeat with each hyperframe. However, it is unlikely that the cellphone conversation will be over 3 hours and accordingly it is unlikely that security will be compromised as a result.

The slots and frames are handled in a very logical manner to enable the system to expect and accept the data that needs to be sent. Organising it in this logical fashion enables it to be handled in the most efficient manner.

Layers and Protocols in GSM:

GSM architecture is a layered model that is designed to allow communications between two different systems. The lower layers assure the services of the upper-layer protocols. Each layer passes suitable notifications to ensure the transmitted data has been formatted, transmitted, and received accurately.

The GMS protocol stacks diagram is shown below −



MS Protocols

Based on the interface, the GSM signaling protocol is assembled into three general layers −

- Layer 1 − The physical layer. It uses the channel structures over the air interface.
- Layer 2 − The data-link layer. Across the Um interface, the data-link layer is a modified version of the Link access protocol for the D channel (LAP-D) protocol used in ISDN, called Link access protocol on the Dm channel (LAP-Dm). Across the A interface, the Message Transfer Part (MTP), Layer 2 of SS7 is used.
- Layer 3 − GSM signalling protocol's third layer is divided into three sublayers −
    - Radio Resource Management (RR),
    - Mobility Management (MM), and
    - Connection Management (CM).

MS to BTS Protocols

The RR layer is the lower layer that manages a link, both radio and fixed, between the MS and the MSC. For this formation, the main components involved are the MS, BSS, and MSC. The responsibility of the RR layer is to manage the RR-session, the time when a mobile is in a dedicated mode, and the radio channels including the allocation of dedicated channels.

The MM layer is stacked above the RR layer. It handles the functions that arise from the mobility of the subscriber, as well as the authentication and security aspects. Location management is concerned with the procedures that enable the system to know the current location of a powered-on MS so that incoming call routing can be completed.

The CM layer is the topmost layer of the GSM protocol stack. This layer is responsible for Call Control, Supplementary Service Management, and Short Message Service Management. Each of these services are treated as individual layer within the CM layer. Other functions of the CC sublayer include call establishment, selection of the type of service (including alternating between services during a call), and call release.

BSC Protocols

The BSC uses a different set of protocols after receiving the data from the BTS. The Abis interface is used between the BTS and BSC. At this level, the radio resources at the lower portion of Layer 3 are changed from the RR to the Base Transceiver Station Management (BTSM). The BTS management layer is a relay function at the BTS to the BSC.

The RR protocols are responsible for the allocation and reallocation of traffic channels between the MS and the BTS. These services include controlling the initial access to the system, paging for MT calls, the handover of calls between cell sites, power control, and call termination. The BSC still has some radio resource management in place for the frequency coordination, frequency allocation, and the management of the overall network layer for the Layer 2 interfaces.

To transit from the BSC to the MSC, the BSS mobile application part or the direct application part is used, and SS7 protocols is applied by the relay, so that the MTP 1-3 can be used as the prime architecture.

MSC Protocols

At the MSC, starting from the BSC, the information is mapped across the A interface to the MTP Layers 1 through 3. Here, Base Station System Management Application Part (BSS MAP) is said to be the equivalent set of radio resources. The relay process is finished by the layers that are stacked on top of Layer 3 protocols, they are BSS MAP/DTAP, MM, and CM. This completes the relay process. To find and connect to the users across the network, MSCs interact using the control-signalling network. Location registers are included in the MSC databases to assist in the role of determining how and whether connections are to be made to roaming users.

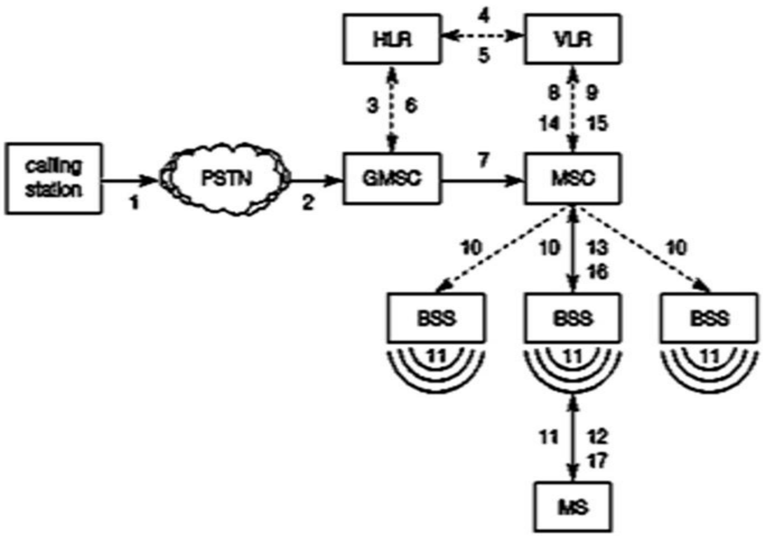
Each GSM MS user is given a HLR that in turn comprises of the user’s location and subscribed services. VLR is a separate register that is used to track the location of a user. When the users move out of the HLR covered area, the VLR is notified by the MS to find the location of the user. The VLR in turn, with the help of the control network, signals the HLR of the MS's new location. With the help of location information contained in the user's HLR, the MT calls can be routed to the user.

Localization and calling in GSM:

GSM has an additional feature of worldwide localization of user's. GSM System always know where a user currently is, and the same phone number is valid worldwide.

Localization:

- GSM performs periodic location updates even if a user does not use the mobile station.
- The HLR always contains information about the current location
- The VLR currently responsible for the MS informs the HLR about location changes.
- As soon as an MS moves into the range of a new location area (new VLR) the HLR sends all user data needed to the new VLR.
- Changing VLRs with uninterrupted availability of all services is also called roaming.
- Following are some numbers which are needed to locate an MS and to address.



- Mobile station international ISDN number (MSISDN): This number consists of the country code (CC), the national destination code (NDC) (i.e., the address of the network provider, e.g., 179), and the subscriber number (SN).
- International mobile subscriber identity (IMSI): IMSI consists of a mobile country code (MCC) the mobile network code (MNC) (i.e., the code of the network provider), and finally the mobile subscriber identification number (MSIN).
- Temporary mobile subscriber identity (TMSI): TMSI is selected by the current VLR and is only valid temporarily and within the location area of the VLR
- Mobile station7 roaming number (MSRN): MSRN contains the current visitor country code (VCC), the visitor national destination code (VNDC), the identification of the current MSC together with the subscriber number.

Calling:

Mobile Terminated Call:

- A situation in which a station calls a mobile station.
- Basic steps needed to connect the calling station with the mobile user are:
- Step 1: a user dials the phone number of a GSM subscriber.
- Step 2: The fixed network (PSTN) notices that the number belongs to a user in the GSM network and forwards the call setup to the Gateway MSC.
- Step 3: The GMSC identifies the HLR for the subscriber and signals the call setup to the HLR.
- Step 4: The HLR now checks whether the number exists and whether the user has subscribed to the requested services, and requests an MSRN from the current VLR.
- Step 5:MSRN is received

Step 6: the HLR determine the MSC responsible for the MS and forwards this information to the GMSC.

- Step 7: The GMSC now forward the call setup request to the MSC indicated.
- Step 8: MSC requests the current status of the MS from the VLR.
- Step 9 &10: If MS is available MSC initiates paging in all cells.
- Step11: BTSs of all BSSs transmit this paging signal to MS If the MS answers (12 and 13), the VLR perform security checks (encryption). The VLR signals to the MSC to set up a connection to the MS (steps 15 to 17).

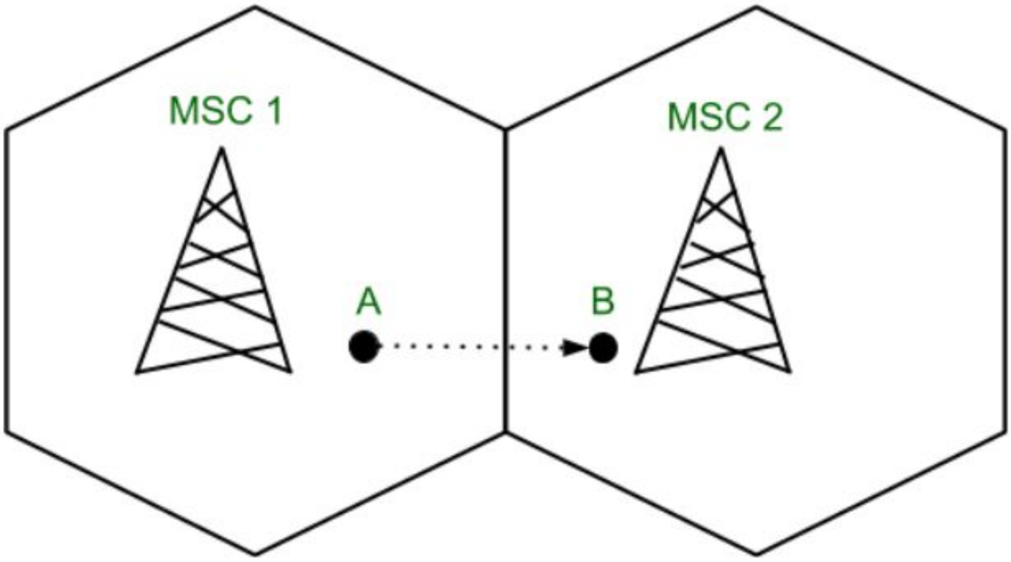
Handoff in Cellular Telecommunications:

In cellular telecommunications, the terms handover or handoff refers to the process of transferring an ongoing call or data connectivity from one Base Station to another Base Station. When a mobile moves into a different cell while the conversation is in progress then the MSC (Mobile Switching Center) transfers 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 users goes on without interrupting.

Types of Handoff

- Hard Handoff
- Soft Handoff
- Delayed Handoff
- Mobile-Assisted Handoff

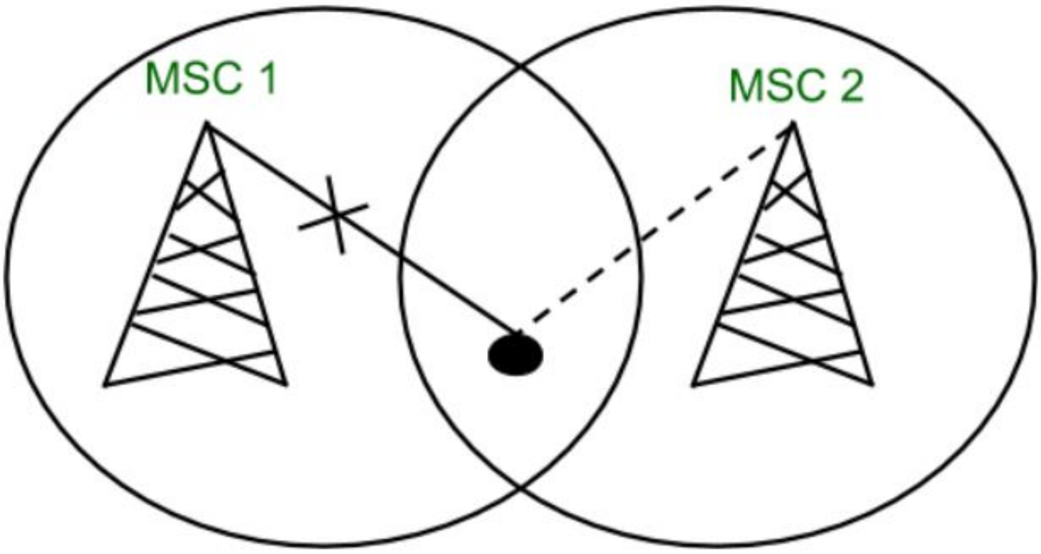


Hard Handoff

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.

It is generally implemented in Time Division Multiplexing and Frequency Division Multiplexing when a user connects to the base station with a fluctuating radio frequency.

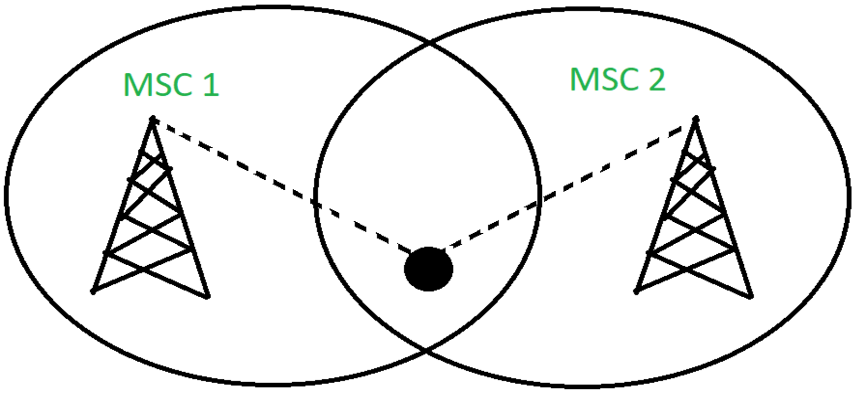
- Hard Handoff is cheaper in cost as compared to soft Handoff because only one channel needs to be active at a time.
- It is more efficient than soft handoff, that’s why hard handoffs are widely implemented.
- Sometimes, a delay can be experienced while switching base stations.



Soft Handoff

Soft Handoff is a mechanism in which the device gets connected with two or more base stations at the same time. 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. If a channel is in power loss then another channel will always be on standby mode so this makes it best in terms of quality as compared to Hard handoff. Soft handoffs are used in devices supporting CDMA/WDMA networks

- High Transmission speed as more than one repeater can transmit signals.
- It has a very low delay in signals.
- It can't be implemented on devices supporting GSM or LTE networks.



Delayed Handoff

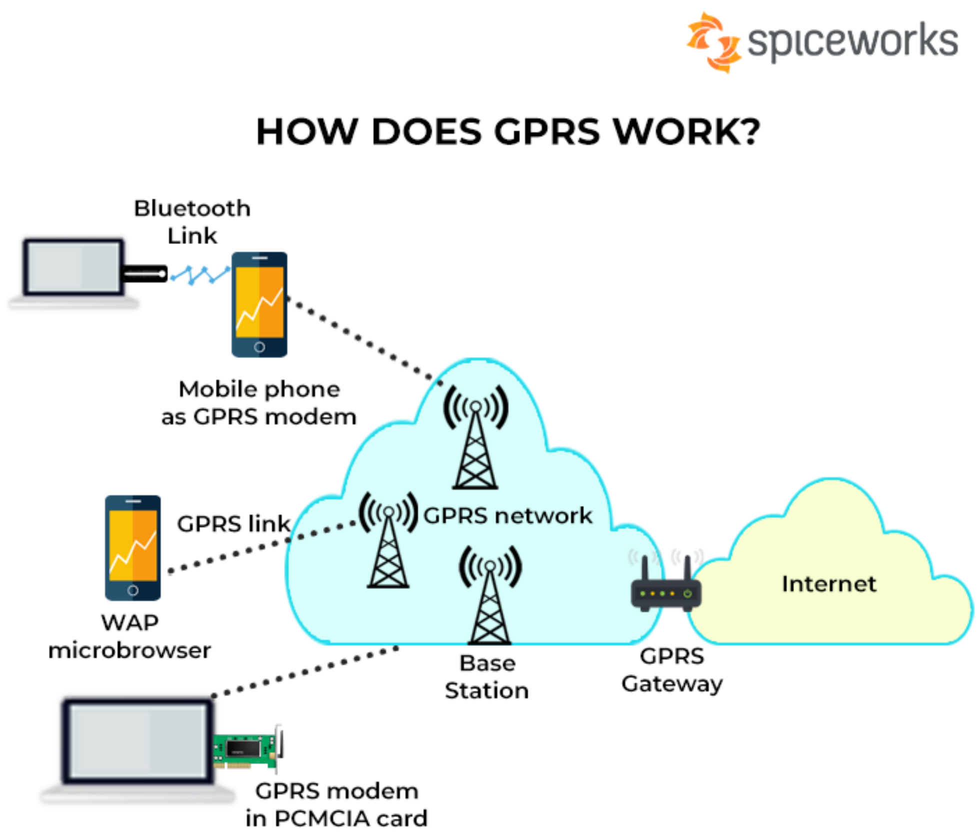
Delayed handoff occurs when no base station is available for accepting the transfer. The call continues until the signal strength reaches a threshold, and after that, the call is dropped. Generally, it happens when the user is out of the network coverage area, or at some dead spots where network reach is very low.

Mobile-Assisted Handoff

Mobile-Assisted handoff is generally used when a mobile phone helps a base station to transfer the call to another base station with better-improvised connectivity and more signal strength. This handoff is used in TDMA technique-based GSM devices.

General packet radio service (GPRS):

General packet radio service (GPRS) is defined as a mobile communications standard that operates on 2G and 3G cellular networks to enable moderately high-speed data transfers using packet-based technologies.



General packet radio service (GPRS) is essentially a packet-switching technology that allows information to be transmitted via mobile networks. This is utilized for internet connectivity, multimedia messaging service, and other types of data transmission. GPRS is supported by GPRS cellphones, as well as laptops and handheld devices equipped with GPRS modems. Subscribers have reported downstream bandwidths of up to 80 Kbps.

GPRS could be employed to facilitate connections related to Internet protocols which provide a set of functions including commercial and enterprise applications. Before the transmission, the information is split into individual packets and routed through the core network and radio. At the receiver's end, the data is reattached.

The global system for mobile communications (GSM) is the primary standard for the second generation (2G) cellular network, while GPRS is an improved version. GPRS is not like GSM's short messaging service (GSM-SMS), which has a message length limit of 160 bytes. GPRS has a theoretical maximum speed of 115 kbps, although most networks operate at roughly 35 kbps. GPRS is sometimes known as 2.5G unofficially. It's a third-generation route to gain availability on the internet.

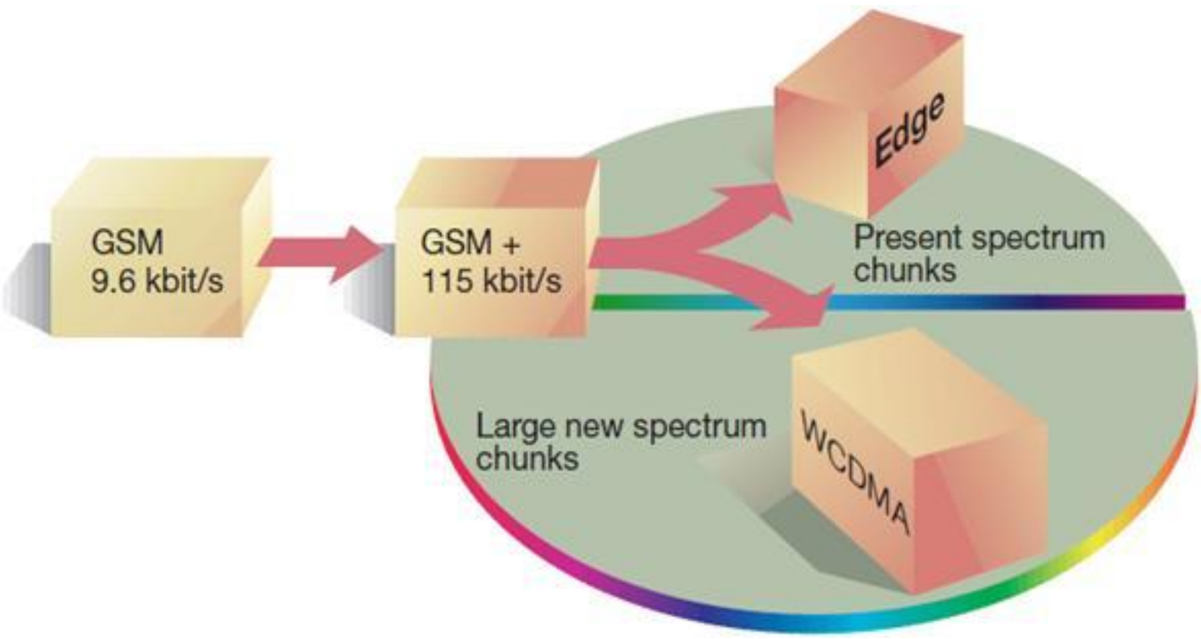
GPRS can operate from either symmetric or asymmetric configuration, whereas frequency for either direction is determined by which one of the 12 multislot provider classes are chosen. The number of time slots for every path is determined by the multislot service class, for every time slot propping up a theoretical connection speed of 21.4 kbps. One of the most basic is service class 1, which allows a one-time slot for each path. Service class 12 is by far the most proficient, with four-time slots in every direction.

GSM-IP stands for global-system mobile communications internet protocol and is also another name for GPRS. It ensures that customers are connected, making audio calls and browsing the internet. This method enables packet radio access to even time division multiple access (TDMA) customers. GPRS also allows network operators to deploy an IP-based core architecture for integrated audio and data applications, which can be used and improved for 3G networks.

GPRS used to be the fastest network-accessible option – this has, however, changed in terms of speed and dependability, as both 3G and 4G networks surpass it. However, it is still used in several areas, particularly rural regions and emerging nations that have not ventured into other more sophisticated technology. When a GPRS network is available, most smartphones might use it, albeit those used to better connections will notice the considerably slower bandwidth and long waits.

EDGE: Enhanced Data Rates for GSM (Global System for Mobile) Evolution:

EDGE is an enhanced version of GSM and offers high-speed 3G built on GSM. It is a type of data system used on the GSM network used to allow improved data transmission rates. It can transmit three times more bits than GPRR in the same length of time. EDGE is an "add-on" to GPRS; it cannot work alone. It was deployed on GSM networks by AT&T in 2003 in the United States.



Data Speed

EDGE has successfully replaced GSM without disrupting the existing frequency reuse scheme. Technically, EDGE provides a speed of 384kbps (which is much higher than the data rate of GPRS) but is labelled as 2.75G by the industry.

Key Elements added in EDGE

- Use of 8PSK: The modulation format has been changed to 8PSK, which provides the advantage of conveying 3 bits per symbol.

- Base station: Some small changes have been made in the base station.
- Upgrade to network architecture: It offers IP based transfer rate, which makes it necessary to add some more network elements.
- Mobile stations: To use EDGE facilities, it is mandatory to give a GSM EDGE handset because each and every set can't be upgraded.

Features

- Provide increased data rate, e.g., high speed on GSM radio carriers as provided by broadband.
- It can retransmit a packet with more robust coding, which means re-segmentation is possible.
- In EDGE, packets are addressed up to 2048, while in GSM it is from 1 to 128.
- Similarly, EDGE has a window size of 1024, and GSM's window size is 64.
- EDGE reduces the number of bursts to retransmit when an error occurs.
- It allows multimedia file transfer, web browsing and video conferencing through wireless terminals.
- It enables operators to triple the data rate of subscribers and provide extra capacity to their voice communications.
- It requires fewer radio resources to support the same traffic as supported by GSM networks.

3G Cellular System:

3G is the next generation of wireless network technology that provides high speed bandwidth (high data transfer rates) to handheld devices. The high data transfer rates will allow 3G networks to offer multimedia services combining voice and data. Specifically, 3G wireless networks support the following maximum data transfer rates:

- 2.05 Mbits/second to stationary devices.
- 384 Kbits/second for slowly moving devices, such as a handset carried by a walking user.
- 128 Kbits/second for fast moving devices, such as handsets in moving vehicles.

These data rates are the absolute maximum numbers. For example, in the stationary case, the 2.05 Mb/second rate is for one user hogging the entire capacity of the base station. This data rate will be far lower if there is voice traffic (the actual data rate would depend upon the number of calls in progress).

The maximum data rate of 128Kbits/second for moving devices is about ten times faster than that available with the current 2G wireless networks. Unlike 3G networks, 2G networks were designed to carry voice but not data.

3G wireless networks have the bandwidth to provide converged voice and data services. 3G services will seamlessly combine superior voice quality telephony, high-speed mobile IP services, information technology, rich media, and offer diverse content.

Some characteristics of 3G services that have been proposed are:

- Always-on connectivity. 3G networks use IP connectivity, which is packet based.
- Multi-media services with streaming audio and video.
- Email with full-fledged attachments such as PowerPoint files.
- Instant messaging with video/audio clips.
- Fast downloads of large files such as faxes and PowerPoint files.
- Access to corporate applications.

Is there a 3G Standard?

The International Telecommunication Union (ITU) is responsible for standardizing 3G. After trying to establish a single 3G standard, ITU finally approved a family of five 3G standards, which are part of the 3G framework known as IMT-2000:

- Three standards based on CDMA, namely CDMA2000, WCDMA, and TD-SCDMA.
- Two standards based on based on TDMA, namely, FDMA/TDMA and TDMA-SC (EDGE).

The CDMA standards are the leading 3G standards.

Europe, Japan, and Asia have agreed upon a 3G standard called the Universal Mobile Telecommunications System (UMTS), which is WCDMA operating at 2.1GHz. Note that UMTS and WCDMA are often used as synonyms. In the USA and other parts of Americas, WCDMA will have to use another part of the radio spectrum. Incidentally, most of the world's wireless operators have chosen to use UMTS.

What are the Advantages of 3G?

3G networks offer users advantages such as:

- New radio spectrum to relieve overcrowding in existing systems.
- More bandwidth, security, and reliability.
- Interoperability between service providers.
- Fixed and variable data rates.
- Asymmetric data rates.
- Backward compatibility of devices with existing networks.
- Always-online devices. 3G will use IP connectivity, IP is packet based (not circuit based).
- Rich multimedia services.

What are Some Disadvantages of 3G?

There are some issues in deploying 3G:

- The cost of upgrading base stations and cellular infrastructure to 3G is very high.
- Requires different handsets and there is the issue of handset availability. 3G handsets will be a complex product. Roaming and making both data/voice work has not yet been

demonstrated. Also the higher power requirements (more bits with the same energy/bit) demand a larger handset, shorter talk time, and larger batteries)
- Base stations need to be closer to each other (more cost).
- Tremendous spectrum-license costs, network deployment costs, handset subsidies to subscribers, etc.
- Wireless service providers in Germany and Britain who won spectrum licenses in auctions, paid astronomical prices for them. As a result, they have little money left for building the infrastructure. Consequently, deployment of 3G in Germany and Britain will be delayed.

What Applications will 3G enable?

3G represents a paradigm shift from the voice centric world of the previous generations of wireless networks to the multi-media centric world of 3G. Reflecting the high 3G bandwidth and the fact that it is packet based, 3G devices will offer capabilities that are a combination of a phone, PC, and a TV. Examples of services that will be 3G networks can offer are:

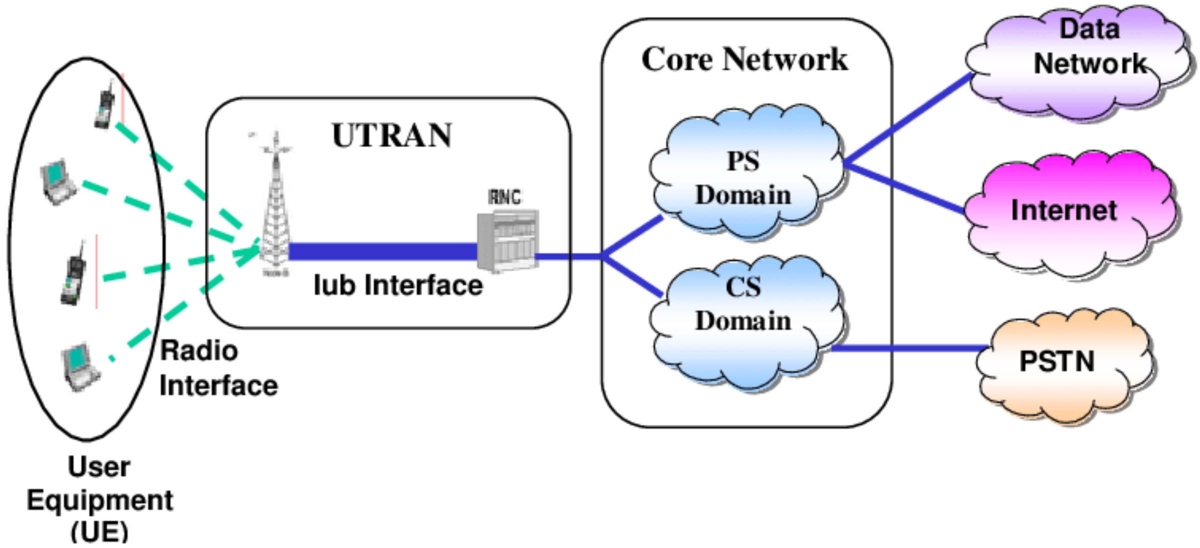
- Always-on connection with users paying only when sending or receiving packets.
- Web surfing.
- Instant messaging and email with multimedia attachments.
- Location based services.
- Personalized services, where content can be pushed to users.
- Broadband multimedia data services like video conferencing and streaming video.
- Receiving faxes.
- Global roaming capability.
- Getting maps and directions with a multi-modal user interface.
- Customized entertainment.
- Simultaneous access to multiple services, each service offering some combination of voice, video, data, etc.

Potential Killer Applications

The high bandwidth of 3G networks will lead to the creation of new services, some of which we have no idea about at this time. The big question is what services will be big revenue makers for the wireless service providers. In 2G networks, the big winners have been short text messaging in GSM networks (Europe and countries other than USA) and image downloads and forwarding on iMode networks in Japan. Two candidate services for big winners in 3G networks are video conferencing and video messaging.

UMTS System Architecture:

Universal mobile telecommunication system (UMTS) is defined as the third-generation (3G) mobile network built on the global GSM standard, compatible with data transfer up to 2 Megabits per second.



Methodology of a UMTS System

UMTS is popularly known as a third-generation (3G) cellular network. It was seen as a better cellular technology for data transfer than its predecessor, the GSM technology, which used GPRS and EDGE data services, primarily due to its speed of transfer and operation. It is a pioneering wireless radio technology associated with third-generation (3G) cellular networks. AT&T first deployed it in North America in the early 2000s, and its use spread globally over the next few years.

Today, UMTS is used interchangeably with 3G. Unlike global system for mobile communications (GSM) – which was widely used before the deployment of UMTS – UMTS offers faster data transfer, improved cellular capabilities, greater range/bandwidth, and better radio spectrum efficiency.

This ensures a better method of transferring data and a better customer experience. Although UMTS uses code division multiple access (CDMA) technology, it has a broader bandwidth than other CDMA systems, e.g., CDMA2000. So, it is sometimes referred to as wideband CDMA or WCDMA.

CDMA is a channel access network that allows multiple transmitters to transmit information over a single communication channel simultaneously. Wideband CDMA was effective in the transfer of 'data packets' over the air from one user to the other, unlike GSM, which worked using a mix of frequency division multiple access (FDMA) and time division multiple access (TDMA) as its communication services.

The frequency spectrum is broken down into smaller channels in GSM communication and then distributed based on time slots. This was not convenient for simultaneously transferring large amounts of information. Hence, big corporations sought a better technology, so UMTS was born.

Despite Its increased functionality, UMTS was not created to serve as a replacement for the GSM system but to act as a complementary technology. This ensures that one can use both network technologies in the same devices if they were made to access either network. Due to the need for better wireless connectivity of the Internet of Things (IoT) devices, UMTS has been widely applied due to its lesser cost, better customer experience, wide bandwidth, reliability, speed, and ease of application. UMTS also introduced more cellular capabilities like video streaming and mobile television, but significantly, a higher data transfer rate.

UTRAN (UMTS Terrestrial Radio Access Network) is a critical component of the Universal Mobile Telecommunications System (UMTS), which is a third-generation (3G) mobile communication system. UTRAN is responsible for providing the radio access to UMTS, facilitating communication between User Equipment (UE) such as mobile phones and the core network infrastructure.

Key Components and Functions of UTRAN:

- Node B (Base Station): The Node B is the primary building block of UTRAN. It is a radio transceiver station that communicates directly with UEs. Node Bs are distributed geographically to cover specific areas called "cells." Each Node B is connected to the UMTS Core Network (CN) through the Iub interface.
- Radio Network Controller (RNC): The RNC is the control element of UTRAN. It manages multiple Node Bs and oversees the overall radio resource allocation, mobility management, and handover procedures. The RNC is responsible for tasks such as power control, admission control, and flow control to ensure efficient and reliable communication.
- Iub Interface: The Iub interface is the connection between Node B and the RNC. It carries both user data and control information, allowing the RNC to manage and control the radio resources of multiple Node Bs.
- Iur Interface: The Iur interface is used to connect different RNCs in UTRAN. It facilitates inter-RNC communication and is essential for handover procedures between cells managed by different RNCs.
- Iu Interface: The Iu interface connects UTRAN to the UMTS Core Network (CN), which includes elements such as the Serving GPRS Support Node (SGSN) for packet-switched services and the Mobile Switching Center (MSC) for circuit-switched services.

Functions of UTRAN:

- Radio Resource Management (RRM): UTRAN manages radio resources, including frequencies and power levels, to optimize network performance and ensure efficient use of available spectrum.
- Mobility Management: UTRAN handles mobility-related tasks, such as tracking UE movements, initiating handovers between cells, and managing soft handover when a UE is within coverage of multiple Node Bs simultaneously.
- Uplink and Downlink Transmissions: UTRAN handles the transmission and reception of data between UEs and the Core Network. Uplink data (from UE to Core Network) is forwarded to the RNC for further processing, while downlink data (from Core Network to UE) is transmitted from the RNC to the appropriate Node B for delivery to the UE.
- Call Setup and Teardown: UTRAN is responsible for establishing and releasing calls, including voice calls and data sessions, between UEs and the Core Network.

- Security and Encryption: UTRAN ensures the security and privacy of user data by implementing encryption and authentication mechanisms during communication between the UE and the Core Network.

Evolution and Transition:

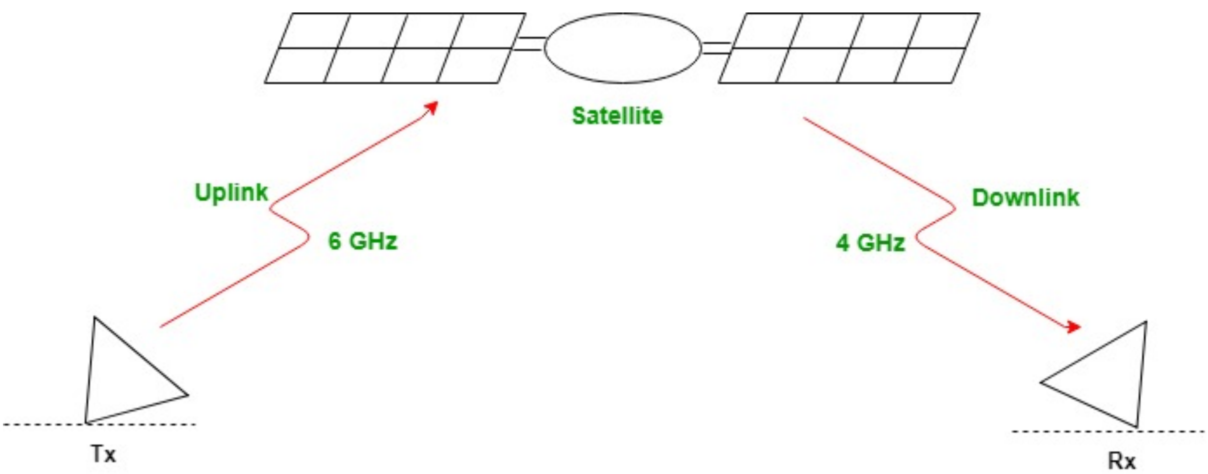
As mobile communication technology advanced, UTRAN evolved to support higher data rates and improved network performance. Enhanced technologies, such as High-Speed Packet Access (HSPA) and HSPA+, were introduced to provide higher data speeds and increased capacity within UTRAN. Eventually, UTRAN was succeeded by the Long-Term Evolution (LTE) technology, which represents the 4th generation (4G) of mobile communication systems. LTE and its advanced versions, such as LTE-Advanced and LTE-Advanced Pro, offer even higher data rates, lower latency, and improved spectral efficiency compared to UTRAN and 3G UMTS.

In conclusion, UTRAN (UMTS Terrestrial Radio Access Network) is a critical component of the UMTS 3G mobile communication system. It consists of Node Bs and Radio Network Controllers (RNCs) responsible for providing radio access, managing radio resources, and facilitating communication between User Equipment (UE) and the Core Network. Over time, UTRAN evolved to support higher data rates and improved performance, eventually leading to the transition to 4G LTE technology.

Global Mobile Satellite System:

GMSS stands for Global Mobile Satellite System. An artificial body which is placed in an orbit around the earth for the purpose of communication is known as Communication satellite. GMSS is a system which consists of various artificial communication satellites orbiting around the earth for the purpose of communication.

A satellite network is a combination of nodes that provides communication from one point on the Earth to another. A node in the network can be Satellite, an Earth station, or an End-user terminal or Telephone. Satellite networks are like cellular networks, they divide the planet into cells.

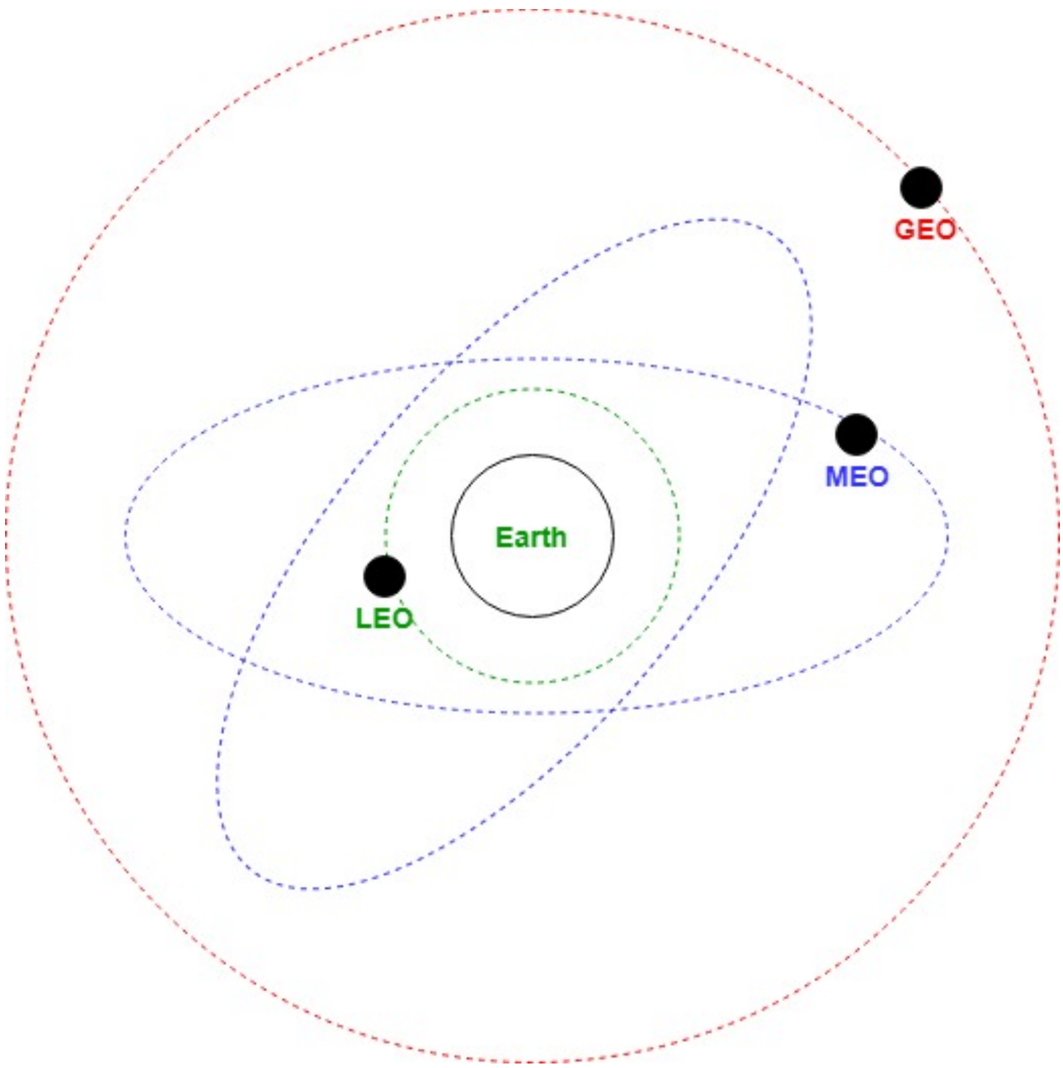


The frequencies reserved for the satellite microwave communication are in gigahertz(GHz) range. Each satellite sends and receives over two different bands. Transmission from earth to satellite is called the Uplink. Transmission from the satellite to the earth is called the Downlink.

Satellite frequency bands

Uplink and downlink frequencies must be different to avoid interference. Now, stations at the earth have greater power sources than that of satellite as it has only solar power. Also, higher frequency results in higher attenuation and to compensate with it more power is required. So, uplink uses higher frequency to penetrate the environment.

Satellite Orbits:



Orbit

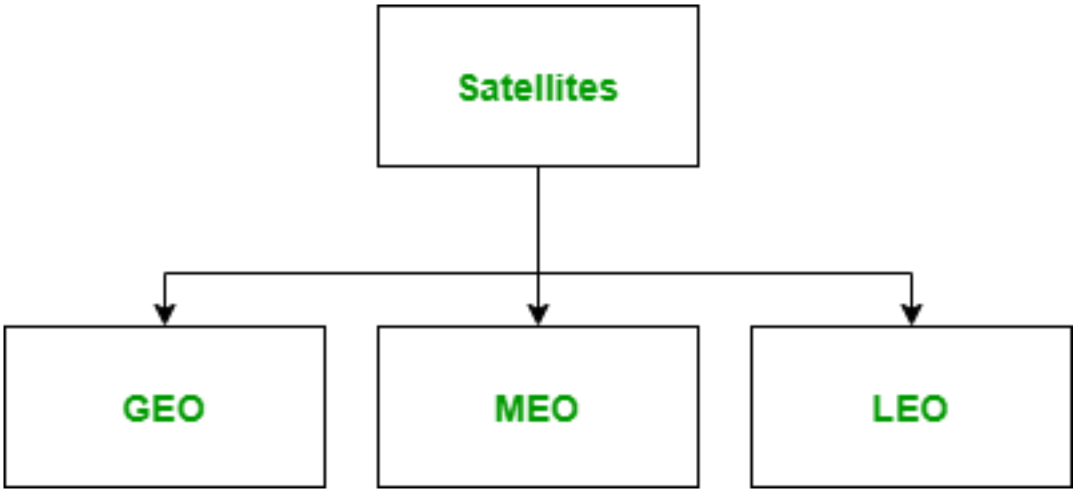
An artificial satellite needs to have an orbit, the path in which it travels around the Earth. The orbit can be equatorial, inclined or polar.

Footprint

Satellite process microwaves with bidirectional antennas. Therefore, the signal from the satellite is normally aimed at a specific area called the footprint.

Satellite Categories

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



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.

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.”

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.

Limitations of GPS:

Global Positioning System (GPS) is a powerful satellite-based navigation system, but it does have some limitations. Here are some of the key limitations of GPS:

- Signal Blockage: GPS signals can be blocked or weakened by physical obstructions like tall buildings, mountains, dense forests, and even certain types of construction materials. This can lead to inaccurate or lost GPS readings in urban environments or heavily wooded areas.
- Indoor Use: GPS signals struggle to penetrate buildings and structures, making it ineffective for indoor navigation. In such environments, alternative technologies like Wi-Fi-based positioning systems (WPS) or Bluetooth beacons are used.
- Urban Canyons: Tall buildings in densely populated areas can create "urban canyons" where GPS signals bounce off buildings, leading to multipath interference. This can result in inaccurate location data.
- Multi-Path Interference: This occurs when GPS signals reflect off surfaces (such as buildings or large bodies of water) before reaching the receiver. This can lead to incorrect positioning.
- Satellite Geometry: The accuracy of GPS depends on the arrangement of satellites in the sky. Poor satellite geometry, where the satellites are clustered in one area of the sky, can result in less accurate readings.
- Atmospheric Conditions: The Earth's atmosphere can affect the speed at which GPS signals travel, leading to minor errors in positioning.

- Signal Jamming and Spoofing: GPS signals can be intentionally jammed or spoofed, which can disrupt accurate navigation and introduce security risks.
- Limited Availability in Polar Regions: The arrangement of GPS satellites means that coverage is less reliable at high latitudes near the Earth's poles.
- Battery Consumption: Continuous use of GPS on a mobile device can drain the battery relatively quickly. This is particularly important for activities like hiking or extended navigation in remote areas.
- Signal Acquisition Time: In some cases, especially when first turned on or after a period of inactivity, GPS devices may take some time to acquire signals and provide an accurate location.
- Selective Availability (SA): While no longer active, the U.S. military used to introduce intentional errors into the GPS signals for security reasons. This could lead to less precise positioning.
- Lack of Vertical Accuracy: While GPS is excellent for horizontal positioning, it's less accurate in determining altitude (height above sea level). Additional systems like WAAS (Wide Area Augmentation System) are used to improve vertical accuracy.

Despite these limitations, GPS remains an invaluable tool for navigation in a wide range of applications, from driving and hiking to aviation and marine navigation. Additionally, technologies like Assisted GPS (A-GPS) and Differential GPS (DGPS) have been developed to mitigate some of these issues.

Beneficiaries of GPS:

Global Positioning System (GPS) technology has a wide range of beneficiaries across various industries and everyday activities. Here are some of the key beneficiaries of GPS:

- Navigation and Transportation:

    - Drivers: GPS navigation systems in cars and mobile devices help drivers find the best routes, avoid traffic, and reach their destinations efficiently.
    - Pilots: GPS is crucial for aircraft navigation, providing accurate information about position, altitude, and direction.
    - Mariners: GPS aids ships and boats in determining their exact location, helping them navigate safely on the open sea.

- Public Safety and Emergency Services:

    - Search and Rescue Teams: GPS allows for precise location tracking, which is critical for locating lost or injured individuals in remote areas.
    - Emergency Responders: GPS helps emergency services quickly locate and reach incidents, especially in unfamiliar or rapidly changing environments.

- Agriculture:

    - Farmers: GPS-guided tractors and machinery enable precise planting, fertilizing, and harvesting, leading to increased crop yields and efficiency in agriculture.

- Surveying and Construction:
    - Land Surveyors: GPS technology is used in land surveying and mapping, providing accurate and reliable data for construction projects, land development, and environmental assessments.
- Geology and Environmental Sciences:
    - Scientists and Researchers: GPS is used for precise positioning in geological studies, monitoring tectonic movements, studying climate change, and tracking wildlife.
- Fleet Management:
    - Companies with Vehicle Fleets: GPS tracking systems help businesses manage their fleets, optimize routes, monitor driver behavior, and improve fuel efficiency.
- Telecommunications:
    - Cellular Networks: GPS assists in synchronizing cell towers and optimizing network coverage, especially in urban areas.
- Mapping and Cartography:
    - Cartographers and GIS Professionals: GPS technology is fundamental in creating accurate and up-to-date maps for a wide range of purposes, from urban planning to environmental conservation.
- Recreation and Outdoor Activities:
    - Hikers and Outdoor Enthusiasts: GPS devices are used for navigation in the wilderness, allowing users to plan and follow trails with confidence.
- Sports and Fitness:
    - Runners, Cyclists, and Athletes: GPS-enabled wearables and devices track performance metrics like distance, speed, and route for training and competition.
- Supply Chain and Logistics:
    - Logistics Companies: GPS aids in tracking shipments, optimizing delivery routes, and providing real-time updates to customers.
- Military and Defense:
    - Armed Forces: GPS is used for navigation, targeting, and coordination of military operations.

- Scientific Research:
    - Various Disciplines: GPS technology is employed in a wide range of scientific studies, from studying plate tectonics to monitoring wildlife migration patterns.
- Precision Agriculture:
    - Farmers and Agricultural Scientists: GPS technology helps in precise application of resources, like water, fertilizers, and pesticides, resulting in more sustainable and efficient farming practices.

Overall, GPS technology has become an integral part of modern life, contributing to increased efficiency, safety, and productivity across a diverse range of industries and activities.

4G Cellular System and Standards:

The Fourth Generation (4G) of broadband cellular network technology is based on the capabilities defined by the ITU(International Telecommunication Union) in IMT Advanced (International Mobile Telecommunications Advanced) which supersede the 3G. It is popularly referred to as MAGIC, which is the acronym for "Mobile multimedia, Any-where, Global mobility solutions over, Integrated wireless and Customized services." According to the ITU, a 4G network requires a mobile device to be able to exchange data at 100 Mbps for high mobility communication and 1 Gbps for low mobility communication. Potential and current applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, 3D television.

4G is much faster than 3G, and this has revolutionised the field of telecommunication by bringing the wireless experience to a new level altogether. 4G systems support interactive multimedia, voice, video, wireless internet and other broadband services. Technologically, 4G is very different compared to 3G.

When was 4G introduced?

- The fourth generation of mobile technology was introduced in 2010 in order to meet out the need for faster speed and better connectivity.
- Airtel was the first company to have launched 4G services using TD-LTE technology in Kolkata in 2012. It was followed by the launch of 4G in Bangalore, Pune, Chandigarh, Mohali and Panchkula.
- Later, 4G services in India was launched by Aircel, Vodafone and RJIO.

What are the features of 4g?

The features of 4G are :

- Better download speed
- Extremely high voice quality.
- Easy access to Internet, IM, social networks, streaming media, video calling.
- Higher bandwidth.
- Much faster than 3G

What are the different Network Standards of 4G?

There are multiple 4G mobile technology standards used by different cellular providers that conform to 4G requirements, namely,

1. LTE (pre – 4G),
2. LTE-Advanced,
3. WiMAX, and
4. Ultra-Mobile Broadband (UMB).

Note – LTE stands for Long Term Evolution (LTE).

How are mobile communication technologies classified?

Based on the architecture of the mobile network, mobile communication technologies are classified into different generations identified as 1G, 2G, 3G, 4G, and 5G. The architecture of the mobile network has rapidly evolved over the last few decades.

The fourth generation of wireless standards for cellular systems is 4G, the planned successor to the 3G standard. The ITU (International Telecommunications Union) has specified that the peak speed requirements for the 4G standard are to be 100Mbps for a mobile connection (such as in a car) and 1Gbps for stationary connections (such as sitting at a computer). 4G services that meet these requirements are not publically available yet (as of June 2011) but telecommunications providers are looking to upgrade their infrastructure to cater for 4G services in the not too distant future. The 4G service is set to offer a fast and secure all-IP, roaming mobile broadband solution to devices such as laptops with wireless 4G modems, 4G smartphone mobile phones and other 4G mobile devices that require internet access with speed intensive facilities being made available, including on-demand HD television, IP telephony, on-demand gaming and, of course, high speed internet access.

Currently marketed technologies such as LTE (Long Term Evolution) and WiMAX have been around for a few years and are being marketed as 4G whilst not meeting the requirements set by the ITU. It was recently announced that these services could continue to be marketed as 4G as they are precursors to the IMT-Advanced, 4G standard whilst also operating on the same basis of technology; however, these should really be considered as "Pre-4G" or "3.9G" as they technically do not offer the required data rates of (stationary) 1Gbps.

The ITU has recognised two standards that are planned to meet the 4G IMT-Advanced requirements put forward by the two groups, 3GPP and IEEE. These are the LTE Advanced and WirelessMAN-Advanced (WiMAX-Advanced) standards and will almost certainly abandon the old spread system technology found in 3G systems for OFDMA and other equalisation schemes, use MIMO technology, channel-dependant scheduling and dynamic channel allocation... all technologies that are being found on new, modern wireless networking equipment.

Applications

The use of the 4G service will be very similar to that of the 3G service whilst offering much higher data transfer rates and therefore allowing either more speed intensive applications or more users to experience good speeds whilst only connected through 1 carrier. Applications could include:

- 4G Ultra high speed internet access - E-mail or general web browsing is available.
- 4G Data intensive interactive user services - Services such as online satellite mapping will load instantly.
- 4G Multiple User Video conferencing - subscribers can see as well as talk to more than one person.
- 4G Location-based services - a provider sends wide spread, real time weather or traffic conditions to the computer or phone, or allows the subscriber to find and view nearby businesses or friends whilst communicating with them.
- 4G Tele-medicine - a medical provider monitors or provides advice to the potentially isolated subscriber whilst also streaming to them related videos and guides.
- 4G HDTV - a provider redirects a high definition TV channel directly to the subscriber where it can be watched.
- 4G High Definition Video on demand - a provider sends a movie to the subscriber.
- 4G Video games on demand - a provider sends game data directly to the subscriber where they can play in real time.

The other main application that 4G could make available that 3G in general did not, or could not, is the capability to be used as a main internet access point within homes or businesses whilst catering for multiple connections at high speeds. If the 1Gbps rate is available within these areas, the speeds would be many times more than those that are currently publicly available and this application could be very useful for creating 4G wireless networks that can be located in rural areas with no access to the high speed, cabled, broadband grid.

Performance

The IMT-Advanced Standard (4G) requires the following specifications to be met:

- It must be based upon an all-IP packet switched network
- Peak data rates must be up to 100Mbps in high mobility situations and up to 1Gbps for low mobility/stationary applications
- Network resources should be utilised and dynamically shared to support more users on same connection
- Channel bandwidth should be scalable between 5, 20 and up to 40MHz
- Spectral efficiency should be no less than 15bit/s/Hz and 6.75bit/s/Hz for outdoor downlink and uplink usage respectively
- Spectral efficiency should be no less than 3bit/s/Hz and 2.25bit/s/Hz for indoor downlink and uplink usage respectively
- Connection transitions across heterogeneous networks should be smooth
- A high quality of service must be available to allow the next generation of multimedia support on mobile devices

3GPP LTE

LTE (Long Term Evolution) has experienced peak download rates of 326.4 Mbps and 172.8 Mbps for 4x4 and 2x2 MIMO antennas respectively when using 20 MHz of spectrum and peak upload rates of 86.4 Mbps for every 20 MHz of spectrum using a single antenna. This means that it does not quite meet the 4G requirements but it is still often branded as 4G by telecommunications providers as it offers a considerable increase in performance over 3G. Its radio interface is often referred to as E-UTRA (Evolved UMTS Terrestrial Radio Access).

3GPP LTE Advanced

4G LTE Advanced is not a new technology but rather an enhancement to the existing LTE standard by using multiplexing and additional spectrum range to achieve the speeds required for 4G; whilst help for system capacity usage is dealt with by co-ordinated multi point transmissions. 4G LTE-Advanced can use up to 8x8 MIMO antennas and 128 QAM (Quadrature Amplitude Modulation) giving performance of almost 3.3Gbps peak download rates per sector of the base station using 100MHz aggregated bandwidth under perfect conditions. With new developing technologies such as smart antennas and advanced network infrastructures, 4G LTE Advanced will take a good few years to become fully developed and integrated.

IEEE WiMAX and WiMAN-Advanced

The WiMAX (IEEE 802.16e) standard offers peak data rates of 128Mbps downlink and 56Mbps uplink over 20MHz wide channels whilst the new standard in development, 4G WiMAN-Advanced (802.16m) is targeting the requirements to be fully 4G using 64Q QAM, BPSK and MIMO technologies to reach the 1Gbps rate. It is predicted that in an actual deployment, using 4X2 MIMO in an urban microcell application using a 20 MHz TDD channel, the 4G WiMAN-Advanced system will be able to support 120Mbps downlink and 60Mbps uplink per site concurrently. WiMAX applications are already in use in many countries globally but research in 2010 gave results that showed only just over 350 set ups were actually in use. Many previous WiMAX operators were found to have moved to LTE along with Yota, who were the largest WiMAX operator in the world.

What is the difference between 4g and 5g?

The major differences between the 4G and 5G networks are listed below:

- 5G network provides enhanced network coverage compared to the 4G.
- Data bandwidth of 5g is above 1gbps, whereas for 4G it lies between 2mbps to 1gbps.
- The latency of the 5G network is smaller compared to 4G.