WMC Unit-3

(*) Introduction to GSM: Global System for Mobile Communication
→ Digital cellular technology used for transmitting mobile voice and data services.
→ Most widely accepted standard in telecommunications and is implemented Globally.
→ Circuit switched system that divides each 200KHz channel into eight 25 KHz time-slots.
→ Owns a market of more than 70% of world's digital cellular subscribers.
→ Makes use of narrowband TDMA technique for transmitting signals.
→ Features: (a) Improved Spectrum efficiency.
(b) International roaming.
(c) Low cost mobile sets and base stations.
(d) High Quality speech.
(e) Support for new services.
→ GSM - Architecture: A GSM network comprises of many functional unit. The network can be broadly divided into:
(a) The Mobile Station (MS)
(b) The Base Station Subsystem (BSS)
(c) The Network Switching Subsystem (NSS)
(d) The Operation Support Subsystem (OSS).
→ GSM - The Mobile Station: Consists of physical equipments such as the radio transceiver, display, SIM card, etc.
→ It provides the air interface to the user.
→ It also provides the receptor for SMS messages, enabling the user to toggle b/w voice and data use.
→ You need to insert the SIM card into another GSM cellular phone to receive calls, make calls, etc.
→ GSM - The Base Station Subsystem: It is composed of 2 parts:
(a) The Base Transceiver Station (b) The Base station Controller.

→ The radio components of a BSS may consist of four to seven or nine cells.
→ A BSS may have one or more base stations.
→ It uses the Abis interface between the BTS and BSC.
→ Base Transceiver Station (BTS):
→ usually placed in the center of the cell.
→ Its transmitting power defines the size of a cell.
→ Each BTS has between 1 and 16 transceivers.
→ Functions include: Encoding, Encrypting, multiplexing, modulating, transcoding, decoding, decrypting, Time and frequency synchronizing, etc.
→ Base Station Controller (BSC):
→ Manages the radio resources for one or more BTS.
→ It assigns and releases frequencies and time slots for MS.
→ Additional functions include: Control of frequency hopping, performing traffic concentration, Time and frequency synchronization, Power management, time-delay measurements of received signals from the MS, etc.
→ GSM- The Network Switching Subsystem:
→ Its main part is the MSC (Mobile Switching Center), that performs the switching of calls b/w the mobiles and the other users.
→ It also looks after the management of mobile services, such as authentication.
→ It includes the following elements:
(a). Home location register → database used for storage. Stores permanent data about the subscriber.
(b). Mobile Services Switching Center (MSC): Central component. Performs switching of calls.
(c). Visitor Location Register (VLR): dB that contains temporary

information about the subscribers. It is always integrated with MSC.

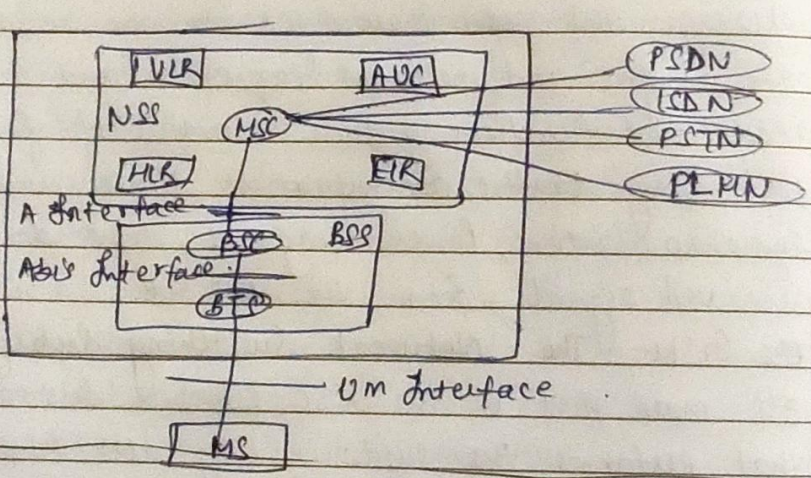
(c) (d) Authentication center (AUC): Protected DB that stores a copy of the secret key stored in each subscriber's SIM card.

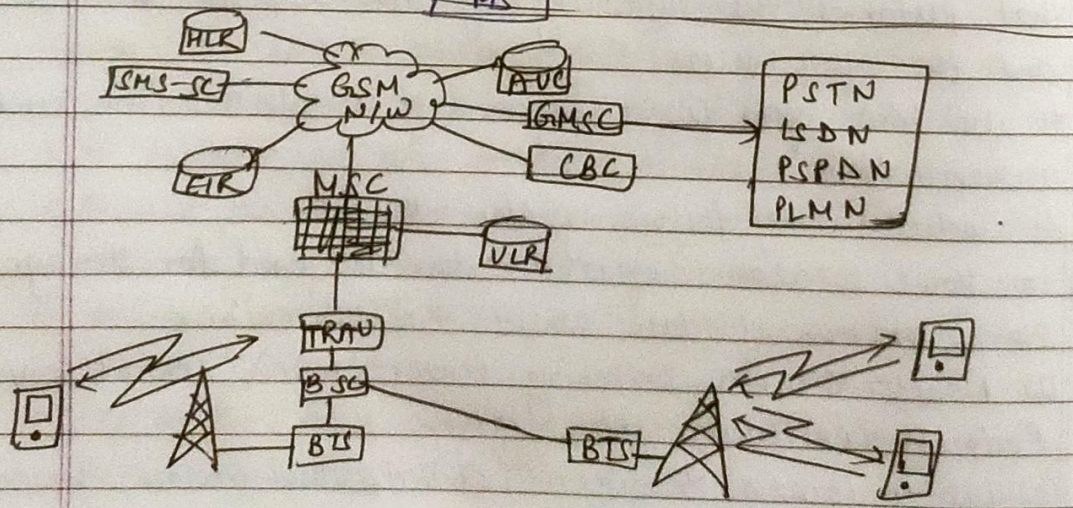
(e) (e) Equipment Identity Register (EIR): DB that contains the list of all valid Mobile Equipments on the network.

→ GSM - The Operation Support Subsystem: (OSS):

→ The operations and Maintenance Center (OMC) is connected to all equipments in the switching system.

→ Functions of OMC: (a) Administration and Commercial operations, (b) Security Management (c) Network Configuration, (d) Task Maintenance, etc.





(v). Frequency Bands and Channels:

(i). Modulation: Process of transforming the input data into a suitable format for transmission medium.

→ Transmitted data is demodulated back to its original form at the receiving end.

→ GSM uses Gaussian Minimum Shift Keying (GMSK) modulation method.

(ii). Access Methods: GSM devised the combination of TDMA/FDMA as the method to divide the bandwidth among users.

→ The FDMA part divides the frequency of total 25MHz bandwidth into 124 carrier frequencies of 200 KHz bandwidth.

→ The frequencies assigned to ~~BS~~ is/are divided into eight timeslots using TDMA scheme. Each slot is used for both transmission and reception of data.

These slots are seperated by time so that a mobile unit does not transmit and receive data at the same time.

(iii). Transmission Rate: Total symbol rate for GSM at 1 bit per symbol in GMSK produce 270.833 K symbols/second.

→ The Gross transmission rate is 22.8 Kbps.

→ GSM is a digital system with an over the air bit rate of 270 Kbps.

(iv). Frequency Band: uplink → 933 - 960 MHz (basic 900 MHz band only)

downlink → 890 - 915 MHz (basic 900 MHz band only).

(v). Channel Spacing: Indicates spacing b/w adjascent carrier frequencies. For GSM, it is 200 KHz.

(vi). Speech coding: GSM uses Linear Predictive coding (LPC).

→ It compresses the bit rate and gives an estimate of speech parameters.

→ When the audio signal passes through filter, it mimics the vocal tract. The speech here is encoded at 13 Kbps.

(vii). Duplex Distance: Space b/w uplink and downlink frequencies.

→ For GSM it is 80 MHz. Each channel has 2 frequencies that are 80MHz apart

(8). NISC: 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:

→ Basic element in the GSM frame structure.

→ Comprises 8 slots, each used for different users within TDMA system.

→ The slots for transmission and reception are offset in time so that the mobile does not transmit and receive at the same time.

→ The basic GSM frame structure defines the structure upon which all timing and structure of GSM messaging and signalling is based.

→ Fundamental unit of time is called burst period and it lasts for approximately 0.577 ms (15/26 ms).

→ 8 burst periods are grouped into a TDMA frame.

→ It lasts approximately (8 x 15/26 ms) and it forms the basic unit for defining logical channels.

→ One physical channel = one burst period.

①. GSM Multiframe: Frames are grouped together to form multiframes.

→ In this way it is possible to establish a time schedule for their operation and now can be synchronised.

→ GSM Multiframe → Traffic multiframe.
→ Control Multiframe.

(a). Traffic Multiframe: Organised into multiframes consisting of 26 bursts and taking 120 ms.

→ 24 bursts are used for traffic. (Numbered 0 to 11 and 13 to 24).
→ One of the remaining multiframe is used to accomodate SACCH, remaining frame is free.
(ii) Control Multiframe: Comprises 51 bursts and occupies 235.4ms.
→ This multiframe is subdivided into logical channels that are time-scheduled. These include:
(a). Frequency correction burst.
(b). Synchronization burst.
(c). Broadcast Channel (BCH)
(d). Paging and Access Grant Channel (PAGCH)
(e). Stand Alone Dedicated Control Channel (SACCH).
(c). GSM Superframe: Multiframes are then constructed into superframes taking 6.12 sec.
→ Consist of 51 traffic Mfs or 26 control Mfs.
→ Different no. of traffic & control frames within the super frame brings them back into line again taking exactly the same interval.
(3). GSM Hyperframe.
→ 2048 superframes (2^{11}) are grouped to form one hyperframe which repeats after every 3hrs 28 mins 53.76 seconds.
→ It is the largest interval within the GSM frame structure.
→ Within the GSM Hyperframe, there is a counter.
→ Every time slot has a unique sequential number comprising frame number and time slot number.
→ Used to maintain synchronization of different scheduled operations.
Functions: (a). Frequency Hopping. (optional feature). It can help reduce interference and fading issues.
(b). Encryption: A counter is used and the encryption process will repeat with each hyperframe.

(*) Layers of GSM and Protocols in GSM:

→ Layered model designed to allow communications between two different systems.

→ Lower layer assures the services of upper layer protocols.

→ Each layer passes suitable notifications to ensure that the transmitted data has been formatted, transmitted and received accurately.

(*) MS Protocols: Assembled into 3 general layers:

- Layer 1: Physical Layer. Uses channel structures over the air interface.
- Layer 2: Data link layer:
- Layer 3 Subdivided into (a) Radio Resource Management (RR)
  (b) Mobility Management (MM)
  (c) Connection Management (CM).

(*) MS to BS Protocols:

→ The RR layer is the lowest layer that manages a link.

→ The main components involved in the formation are MS, BSS and MSC.

→ The responsibility of RR layer is to manage the RR session, the time when the mobile is in dedicated mode.

→ The MM layer is stacked above the RR layer.

→ It handles the functions that arise from the mobility of a subscriber, as well as 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 BTSM protocol stack.

→ This layer is responsible for Call control, Supplementary Service Management, and Short Message Service Management.

→ Each of these services are treated as single layer within the CM layer.

→ other functions include: call establishment, selection of the type of service, call release, etc.

(iv). BSC Protocols:

→ It uses a different set of protocols after receiving data from the BTS.

→ The Abis interface is used in between BTS & BSC.

→ At this level, the radio resources at the lower portion of layer 3 are changed from RR to the Base Transceiver Station Management (BTSM).

→ The BTSM layer is the 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 BTS.

→ These services include controlling the initial access to the system, paging for MT calls, handover of calls between cell sites, power control and call termination.

→ To transit from the BSC to MSC, the BSS Mobile application part or the direct application part is used.

(v). MSC Protocols:

→ The information is mapped across the A interface to the MTP layers 1 through 3.

→ Here, the Base Station System Management Application Part (BSS MAP)

is said to be the equivalent set of resources.
→ The relay process is finished by the layers that are stacked on top of layer 3 protocols, they are BSS MAP/DTAP, MM & CM.
→ Thus completes the relay process.
→ To find and connect to the users accross the network, MSCs interact using the control-signalling network.
→ location registers are used in MSC to database 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 comprises of users location.
→ HLR is seperate register used to track location of user.
→ When the user moves out of HLR area, VLR is notified by MS to find the location of user.
→ The VLR, with the help of control network, signals HLR of the MS's new location.
→ With the help of location information contained in user's HLR, the call can be routed to the user.

(*) Localization and Calling:

(*) Localization:
→ GSM performs periodic location updates even if the user does not use the MS.
→ HLR has info about current location.
→ The VLR informs the HLR about location changes.
→ As soon as MS reaches into the range of new location area (new VLR), the HLR sends the data to new VLR.
→ Changing VLRs with uninterrupted availability of services is also called roaming.
→ Mobile Station International ISDN Number (MSISDN): It

consists of the country code (CC), the National destination code (NDC), the subscriber Number (SN)

→ International Mobile Subscriber Identity (IMSI): Consists of Mobile Country Code (MCC) and the Mobile subscriber Identification Number (MSIN).

→ Temporary Mobile Subscriber Identity (TMSI): Selected by current VLR and is valid only within location area of VLR.

→ Mobile Station Roaming Number (MSRN): Contains the current visitor Country Code (VCC), the visitors National Destination code (VNDC), identification of current MSC together with subscriber number.

(*) Calling: Basic steps to connect calling station with mobile user:

① User dials a phone number of GSM subscriber.

② PSTN notices that number belongs to a user in the GSM N/W and forwards the call setup to Gateway MSC.

③ The GMSC identifies HLR for subscriber & signals the call setup to HLR.

④ The HLR checks whether the number exists and requests for MSRN.

⑤ MSRN is received.

⑥ HLR determines the MSC responsible for MS and forwards info to GMSC.

⑦ GMSC forwards the call setup request to MSC indicated.

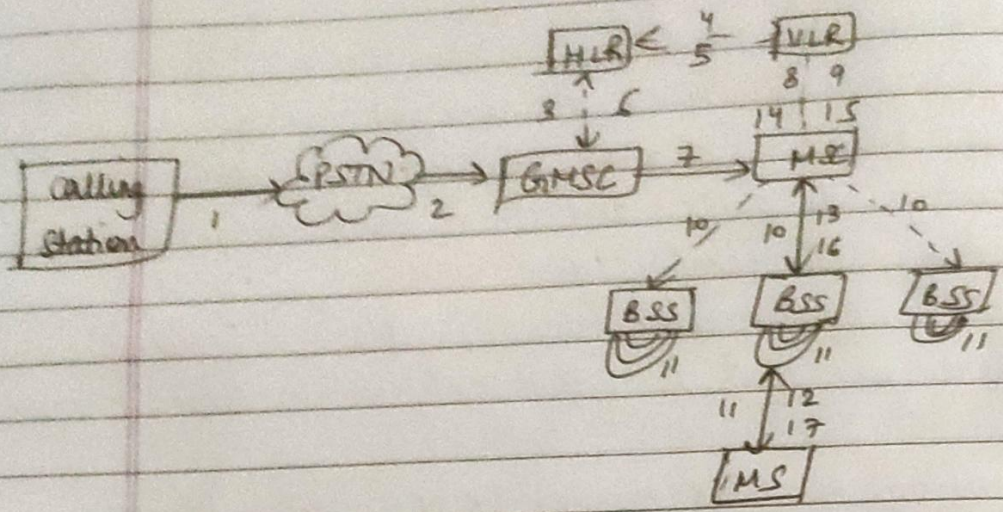
⑧ MSC requests current status of MS from VLR.

⑨ & ⑩ If MS is available, MSC initiates paging in all cells.

⑪ BTSs of all BSSs transmit this signal to MS.

⑫ If MS answers, VLR performs security checks (encryption).

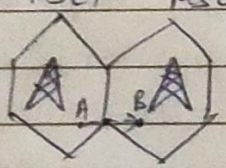
⑬ - ⑰ : VLR signals to MSC to set up a connection through MS.



(X) Handoff in Cellular Telecommunications:

→ Handover or handoff refers to the process of transferring an ongoing call from one Base Station to another.

→ When mobile moves into a different cell while conversation is in progress, then MSC transfers call to a new channel belonging to a new BS.



Types: ① Hard Handoff
② Soft Handoff
③ Delayed Handoff
④ Mobile Assisted Handoff.

(a) Hard Handoff:

→ When there is an actual break in the connectivity while switching from one BS to another.

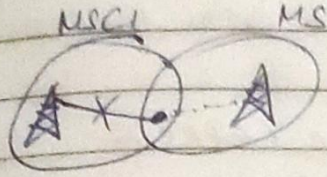
→ The switching takes place so quickly that it can hardly be noticed by the users.

→ Connection quality is not good.

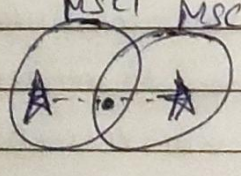
→ Adopted the "Break before Make" policy.

→ Generally implemented in TDM & FDM when a user connects to BS with fluctuating radio frequency.

→ Cheaper in cost.
→ Only one channel needs to be active at a time.
→ Widely implemented, more efficient than soft handoffs.
→ Sometimes, a delay can be experienced.



2. Soft Handoff:
→ Device gets connected with two or more BS at same time.
→ Atleast one of the ~~signals~~ links is kept when radio signals are added or removed to the Base Station.
→ It adopted "Make before break" policy.
→ If a channel is in power loss, then another channel will be in standby mode.
→ Best in terms of quality as compared to hard handoffs.
→ Used in devices supporting CDMA/WCDMA ~~signals~~ networks.
→ High transmission speed.
→ Very low delay



3. Delayed Handoff:
→ When no BS is available for accepting the transfer.
→ Call continues until the signal strength reaches threshold, then the call is dropped.
→ Generally happens when the user is out of NW coverage area, or at spots where NW reach is low.

(*) Mobile Assisted Handoff:

→ Used when a mobile phone helps a B.S to transfer call to another BS with better improvised connectivity and more signal strength.

→ Used in TDMA technique based GSM devices.

(*) General Packet radio Service (GPRS):

→ A mobile communications standard that operates on 2G & 3G cellular networks.

→ It operates to enable moderately high-speed data transfers using packet based technologies.

→ Packet switching technology that allows information to be transmitted via mobile networks.

→ It is utilised for internet connectivity & other types of data transmission.

→ It is supported by GPRS cellphones, laptops, etc.

→ Employed to facilitate connections related to Internet protocols.

→ Before the transmission, the information is split into individual packets and routed through the core N/w.

→ At the receiver's end, the data is reattached.

→ GSM is the primary standard for 2G cellular network, GPRS is an improved version.

→ It is not like GSM's Short Messaging Service (GSM-SMS) which has a message length limit of 160 bytes.

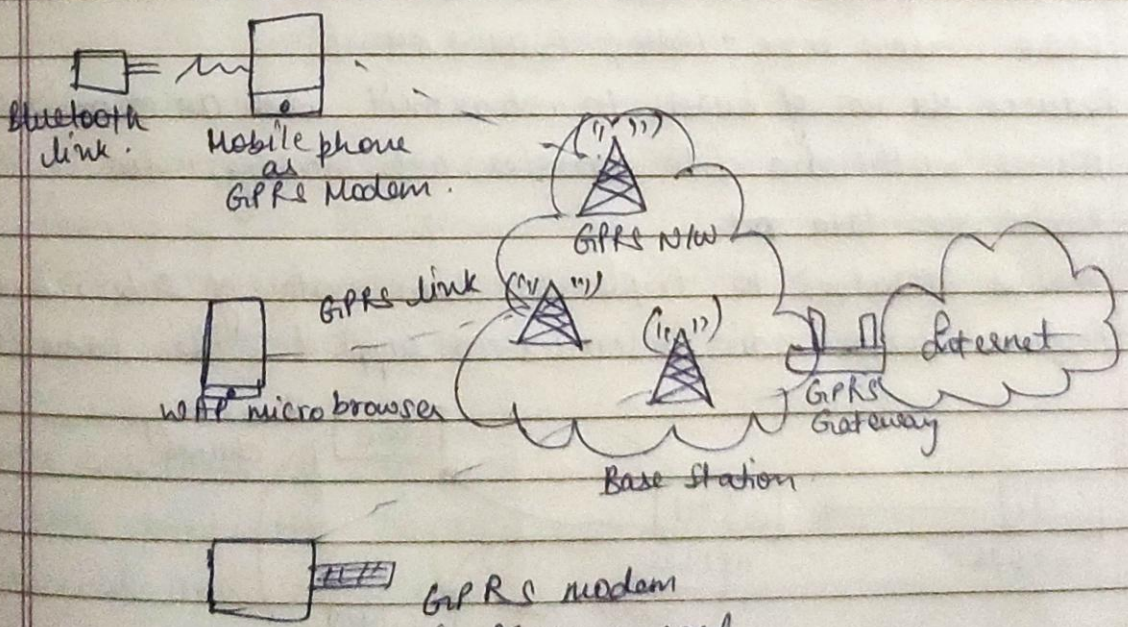
→ GPRS has a theoritical max. speed of 115 Kbps, although most N/w operate roughly at 35 Kbps.

→ Sometimes known as 2.5G unofficially.

→ It is a 3G route to gain availability on internet.

→ Can operate from either symmetric or asymmetric configuration.

→ frequency for either direction is determined by which one of the 12 multislot provider classes are chosen.
→ The no of time slots for every path is determined by the multislot service class.
→ for every slot, there is a theoritical connection speed of 21.4 kbps.
→ One of basic is service class 1, which allows a one time slot for each path.
→ service class 12 is is by far the most proficient, with 4 time slots in every direction.
→ GSM-IP is another name for GPRS.
→ It ensures that customers are connected, making audio calls and browsing the Internet.
→ It used to be the fastest network-accessible option. This has, however changed in terms of speed and dependability, as both 3G and 4G Plus surpass it.
→ It is still used in some areas, particularly rural and emerging nations (that do not have a more sophisticated technology).



GPRS modem is PCMCIA card.

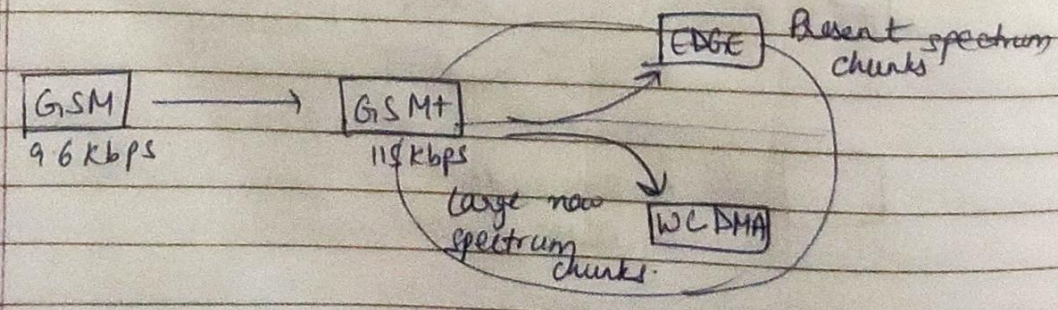
(*) EDGE (Enhanced Data Rates for GSM Evolution:

→ Enhanced version of GSM.
→ Offers high speed 3G built on GSM.
→ It is used to allow improved data transmission rates.
→ Can transmit 3 times more bits than GPRS in the same length of time.
→ It is an "add-on" to GPRS, it cannot work alone.
→ Provides a speed of 384 Kbps (much higher than GPRS).
→ Labelled as 2.75G by the industry.

Key Elements → The modulation has been changed to 8PSK. It provides the advantage of conveying 3 bit per symbol.
→ Some small changes have been made in the BS.
→ Offers IP based transfer rate.

Features:

→ Provides increased data rate.
→ Can retransmit a packet with more robust coding.
→ Re-segmentation is possible.
→ In EDGE, packets are addressed upto 2048, in GSM it's from 1-128
→ EDGE window size → 1024, GSM → 64.
→ Reduces the no. of bursts to retransmit when an error occurs.
→ Allows multimedia file transfer, web browsing, video conferencing.
→ ~~Adapts the data rate.~~
→ Enables operators to triple the data rate of subscribers.
→ Requires fewer radio resources to support the same traffic.



3G Cellular System:

→ 3G is the next generation of wireless N/W Technology that provides high speed bandwidth (high data transfer rates) to handheld devices.
→ Offers multimedia services including voice and data.
→ Supports the following max data transfer rates:
- 2.05 Mbps to stationary devices.
- 384 Kbps for slowly moving devices.
- 128 Kbps for fast moving devices.

→ The data rate will be lower if there is voice traffic.
→ The data rate for fast moving devices is about ten times faster than available with the 2G wireless networks.
→ 2G N/Ws were designed to carry voice but not data, unlike 3G.

Characteristics:
→ 3G N/Ws use IP connectivity, which is packet based.
→ Multimedia services with fully fledged audio and video.
→ Emails with attachments such as PPt files, etc.
→ Instant messaging with video/audio clips.
→ Fast downloads to large files.
→ Access to corporate applications.

3G Standard:
→ ITU (International Telecommunication Union) approved a family of 5 3G standards:
- 3 standards based on CDMA (CDMA2000, WCDMA & TD-SCDMA)
- 2 standards based on TDMA (FDMA/TDMA & TDMA-SC (EDGE))

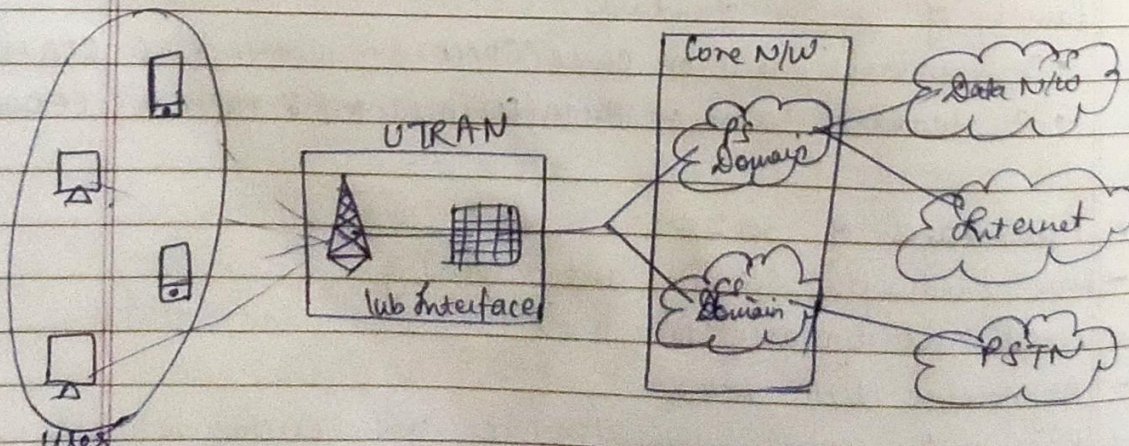
Advantages of 3G:
→ More bandwidth, security and reliability.
→ Fixed and variable data rates.
→ Asymmetric data rates.
→ Backward compatibility of devices with existing networks.

→ Uses IP connectivity (packet based, not circuit based).
→ Rich multimedia services

Disadvantages of 3G:
→ High cost of upgrading.
→ Base stations need to be closer to each other.
→ Requires different handsets & there's an issue in handset availability.

Services offered:
→ Users pay only when sending / receiving packets.
→ Web surfing.
→ Instant Messaging, emails with multimedia attachments.
→ Video conferencing, streaming videos, etc.
→ Getting maps & directions with multi-modal user interface.
→ Customized Entertainment.
→ Simultaneous access to multiple services.

(*) UMTS System Architecture: Universal Mobile Telecommunications System.
→ 3G mobile network built on the global GSM standard.
→ Compatible with data transfer up to 2 Mbps.



→ Popularly known as 3G cellular NW.
→ Better cellular technology than GSM.
→ Offers faster data transfer, improved cellular capabilities, greater range/bandwidth, better radio spectrum efficiency, etc.
→ It uses CDMA technology.
→ It is sometimes referred to as wideband CDMA or WCDMA
→ CDMA allows multiple transmitters to transmit information over a single communication channel simultaneously.
→ WCDMA is effective in transfer of packets over air from one user to another unlike GSM, which uses a mix of FDMA & TDMA.
→ It was not created to replace GSM but to act as a complementary technology.
→ In GSM, the frequency spectrum is broken down into smaller channels and then distributed based on time slots. This is not convenient for simultaneously transferring large amount of data.
→ Ensures than one can use both the technologies on a device if the device is made to access either network.
→ less cost, best customer experience, reliability, speed, ease of application, etc.
→ UTRAN is responsible for providing radio access to UMTS.

(4) Key components of UTRAN:

① Node B: (Base Station): → Primary building block of UTRAN.
→ A radio transceiver system that communicates directly with UEs.
→ Each node B is connected to UMTS core NW through Iub interface.

② Radio Network Controller (RNC): → Control element of UTRAN.
→ Manages multiple node Bs and oversees the overall radio resource allocation, mobility management, etc.

→ Responsible for tasks such as power control, admission control, flow control, etc.

③ Iub Interface: → Connection b/w node B & RNC.
→ Carries both user data and control information.

④ Iur Interface: → Used to connect different RNCs in UTRAN.
→ It facilitates inter-RNC communication.
→ Essential for handover procedures.

⑤ Iu Interface: → Connects UTRAN to UMTS Core Network.
→ Includes elements such as Serving GPRS Support Node (SGSN) for packet switched services & Mobile Switching Center (MSC) for circuit switched services.

(iv) Functions of UTRAN:

① Radio Resource Management (RRM):
→ Manages Radio Resources, frequencies & power levels to optimize n/w performance.
→ Ensures efficient use of available spectrum.

② Mobility Management:
→ Handles mobility related tasks such as tracking movement, initiating handovers, etc.

③ Uplink and Downlink transmission:
→ Handles transmission and reception of data between UEs and core N/w.
→ Uplink data (from UE to core N/w) is forwarded to RNC.
→ Downlink data (from core N/w to UE) is transmitted from the RNC to appropriate Node B.

④ Call Setup and Teardown:
→ Responsible for establishing and releasing calls, including voice calls and data sessions between the UEs & core N/w.

⑤ Security and Encryption:

→ Ensures the privacy and security of user data by implementing encryption and authentication.

Evolution & Transition:

→ UTRAN evolved to support higher data rates and improved N/w performance.
→ Enhanced technologies such as High-Speed Packet Access (HSPA) were introduced to provide higher data speeds.
→ Represents the 4th Generation (4G) of mobile communication systems.

(*) Global Mobile Satellite System (GMSS):

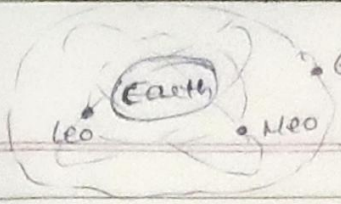
→ Satellite is an artificial body that is placed in an orbit around the earth for the purpose of communication.
→ Frequencies reserved for the satellite microwave communication are in the gigahertz (GHz) range.
→ Transmission from Earth to satellite is called Uplink
→ Transmission from the satellite to Earth is called downlink.

→ Uplink and downlink frequencies must be different to avoid interference.
→ Higher frequency results in higher attenuation and to compensate with it, more power is required.

→ Uplink uses higher frequency to penetrate the environment.
→ Orbit: The path in which the satellite travels around the earth
→ Footprint: The signal from the satellite is normally aimed at a specific area called footprint.
→ Satellite categories: (a). GEO
(b). MEO
(c). LEO

(*). GEO: Geostationary Earth Orbit.
→ Satellites in this orbit operate at a distance of about 36000 km above the earth's surface.
→ Orbital time period is about 24 hours.
→ Used for radio broadcasting.
→ To ensure constant communication, they need to move at the same speed as that of the Earth so that it seems to remain fixed at a certain spot.
→ Such satellites are called geostationary.
→ One geo-stationary satellite cannot cover the whole Earth.
→ It takes minimum of three satellites equidistant from each other in GEO to provide full global transmission

(*). MEO: Medium Earth Orbit.
→ 5000 to 12000 km above the Earth's surface.
→ Positioned between the two Van Allen belts.
→ A satellite in this orbit takes approximately 6 to 8 hours to circle the Earth.
→ Example is Global Positioning System (GPS), about 18000 km above the Earth's surface.



→ GPS ~~System~~ consists of 24 satellites and is used for land, sea, and air navigation to provide time and location of vehicles and ships.
→ Locations are designed in such a way that at any time, four satellites are visible from any point on the Earth.
→ GPS is based on a principle called Trilateration also called Triangulation. It means that "On a plane, if we know our distance from three points, we know exactly where we are.

(a) LEO: Low Earth Orbit.
→ 500 - 1200 km above the Earth's surface.
→ Orbital time period is 95 to 120 minutes.
→ Speed of 20000 - 25000 kmph.
→ Satellites in this orbit make global radio coverage possible.
→ This system is made up of a constellation of satellites that work together as a network, where each satellite acts as a switch.
→ Satellites that are close to each other are connected through Inter-satellite links. (ISL's).
→ A mobile system communicates with the satellite through a user Mobile link (UML).
→ A satellite can also communicate with Earth station ~~using~~ (gateway) using a gateway link (GWL).
→ Can be divided into three categories: (a) Little LEOs
(b). Big LEOs
(c). Broadband LEOs.
→ Little LEOs work under 1 GHz. Mostly used for low data rate messaging.
→ Big LEOs operate b/w 1 and 3 GHz.

→ Bread Band LEOs provide communication similar to fiber optics networks. 1st broadband LEO was Teledesic.

(8) Limitations of GPS:

① Signal blockage: Signals can be blocked by physical obstructions like tall buildings, mountains, etc.
→ This can lead to lost or inaccurate GPS readings.

② Indoor Use: GPS signals struggle to navigate buildings, making it ineffective for indoor navigation.
→ In such environments, alternate technologies like wi-fi based positioning systems (WPS) or Bluetooth beacons are used.

③ Urban Canyons: Tall buildings in densely populated areas can create "urban canyons" where GPS signals can bounce off the buildings leading to multipath interference.

④ Multi-Path Interference: When GPS signals reflects off surfaces before reaching the receiver.

⑤ Satellite Geometry: Accuracy depends on the arrangement of satellites in the sky.
→ Poor satellite geometry where the satellites are clustered in one area can lead to less accurate readings.

⑥ Atmospheric conditions: The Earth's atmosphere can affect the speed at which the GPS signals travel, leading to minor errors in positioning.

⑦ Signal Jamming & Spoofing: GPS signals can be intentionally jammed or spoofed, which can disrupt accurate navigation.

⑧ Limited Availability in Polar regions: Coverage is less reliable at high ~~altitudes~~ latitudes near Earth's pole.

⑨ Battery Consumption: Continuous use of GPS on a mobile device can drain the battery relatively quickly.

⑩ Signal Acquisition Time: In some areas, esp when first turned on after a period of inactivity, GPS devices may take some time to acquire signals.
⑪ Lack of vertical Accuracy: Excellent for horizontal positioning, less accurate in determining latitude (height above sea level).
⑫ Selective Availability.

(*) Beneficiaries of GPS:
1. Navigation and Transportation: Drivers, Pilots, Mariners.
2. Public safety and Emergency Services: (a) Search & Rescue Teams.
(b) Emergency Responders.
3. Agriculture: Farmers use GPS guided tractors for precise planting.
4. Surveying & Construction: Provide reliable data for construction projects.
5. Geology & Environmental Sciences: Study climate change, etc.
6. Fleet Management: optimize routes, improve fuel efficiency.
7. Telecommunications: Helps in synchronizing cell towers.
8. Mapping & Cartography: helps to capture accurate & up to date maps.
9. Sports & Fitness: GPS enabled wearables track performance metrics.
10. Supply Chain and Logistics: aid in tracking shipments.
11. Military & Defence: Used for navigation, targetting & coordination.
12. Scientific Research: Monitoring wildlife patterns.

(*) 4G Cellular System and Standard:
→ Popularly referred to as MAGIC (Mobile Multimedia, Any-where, Global mobility solutions over, Integrated wireless and Customized Services".
→ 4G NW requires a mobile device to be able to exchange data at 100mbps for High mobility communication & 1Gbps for

low mobility communication.

→ It was introduced in 2010 in order to meet out the needs for faster speed and better connectivity.

→ Airtel was the 1st company to launch 3G services.

→ later launched by aircell, Vodafone & RJIO.

Features:

① Better download speed.
② Extremely High voice quality.
③ Easy access to Internet.
④ High bandwidth.
⑤ Much faster than 3G.

(*) Standards: ① LTE (pre 4G) [Long Term Evolution].
② LTE Advanced,
③ WiMAX
④ Ultra-Mobile Broadband (UMB)

→ Peak speed requirements specified by ITU:
100 Mbps for mobile connection & 1 Gbps for stationary connections.

→ Currently marketed technologies such as LTE & WiMAX have been around for a few years.

→ Use of 4G service is similar to 3G service while offering much higher data transfer rates.

→ Applications include: 4G ultra high speed internet access, 4G Multiple user video conferencing, 4G location based services, 4G Video Games on demand, etc.

→ Specifications:

(a) all IP-Packet switched NIW
(b) Peak data rates must be upto 100 mbps.
(c) Connection transitions must be smooth.
(d) High quality of service must be available.

(iii) 3GPP LTE: → Peak download rates of 326.4 Mbps & 172.8 Mbps for 4x4 and 2x2 MIMO antennas respectively.
→ It does not quite meet the 4G requirements.

(iv) 3GPP LTE Advanced: enhancement to existing LTE standard.
→ can use upto 8x8 MIMO antennas & 128 QAM.
→ 3.3 Gbps peak download speed.
→ It would take a few years to become fully developed & integrated.

(v) IEEE WiMAX & WiMAN-Advanced: (IEEE 802.16m) (IEEE 802.16e)
→ Peak data rates of 128 Mbps downlink & 56 Mbps uplink.
→ WiMAN advance will support 120 Mbps downlink & 60 Mbps uplink.
→ WiMAX Applications are already in use in many countries.

(vi) Differences between 4G & 5G.
→ 5G provides enhanced n/w coverage compared to 4G.
→ Data bandwidth of 5G is above 1 gbps, 4G is 2 mbps - 1 Gbps.
→ latency of 5G n/w is smaller compared to 4G.

LAYERS & PROTOCOLS IN GSM (BSC, RAM)