IAT 1 solution and scheme (Units 1,2)	Wireless communication
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1. **Signaling System #7 (SS7)**

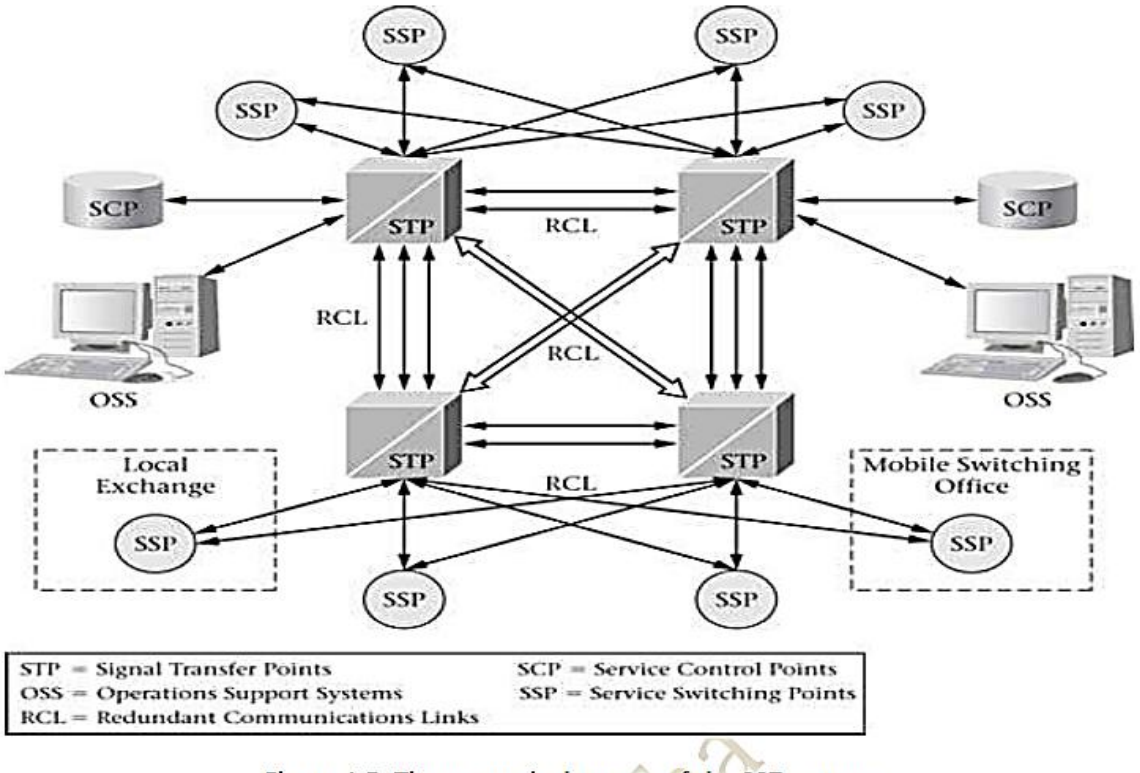


Figure 1.5: The network elements of the SS7 system

4m

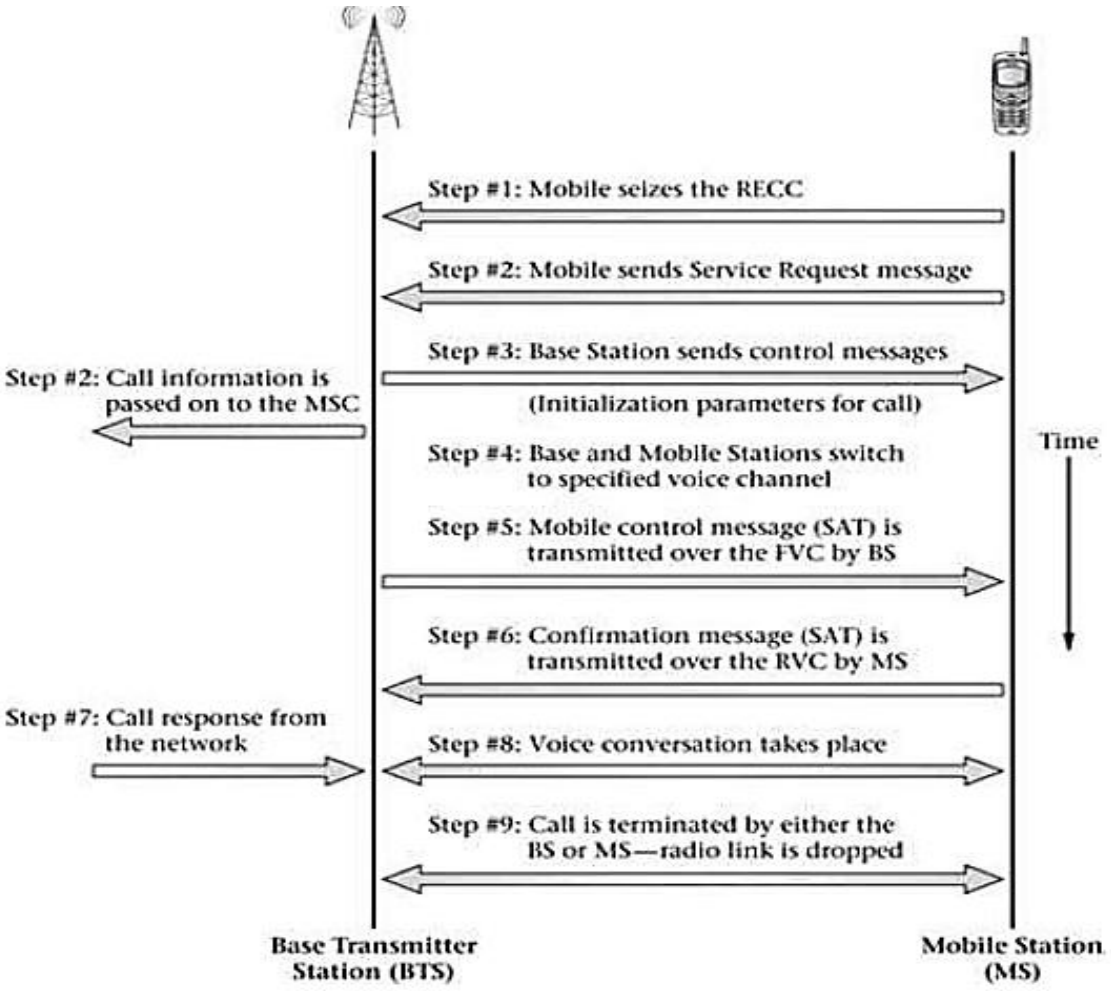
In - band" signaling means that the same facilities used to create an actual physical circuit for the call to be sent over.

1m

As the PSTN evolved into digital network, for economic reasons and for both efficiency and security, an entirely separate network was created for the purpose of routing long distance calls (calls between different exchanges or switches).
This system of using separate facility to channel to perform the call routing function is known as "out of band" signaling.
The network elements of the SS7 system: SS7 is packet network shown in figure 1.5. It consists of three main elements, they are:

1. ***Service Switching Point (SSP)****:* It communicates with the voice switch via primitives and creates signal units for communication over SS7 network. It converts signaling from voice switch into SS7 format. It may send messages for data base queries through SS7 network. Voice connection is established through look-up of routing tables and sending SS7 messages to adjacent switches to request circuit connection

	2. Signal Transfer Point (STP) : It connect to service switching points (SSP) at the local exchange and the interface with the local exchange switch or mobile switching center in the case of a PLMN. SS7 messages travel from one SSP to another through the services of a Signal Transfer Point (STP). It acts as a router for SS7 messages. It exchanges information in form of packets related to either call connections or database queries. Other tasks of the STP include: Traffic measurements for performance monitoring of the SS7 and telecommunication network and Usage measurements for billing purposes. Three levels of STP 1. *National STP*: It exists in one network, no capability to convert messages into other formats. 2. *International STP*: It provides SS7 based interconnection between national networks. 3. Gateway STP: It provides protocol conversion between a national and international network or with other non-SS7 networks ***3. Service Control Point (SCP):*** It is a computer used as a front-end to a database. SCP serves as interface to a telephone company's database. It stores o Subscriber's services, Routing of special service numbers o Calling card validation and fraud protection, advanced intelligent network features for service creation.	5m
2.	AMPS Mobile originated call ***Task description:*** o *Step #1*: MS enters the System Access Task mode and then attempts to seize the RECC once it becomes idle. o *Step #2*: MS starts to transmit a service request message to the BS over the RECC. This message will include MIN, ESN, and the phone number of the dialed party. After transmitting a service request message to the BS the mobile station goes into an Await Message mode. o *Step #3*: If the BS grants to service request it will send an initial voice Channel designation message. The BS has also passed this information on to the network side (i.e., MSC). The mobile will switch to the initial voice channel number provided by the BS . Other information is also included in the base station message – the power level for the mobile and as SCC that will designate what SAT tone to use on the traffic channel. o *Step #4:* At this point, both the base and MSs have switched their communications to the voice channels. o *Step #5:* The BS sends a mobile control message over the FVC with the SAT Signal. o *Step#6*: the MS responds to this message over the RVC with the SAT signal, which confirms the radio link.	

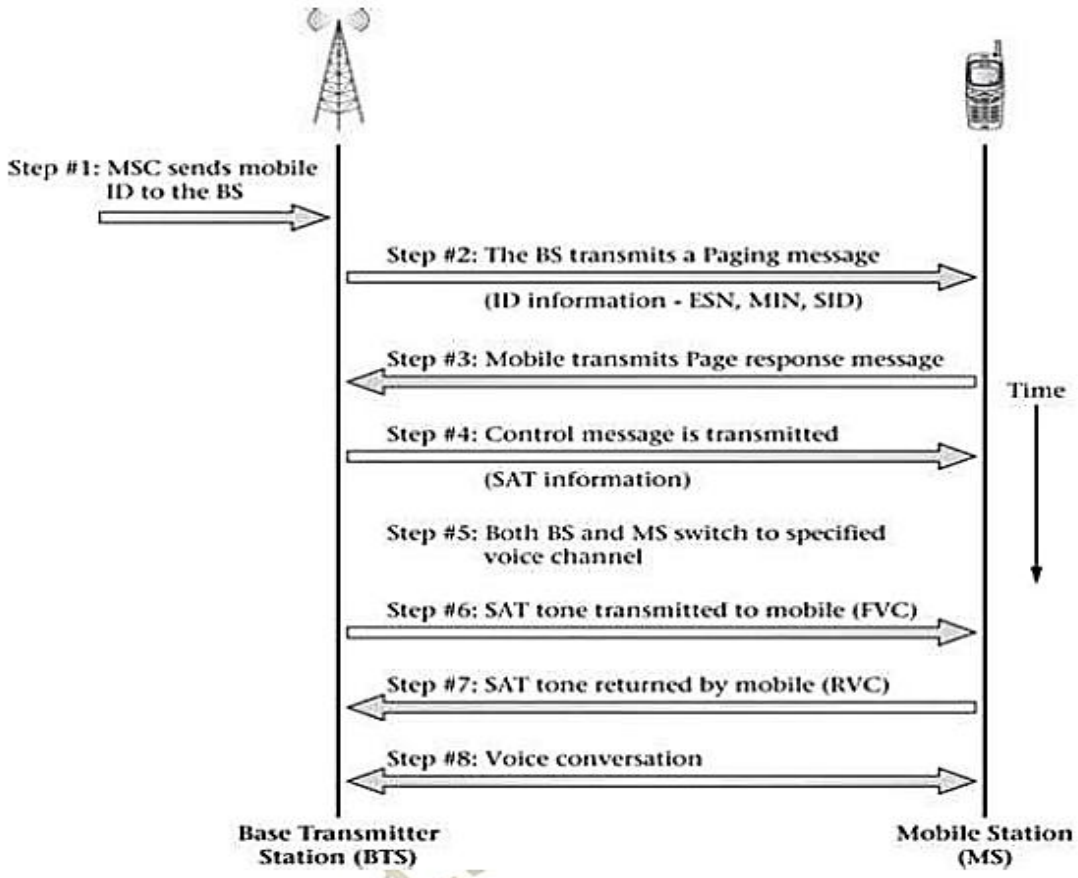
	o *Step #7:* The MS now awaits completion of the call with the resultant signal coming from the network (MSC). o *Step #8*: Finally, the conversation takes place between the users. o *Step #9:* To disconnect or complete the call, either the BS sends a release order message or the mobile sends a signaling tone (ST) for 1.8 seconds at which point the base and mobile station drop the voice channel radio link.  Figure 1.12: AMPS Mobile originated call	
3.(a)	***Subscriber Device Identification (SD)*** o The mobile subscriber device (SD) can have several different system identification numbers associated with it. o The identification information used depends upon - The type of cellular technology (TDMA, GSM, or CDMA). - The scope of the network (e.g., national or international).	1m

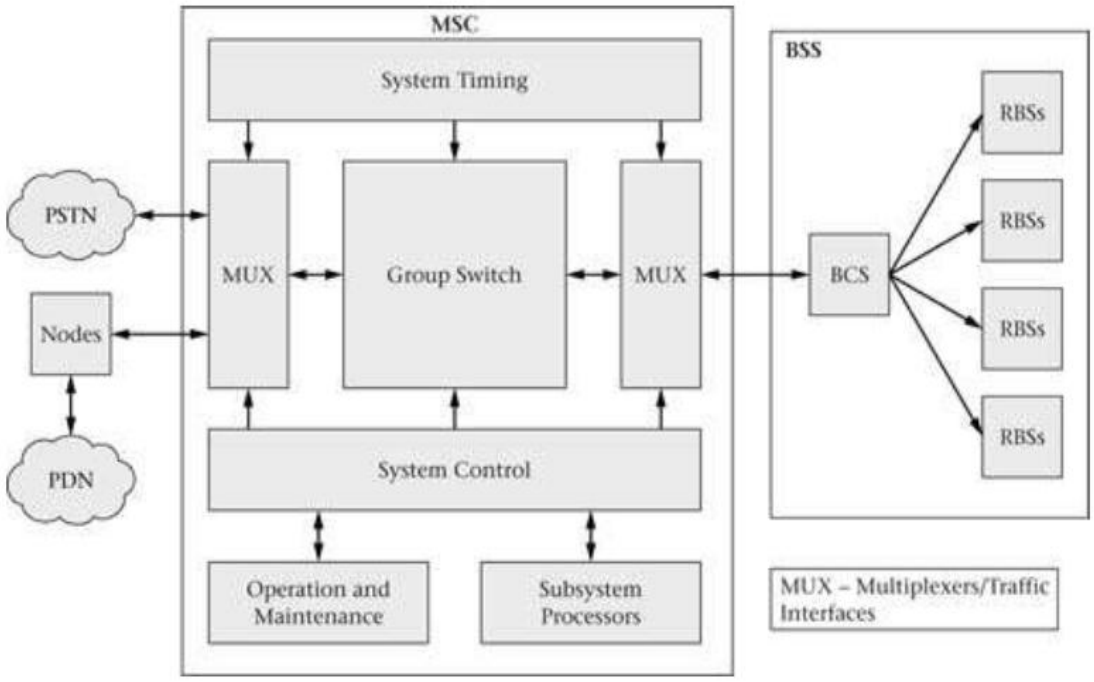
	o Accordingly we have ***a. Mobile Station ISDN Identification Number (MSISDN)*** ***b. International Mobile Subscriber Identity (IMSI)*** ***c. International Mobile Equipment Identity (IMEI)*** ***<u>a. Mobile Station ISDN Identification Number (MSISDN)</u>***	1.5m
	o In North America an MSISDN number consists of the following. **MSISDN=CC+ NPA+ SN** Where, CC = Country Code NPA = Number Planning Area, and SN = Subscriber Number o In the rest of the world an MSISDN number consists of the following: MSISDN = CC+ NDC+ SN Where NDC = National Destination Code. **(b). International Mobile Subscriber Identity (IMSI)**	1.5m
	□ It is assigned to each subscriber of international public land mobile networks. □ It is also used for acquiring other details of the mobile in HLR or in VLR □ IMSI number consists of the following: **IMSI = MCC + MNC + MSIN** Where, MCC = Mobile Country Code MNC = Mobile Network Code, and MSIN = Mobile Subscriber Identification Number. **International Mobile Equipment Identity(IMEI):**	1m
	o It is required for international mobile networks. o It is used to uniquely identify a MS as a piece of equipment to be used within the network. o IMEI is a number, usually unique, to identify GSM, WCDMA, and iDEN mobile phones, as well as some satellite phones	
3.(b)	***Visitor location register (VLR)*** o It is a database that *temporarily stores* information about any MS that attaches to a RBS in the area serviced by a particular MSC. o This temporary subscriber information is required by the MSC to provide service to a visiting	

	subscriber. o When an MS registers with a new MSC service area, the new VLR will request subscriber information from the MS's Home Location Register (HLR). o The home HLR sends the subscriber information to the VLR. o In a typical wireless network the VLR is integrated with the MSC to from an MSC/VLR. o Data stored in VLR include: a. IMSI (the subscriber's identity number). b. Authentication data. c. MSISDN (the subscriber's phone number). d. GSM services that the subscriber is allowed to access. e. Access point (GPRS) subscribed. f. The HLR address of the subscriber. **Interworking Location Register(ILR)** o These are used to provide for intersystem roaming. o It allows a subscriber to roam in several different systems.	3m 2m
4.	<u>characteristics of 1G, 2G and 3G cellular systems</u> **1G CELLULAR SYSTEM** *Features/ characteristics of 1G or AMPS System* o 1G (or 1-G) refers to the first-generation. o It is a analog based voice oriented telecommunications standards o AMPS (Advanced Mobile Phone system) were the popular 1G cellular system. o Used analog frequency modulation FM). o FDD used to achieve Duplexing. o Type of multiple access is FDMA o Channel B.W is 30Khz o Frequency band is 824-894 MHz.	

	o Forward link and Reverse link separated by 45 MHz. o ID numbers were assigned to the cellular system (SID) and mobile handset (MIN, SIM). o The system standard also defines physical layer technical parameters such as max. Permissible power level, Maximum out of band radiation level. o The standard also prescribes the required protocol for system operations. **Other IG systems:** Other first generation cellular other than AMPS are as follows *1. TACS (Total Access Communication System) cellular system)* *2. NMT (Nordic Mobile Telephone) cellular system)* *3. NTT (Nippon Telegraph and telephone) Cellular system* **2G Cellular Systems** *Features/ characteristics of 2G* o 2G is digital cellular system o It uses digital modulation techniques. o Introduce two major multiplexing schemes called TDMA and CDMA. o Use digital modulation techniques to send digital control messages rather than SAT tones. o Use Digital encryption used for security and privacy for the mobile network subscriber. o Use of digital encoding and decoding schemes. o Use of error detection and correction codes for reliability. o Two major 2G technologies and standards are GSM and CDMA. **<u>How do 2G cellular systems support more than one user per channel:</u>** **GSM(Global System for Mobile communication)** o It is a 2G digital cellular system o Began operation in late 1992. o Approximately 72% of the world's cellular customers subscribing this service. o GSM technology uses TDMA to allow up to eight users per channel.	3m 2m

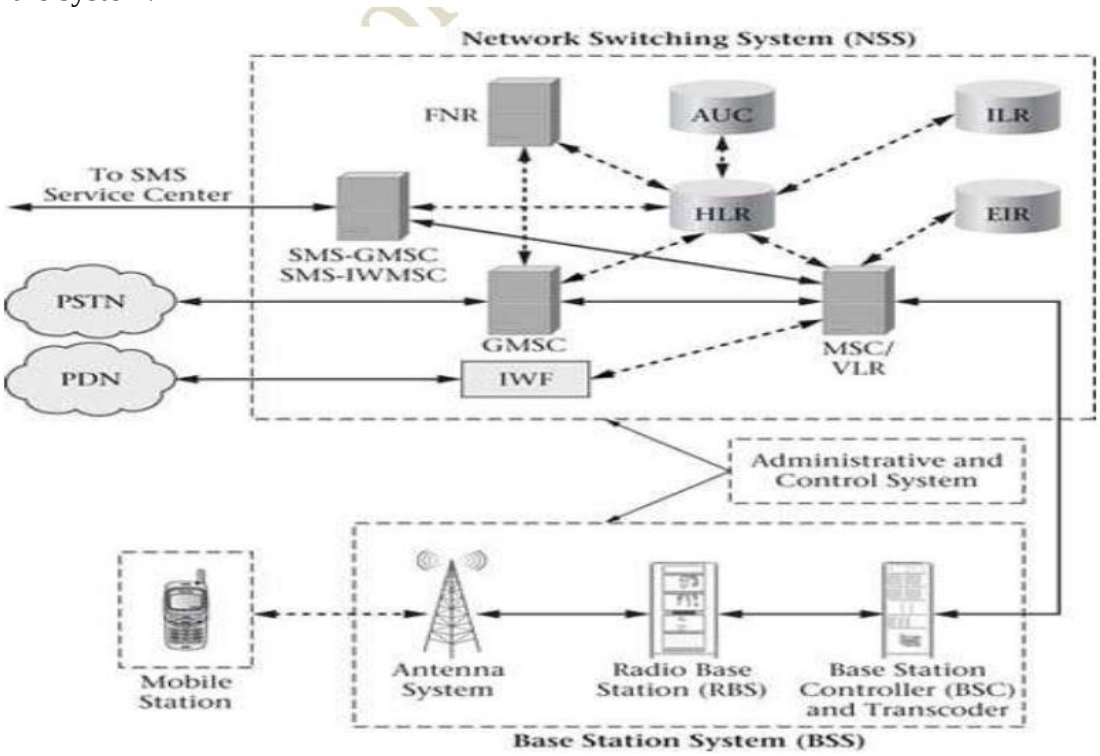
	o Channels are spaced 200 kHz apart. o Different Operating frequency bands. □ The basic system uses frequencies in the 900-MHz band (GSM 900), □ An up banded version was added at 1800 MHz (GSM 1800) □ 1900-MHz band was added in the United States for PCS service (GSM 1900). o GSM service supported circuit-switched data rates of up to 9.6 kbps. **CDMA(Code Division Multiple Access)** o It is totally new digital technology known developed by Qualcomm Corporation introduce in 1990s o CDMA cellular systems use a digital modulation technique known as spread spectrum. o It is also called for the next generation of wireless service o CDMA air interface is IS-95. o The first CDMA commercial network began operation in Hong Kong in 1995. o CDMA systems have been used in both the cellular and PCS bands extensively in the United States and throughout the rest of the world. o TDMA or CDMA cellular systems, both control information and traffic share the same radio channel. o For CDMA systems, control information is carried by dedicated channel elements and traffic is placed on any available traffic channel element. o Channel elements (CEs) are individual transmitters that are all transmitting on the same frequency simultaneously. **3G Cellular Systems** *Features/ characteristics of 3G* o Support high-speed data transfer from packet networks o Permit global roaming. o Advanced digital services (i.e., Multimedia) and o Work in various different operating environments (low through high mobility, urban to suburban to global locations, etc.). o These standards are being facilitated by the International Telecommunication Union (ITU) and	2m 3m

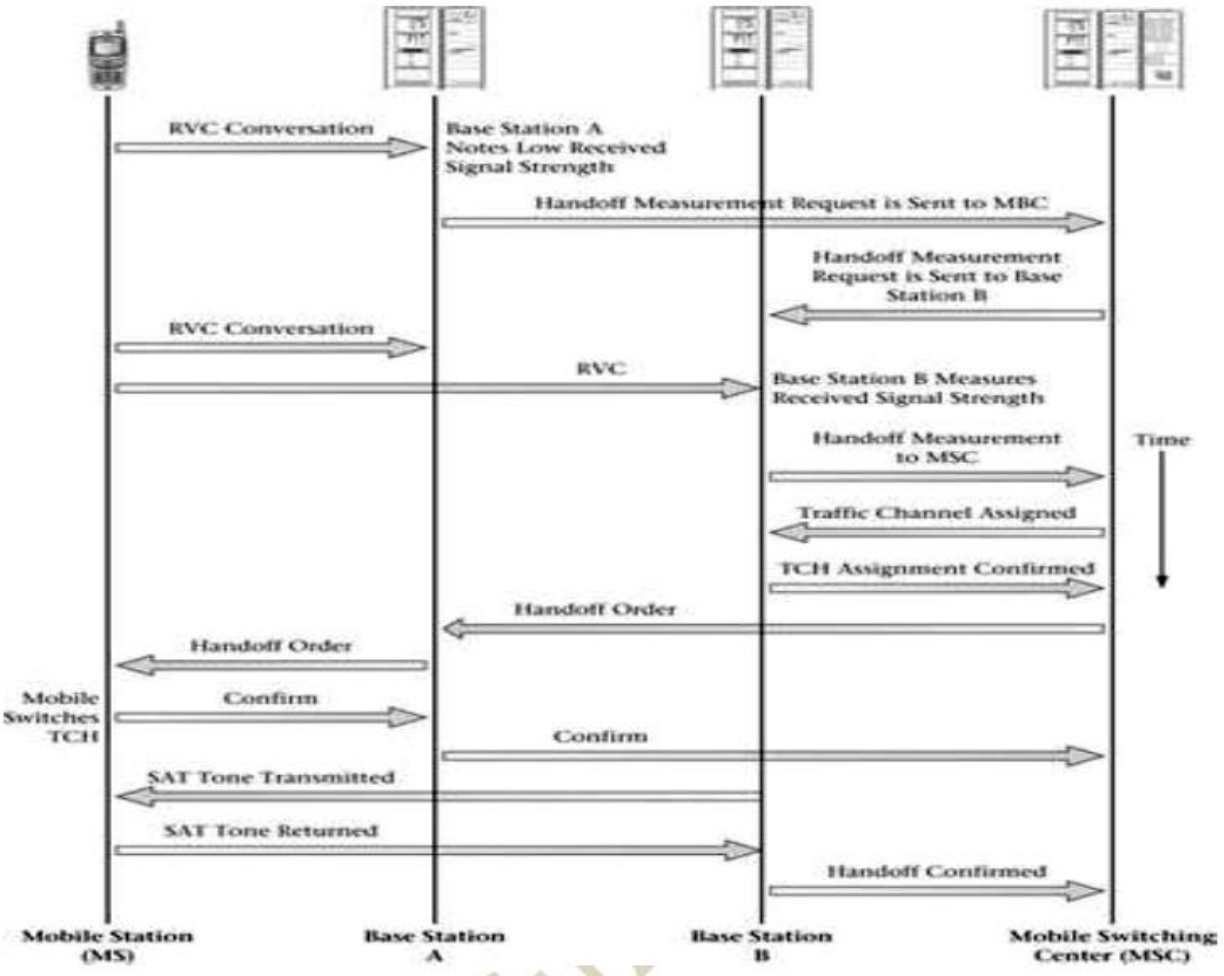
	other regional bodies *Requirements for 3G systems*: o It must be able to support varying data rates by providing bandwidth on demand to the subscriber. o 3G subscriber devices (SDs) or end terminals (ETs) will be required to support multiple technologies and frequency bands and have the ability to be reprogrammed by their home cellular systems. o Mobile phones have dual band and tri mode capabilities, can provide limited video multimedia support, and have limited reprogramming features. o 3G systems must be able to support multiple simultaneous connections, IP addressing and be backward compatible with 2G networks. **Some popular 3G system** 1. *UMTS (Universal Mobile Phone system)* 2. *CDMA2000* 3. UWC-136/EDGE	
5.	Explain the steps in AMPS mobile terminated call.  Figure 1.13: AMPS Mobile terminated call	5m

	Task description: o Step #1: MSC sends the ID of the MS to the BS. o Step #2: The BS constructs a page control message. The ID information (ESN, MIN, and SID) is added to the message as s the initial voice channel information. o Step #3: The MS responds to the page by returning identification information over the RECC in a page response message. o Step #4: Another control message is sent over the FOCC by the BS that contains an SCC value to inform the mobile as to the correct SAT to be used on the voice channel. o Step #5: The base and mobile station both switch to the voice channels and alternately use SAT tones to verify the radio link (step #6 and #7). o Step #8: After this last handshake occurs, the traffic channel is then opened to conversation	5m
6.	Explain MSC subsystem with a neat block diagram.  Figure 3.2: typical MSC subsystem MSC is at the heart of the cellular switching system. o It is responsible for the setting up, routing and supervision of voice calls to and from the MS to the PSTN.	5m

	o The basic functions performed by the MSC/VLR are as follows: □ Setting up and control of voice calls including subscriber supplementary services □ Providing voice path continuity through the use of the handoff process □ Call routing to a roaming subscriber □ Subscriber registration and location updating □ Subscriber data updating, authentication of MSs, delivery of short messages, □ Signaling to other network elements like BSC, HLR, PSTN, PLMN, etc. □ Performing of charging/accounting, statistical, and administrative input/output processing functions. o It typical block diagram of MSC as shown in figure 2.5, it consist of the following components or subsystems devoted to network operations: 1. Central processor and associate processors 2. Group switch 3. Traffic interfaces 4. Timing and synchronization module 5. Software to provide operations and maintenance (O&M) functions *MSC performs following functions*: **1. Interface functions :** Use fiber optic cable trunk connections between components in MSC to other to facilitate make available the transport of high bit-rate digital signals. o fiber-optic cables are trunks that are carrying SONET-based optical signal at bit rates in the 100s of Mbps range or higher o SONET is capable of transporting multiple TI/EI/JI carriers and asynchronous transfer mode (ATM) traffic. The MSC can be thought of as just another central office exchange in that it has its on local exchange routing number (s)(i.e., N1/0N-NNX-XXXX where N1/0N is the 3 digit area code and NNX is the exchange number **2. Switching Functions :** MSC provide multiplex and demultiplex signals to and from the PSTN.	2m 3m

	o Interface units will bring the high bit rate data streams down to the base T1/E1/J1 carrier signal after demultiplexing of the signals from the PSTN and vice versa o The connection between the MSC and the BSC services is also implemented with the same standard transmission T1/E1/J1 facilities or larger capacity fiber facilities **3. signaling functions :** It coordinate the processing of calls both to and from the MS o MSC and BSC must exchange messages using message transfer part (MTP) signaling connection control part (SCCP) of signaling system #7 (SS7). o The MTP provides reliable transfers of signaling messages over standard (T1/E1/J1) digital transmission links running in parallel with digital traffic links . **4. MSC database functions :** o various functional databases contained in the cellular NSS about the information of a. The system subscribers b. Their network privileges c. Supplementary services o The present and other information necessary to locate, authenticate and maintain radio link connections to the subscriber's devices. o The MSC/VLR is continually sending and receiving data from the HLR and AUC/EIR Databases. o The signaling and data transfer between the MSC/VLR and these databases is carried out using MTP and SCCP over SS7.	
7.	Draw a neat diagram showing typical wireless system components and describe each component in brief. o Cellular systems divided in to three sections as shown in figure 2.1.They are 1. *Mobile Station (MS*) 2. *Base Station System (BSS)* 3. *Network Switching System (NSS)* elements designed to perform certain operations in support of the entire system. For 2G and 2.5G cellular networks, the air interface functions are typically performed by a fixed radio base station (RBS) and a MS that provide user mobility.	

	o The radio base station controller (BSC) and this portion of the cellular system is usually referred to the base station system (BSS). o The BSS is connected to a fixed switching system (SS) that handles the routing of both voice calls and data services to and from the MS. o The switching system usually consists of a Mobile Switching Center (MSC) and various databases and functional nodes used to support the mobility management and security operations of the system.  Figure 2.1 Typical cellular system components The main components are: 1. Visitor Location Register (VLR) 2. Mobile Switching Center (MSC) 3. Home Location Register(HLR) 4. Interworking Location Register (ILR) 5. Authentication Canter (AUC) 6. Equipment Identity Register (EIR) 7. Gateway MSC (GMSC) 8. Interworking Units (IWU)	3m 4m

	o The switching system is usually connected to the PSTN, the PDN, other public land mobile networks (PLMNs), and various data management networks through gateway switches (GMSCs). o Other typical connections to the switching system are to network management systems and other accounting or administrative data entry systems. o The various network elements that make up the wireless system are interconnected by communication links that transport system messages between network elements to facilitate network operations and deliver the actual voice call or data services information.	3m
8.	Describe AMPS handoff operation with a neat diagram showing the time sequences of events, signals and messages used.  Handover or Handoff refers to the process of transferring an ongoing call or data session from one channel connected to the **core network** to another. *Handoff operations*	6m

	o A handoff operation occurs in a cellular system when a MS moves to another cell. o Consider that BS A is handling an active call from a MS within its area of coverage. o However the MS is in transit and is moving from BS A and towards BS B's coverage area. o BS A constantly monitors the received signal power from MS. When the signal from MS goes below a predetermined threshold level, BS A sends a handoff measurement request to the MSC. The MSC requests that all the BSs that are able to receive the transmissions from the specified MSs monitor its power level. It is determined that BS B is receiving the strongest signal from the mobile. o The MSC assigns a traffic channel (TCH) to BS B. Base station B responds and handover order is sent from the MSC to BS A. o BS A sends a handoff control signal to the MS with the necessary new channel information and then mobile switches to new voice channel with its newly prescribed output power and new SCC code. o The mobile receives Base station B's SAT and returns it. If everything goes well, the handoff is successful.	4m