Unit 6 - Cellular Telephone Systems

1. What is meant by first-generation cellular telephone system?
The first generation of cellular systems used analog radio technology. Nippon Telephone and Telegraph (NTT) in Tokyo started the first commercial analog cellular system on December, 1979. In 1981, the commercial Nordic Mobile Telephone (NMT) system was started in the Nordic countries. Although there was an Advanced Mobile Phone Service (AMPS) test system operating in 1979, the first commercial AMPS system was not introduced in the United States until 1983. By 1985, a commercial TACS system began in the United Kingdom. Since their introduction, these first generation analog cellular technologies have evolved to provide higher system capacity and advanced features.

Analog cellular systems consist of three basic elements: a mobile telephone (mobile radio), cell sites, and a mobile switching center (MSC). Figure below shows a basic cellular system in which a geographic service area such as a city is divided into smaller radio coverage area cells. A mobile telephone communicates by radio signals to the cell site within a radio coverage area. The cell site s base station (BS) converts these radio signals for transfer to the MSC via wired (landline) or wireless (microwave) communications links. The MSC routes the call to another mobile telephone in the system or the appropriate landline facility.

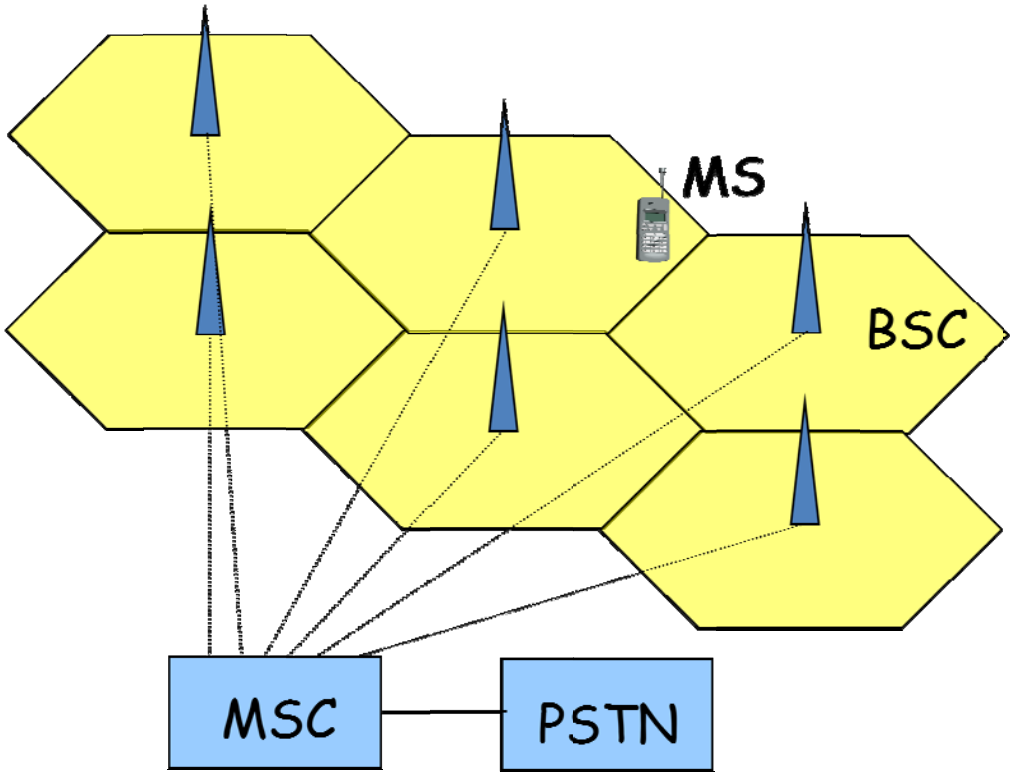


Figure: Basic Cellular System.

These three elements are integrated to form a ubiquitous coverage radio system that can connect to the public switched telephone network (PSTN).

2. Briefly describe the AMPS system. Outline the AMPS frequency allocation.
AMPS was invented at Bell Labs and initially deployed in the U.S. in the early 1980's using the 800-MHz to 900-MHz frequency band and the 30 kHz bandwidth for each channel as a fully automated mobile telephone service. It was the first standardized cellular service in the world and is currently the most widely used standard for cellular communications. Designed for use in cities, AMPS later

expanded to rural areas. It maximized the cellular concept of frequency reuse by reducing radio power output. The AMPS telephones (or handsets) have the familiar telephone-style user interface and are compatible with any AMPS base station. This makes mobility between service providers (roaming) simpler for subscribers. Limitations associated with AMPS include:

1. low calling capacity
2. limited spectrum
3. no room for spectrum growth
4. poor data communications
5. minimal privacy
6. inadequate fraud protection

AMPS is used throughout the world and is particularly popular in the United States, South America, China, and Australia. AMPS uses frequency modulation (FM) for radio transmission. In the United States, transmissions from mobile to cell site use separate frequencies from the base station to the mobile subscriber.

AMPS Channels

The frequencies allocated to AMPS by the FCC range between 824 to 849 MHz in reverse channels (mobile to base) and 869 to 894 MHz in forward channels (base to mobile). As displayed in Table, they are not contiguous blocks because the initial 40 MHz allocation by the FCC was later extended by 10 MHz when the service's popularity became evident. There are now a total of 416 channels available in each direction, numbered from 1 to 1024 with gaps in the numbering.

Table: AMPS Frequency Allocations

Carrier Side	Reverse Direction	Forward Direction
A (initial)	824-834 MHz	869-879 MHz
A (extended)	844-846.5 MHz	889-891.5 MHz
B (initial)	834-844 MHz	879-889 MHz
B (extended)	846.5-849 MHz	891.5-894 MHz

Each physical channel is 30 kHz wide and is dedicated to a single mobile station for the duration of the call while the mobile is in the current cell. Each call uses a dedicated forward channel paired with a dedicated reverse channel at a 45 MHz offset. Some of the channel pairs (21 of them) are used for control purposes in the AMPS environment. Analog *frequency modulation (FM)* with 8 kHz deviation is used in the *traffic channels*, which convey voice conversations. Binary *frequency shift keying (FSK)* at 10 kbps-a digital modulation technique-is used in the *control channels* used for signalling.

AMPS is an analog FM system, with all of the associated ramifications of such a system. AMPS channels are insecure-anyone with a channel scanner can listen to unsuspecting AMPS users. AMPS channels can suffer from interference, which sounds like static to a user; analog signals suffering from multipath fading cannot be corrected. Finally, AMPS radio resource management is based on signal strength (rather than C/I), which can only be measured indirectly via *supervisory audio tones* or *SAT*.

3. List and describe the three classifications of AMPS cellular telephones.

Analog Cellular Systems in the US - AMPS Variants

There are three variations of the analog cellular system in operation in the US:

- **AMPS - Advanced Mobile Phone System**
  Original system that had 666 channels (42 control, 624 voice)
- **EAMPS - Extended AMPS**
  Current system that has 832 channels (42 control, 790 voice) and has replaced AMPS as the US standard
- **NAMPS - Narrowband AMPS**

New system that has three times as many voice channels as EAMPS with no loss of signal quality

All three systems have 42 control channels that are for setting up calls; the remaining channels are for voice conversations. All three systems are also analog systems. The systems are listed in chronological order and are backward compatible; that is, the infrastructure is designed so that older phones work on the newer systems.

4. List and describe the classifications of TACS.

Analog Cellular Systems outside the US - TACS Variants

There are several variations of analog cellular systems in operation outside the US that were originally based on the US AMPS cellular system:

- **TACS - Total Access Communications System**
  Original UK system that has either 600 or 1000 channels (42 control, 558 or 958 voice)
- **ITACS - International TACS**
  Minor variation of TACS to allow operation outside of the UK by allowing flexibility in assigning the control channels
- **ETACS - Extended TACS**
  Current UK system that has 1320 channels (42 control, 1,278 voice) and has replaced TACS as the UK standard
- **JTACS - Japan TACS**
  A version of TACS designed for operation in Japan
- **IETACS - International ETACS**
  Again, a minor variation of ETACS to allow operation outside of the UK by allowing flexibility in assigning the control channels
- **NTACS - Narrowband TACS**
  New system that has three times as many voice channels as ETACS with no loss of signal quality

All systems have 42 control channels that are for setting up calls; the remaining channels are for voice conversations. All these systems are also analog systems. The systems are listed in chronological order and are roughly backward compatible; that is, the infrastructure is designed so that older phones work on the newer systems.

5. **List the advantages of a digital cellular system. Describe the United States Digital Cellular system.**

Analog v. Digital Cell Phones

Cellular telephone systems can be "analog" or "digital". Older systems (AMPS, TACS, NMT) are "analog" and newer systems (GSM, PCS) are "digital".

The major difference is in how the audio signals, e.g. your voice, is transmitted between the phone and base station. "Analog" and "digital" refer to this transmission mechanism.

The advantages of digital cellular technologies over analog cellular networks include increased capacity and security. Technology options such as TDMA and CDMA offer more channels in the same analog cellular bandwidth and encrypted voice and data.

United States Digital Cellular system

Another name for IS-54 is United States Digital Cellular (USDC). It is a digital extension of AMPS and maintains compatibility with Advanced Mobile Phone System (AMPS) in many ways.

AMPS/DAMPS Comparison:

	Analog	**Digital**

Standard	EIA–553 (AMPS)	IS–54 (TDMA + AMPS)
Spectrum	824 MHz to 891 MHz	824 MHz to 891 MHz
Channel Bandwidth	30 kHz	30 kHz
Channels	21 CC / 395 VC	21 CC / 395 VC
Conversations per Channel	1	3 or 6
Subscriber Capacity	40 to 50 Conversations per cell	125 to 300 Conversations per cell
TX / RCV Type	Continuous	Time shared bursts
Carrier Type	Constant phase, Variable frequency	Constant frequency, Variable phase
Mobile/Base Relationship	Mobile slaved to base	Authority shared cooperatively
Privacy	Poor	Better—easily scrambled
Noise Immunity	Poor	High
Fraud Detection	ESN plus optional password (PIN)	ESN plus optional password (PIN)

6. Explain the following:

i. Basic Components of Cellular Systems
ii. Personal communications service
iii. Personal communications network

Basic Components of Cellular Systems (Architecture of a cellular system)
There are various cellular systems in the world, such as the GSM and CDMA. The architecture of most cellular systems can be broken down into six basic components:

a) Mobile Station (MS): A mobile station is basically a mobile or wireless device that contains a control unit, a transceiver and an antenna system for data and voice transmission. For example, in GSM networks, the mobile station will consist of the mobile equipment (ME) and the SIM card.

b) Air Interface Standard: There are three main air interface protocols or standards: frequency division multiple access (FDMA), time division multiple access (TDMA) and code division multiple access (CDMA). These standards are basically the medium access control (MAC) protocols that define the rules for entities to access the communication medium.

These air interface standards allow many mobile user to share simultaneously the finite amount of radio channels.

c) Base Station (BS): A base station is a fixed station in a mobile cellular system used for radio communications with mobile units. They consist of radio channels and transmitter and receiver antenna mounted on a tower.

d) Gateway: The gateway is the communication links between two wireless systems or between wireless and wired systems. There are two logical components inside the Gateway: mobile switching center (MSC) and interworking function (IWF).

The MSC connects the cellular base stations and the mobile stations to the public switched telephone network (PSTN) or other MSC. It contains the EIR database.

The IWF connects the cellular base stations and the mobile stations to Internet and perform protocol translation if needed.

e) Databases: Another integral component of a cellular system is the databases.

There are two main databases: the Home Location Register (HLR) and Visitor Location Register (VLR). The HLR contains the information of each subscriber who resides in the same city as the mobile switching center (MSC). The VLR temporarily stores the information for each visiting subscriber in the coverage area of a MSC. The VLR is the database that supports roaming capability.

f) Security Mechanism: The security mechanism is to confirm that a particular subscriber is allowed to access the network and also to authenticate the billing.

There are two databases used for security mechanism: Equipment Identify Register (EIR) and Authentication Center (AuC). The EIR identifies stolen or fraudulently altered phones that transmit identity data that does not match with information contained in either the HLR or VLR. The AuC, on the other hand, manages the actual encryption and verification of each subscriber.

The Mobile Telephone Switching Office (MTSO) or Mobile switching center (MSC) is the heart of a cellular system. It is responsible for assigning frequencies to each call, reassigning frequencies for handoffs, interconnecting calls with the local and long distance landline telephone companies, compiling billing information, etc. It also provides resources needed to efficiently serve a mobile subscriber such as registration, authentication, location updating and call routing.

All cellular systems have at least one MTSO. The MTSO is responsible for switching calls to mobile units as well as to the local telephone system, recording billing data and processing data from the cell-site controllers. It s also responsible for controlling handoffs so a mobile phone leaving one cell can be switched automatically to a channel in the next cell.

The MTSO is connected to a close telephone exchange by a trunk group. This provides an interface to the (Public Switched Telephone Network) (PSTN). It also provides connectivity to the PSTN. The region to be served by a Cellular Geographic Serving Area (CGSA) is split into geographic cells. These cells are ideally hexagonal in shape and they are initially laid out with their centers about 4 to 8 miles apart from each other. The MTSO also provides switching and control functions for a group of cell sites. To achieve this, there has to be a method of connectivity between the MTSO and the facilities in the cell site. Besides providing a means of connection to the public network, the MTSO also controls the activities of cell sites and actions of mobile phones through command and control data channels.

Personal communications service (PCS System)
PCS is a wireless phone service similar to cellular telephone service but emphasizing personal service and extended mobility. PCS is the name given to a number of wireless technologies and services that typically operate in the 2 GHz range [Uses frequencies between 1.85 and 1.99 GHz (1850 MHz to 1990 MHz)]. PCS has smaller cells and therefore requires a larger number of antennas to cover a geographic area.

Personal Communications Network (PCN)
PCN is the European digital cellular mobile telephone network, developed in accordance with GSM standards.

The PCN system was first initiated by Lord Young, UK Secretary of State for Trade and Industry, in 1988.

The main characteristics of PCN are as follows:

1. Operating frequency - 1.7 to 1.88 GHz (1710 - 1785 MHz and 1805 - 1880 MHz).
2. Uses 30 GHz or up for microwave back bone system.
3. Covers both small cells and large cells.
4. Coverage inside and outside buildings.
5. Hand over.
6. Cell delivery.
7. Portable hand set.
8. User intelligent network.

PCN uses the DCS-1800 systems, which is similar to GSM, but up converts the frequency to 1.7 to 1.88 GHz, therefore the network structure, the signal structure and the transmission characteristics are similar between PCN and GSM, but operational frequencies are different.

7. Briefly describe about Personal communications services system (PCSS) and its architecture.
PCS is a wireless phone service similar to cellular telephone service but emphasizing personal service and extended mobility. PCS is the name given to a number of wireless technologies and services that typically operate in the 2 GHz range [Uses frequencies between 1.85 and 1.99 GHz (1850 MHz to 1990 MHz)]. PCS has smaller cells and therefore requires a larger number of antennas to cover a geographic area.

Each PCS technology has similar architectures which consists two parts as shown in the figure below:

- Radio Network
    - MS (Mobile Station) (or so-called mobile phone)
    - BS (Base Station)

- Wired Transport Network
    - MSC (Mobile Switching Center)
    - Mobility database attached with MSC

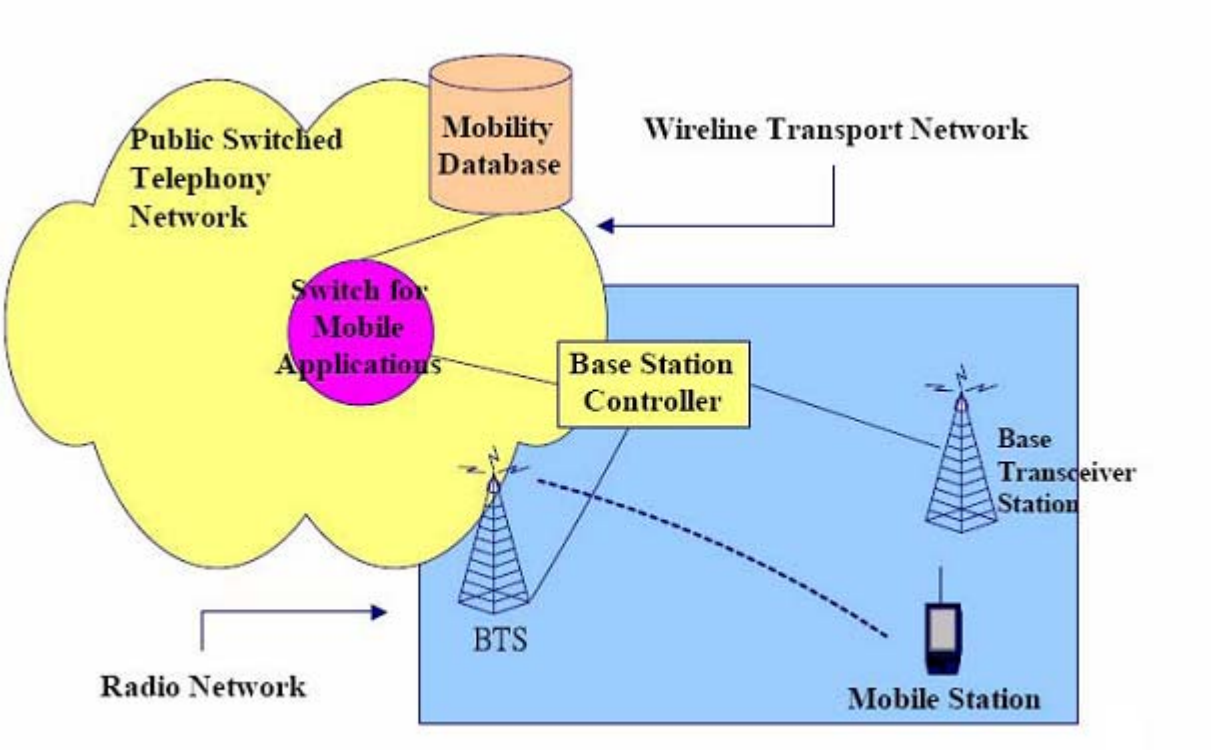


Fig: Basic Architecture of PCS

8. List the advantages of a PCS cellular system compared to a standard cellular system.
Personal Communications Services (PCS) is a wireless phone service very similar to cellular phone service, but with an emphasis on personal service and greater user mobility. The term "PCS" is often used in place of "digital cellular" but true PCS means that other services like paging, caller ID and Email are bundled into the service whereas Cellular service started as a phone for cars. Consequently, the networks originally covered major roads and highways. As handsets became smaller and more portable, carriers began to add residential neighborhoods, shopping malls, business districts.

The service's pricing and network layout however, are still based largely on the "car phone" concept. PCS, on the other hand, began as service that allows consumers to communicate regardless of where they are and without being in their cars.

PCS has smaller cells and Compared to Cellular networks, therefore requires a larger number of antennas to cover a geographic area.

Technically in United States

- Cellular Operates in 824 MHz to 894 MHz frequency bands
- PCS operates in 1850 MHz to 1990 MHz bands

All other things being equal, this difference in frequency use does not translate into any real advantage for PCS operators because the higher frequencies do not allow signals to travel as far as cellular signals.

Detractors of digital services (regular and PCS) say that analog has better coverage. If you live on a mountain areas or drive over one frequently you might not have your phone conversation cut short as often with an analog phone. But quality of sound in a PCS and Digital Cellular Networks are better.

Another pitfall of PCS is that the networks are still relatively new, it isn´t nationwide yet and only

works consistently in metropolitan areas of the country and pockets where the service has been built up.

9. Briefly describe the N-AMPS cellular telephone system. What are the four types of handoffs possible with N-AMPS?
AMPS (Advanced Mobile Phone Service) was the first *cellular* mobile system in the United States. AMPS operates as an analog system using 30 kHz wide channels.

AMPS was later enhanced to NAMPS (Narrowband Advanced Mobile Phone Service), a version of AMPS that uses 10 kHz channels and by doing so triples cellular capacity i.e. increases the number of calls that can be handled by the system. This is intended as an interim solution until a digital cellular system is agreed upon.

AMPS is defined in the EIA/TIA-553 standards. NAMPS is defined in the TIA/EIA/IS-91 standard.

Types of Handoffs
Handoffs are broadly classified into two categories—hard and soft handoffs. Usually, the hard handoff can be further divided into two different types—intra- and intercell handoffs. The soft handoff can also be divided into two different types—multiway soft handoffs and softer handoffs.

- A **hard handoff** is one in which the channel in the source cell is released and only then the channel in the target cell is engaged. Thus the connection to the source is broken before the connection to the target is made—for this reason such handoffs are also known as *break-before-make*. Hard handoffs are intended to be instantaneous in order to minimize the disruption to the call. A hard handoff is perceived by network engineers as an event during the call.

- A soft handoff is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. In this case the connection to the target is established before the connection to the source is broken, hence this handoff is called *make-before-break*. The interval, during which the two connections are used in parallel, may be brief or substantial. For this reason the soft handoff is perceived by network engineers as a state of the call, rather than a brief event. A soft handoff may involve using connections to more than two cells, e.g. connections to three, four or more cells can be maintained by one phone at the same time. When a call is in a state of soft handoff the signal of the best of all used channels can be utilised for the call at a given moment or all the signals can be combined to produce a clearer copy of the signal. The latter is more advantageous, and when such combining is performed both in the downlink (forward link) and the uplink (reverse link) the handoff is termed as *softer*. Softer handoffs are possible when the cells involved in the handoff have a single cell site.

10. Explain about the GSM system architecture.

The GSM Network Components:
A GSM network is composed of several functional entities, whose functions and interfaces are specified. The subscriber carries the mobile station (MS). A base station subsystem (BSC) controls the radio link with the mobile station. The network subsystem, the main part of which is the mobile services switching center (MSC), performs the switching of calls between the mobile users, and between mobile and fixed network users. The MSC also handles the mobility management operations. The mobile station and the base station subsystem communicate across the Um interface, also known as the air interface or radio link. The base station subsystem communicates with the mobile services switching center. Each b*ase transmitting station* operates on a set of frequencies to avoid mutual interference. A couple of BTSs are managed by *Base Station Controllers* (BSC)

handling functions like handover or power control. A number of BSCs are handled by one *Master Control Centre* (MSC) that controls calls to and fro from other networks.

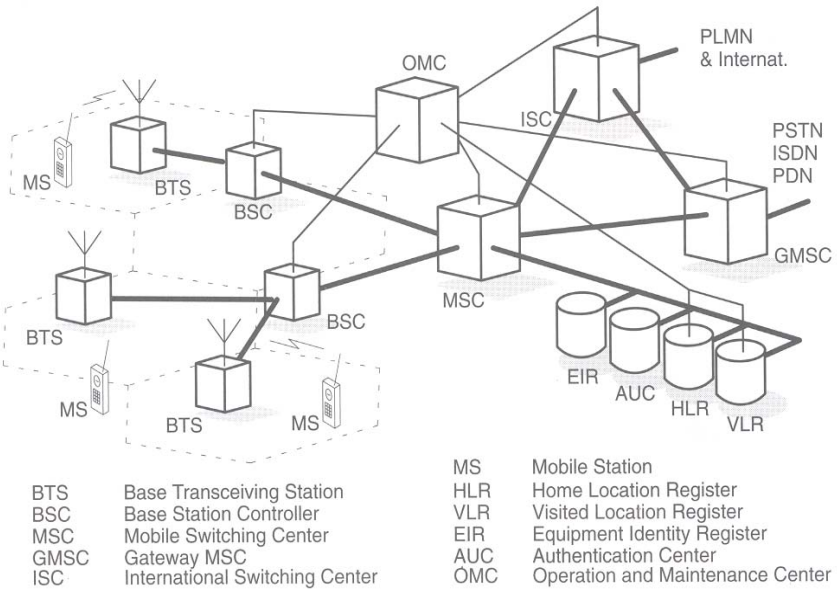
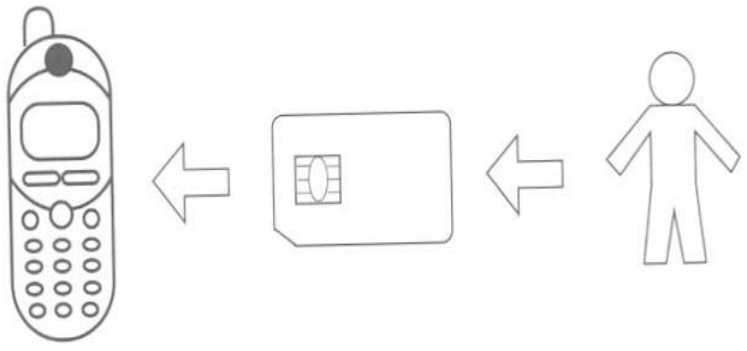


Fig: GSM system architecture with essential components

The Mobile Station (MS):

A MS as shown in figure below, consists of the mobile equipment (the terminal) and a smart card called the subscriber identity module (SIM). The SIM is a microchip planted in a plastic card. A mobile set becomes mobile station when SIM is inserted into a GSM phone. A SIM contains an elaborate database. The SIM provides personal mobility, so that the user can have access to subscribed services irrespective of a specific terminal. By inserting the SIM card into another GSM terminal, the user is able to receive calls at the terminal, make calls from that terminal, and receive other subscribed services.



Mobile Station and SIM card.

The mobile equipment is uniquely identified by the international mobile equipment identity (IMEI). The SIM card contains the international mobile subscriber identity (IMSI) used to identify the subscriber to the system, a secret key for authentication and other information. The IMEI & the IMSI are independent, thereby allowing personal mobility. The SIM card may be protected against

unauthorized use by a password or personal identity number. This bars the reuse of a stolen mobile simply by using any other SIM.

A block diagram of MS has been shown in figure below:

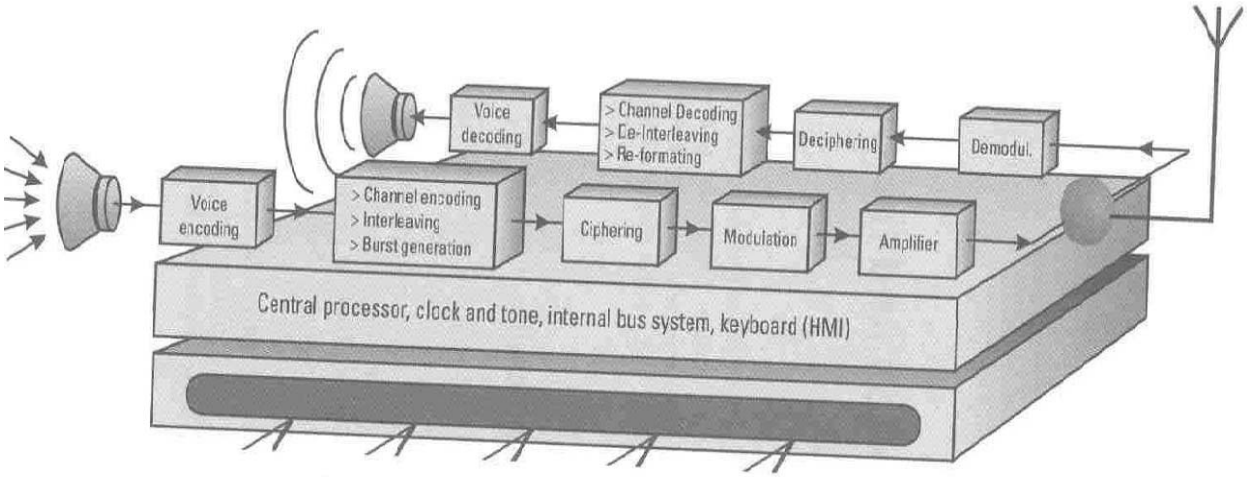


Fig: Block diagram of a GSM MS

A MS contains the following:

- *Antenna Combiner*: Couples the transmitting & receiving signals to a common antenna.
- *A receiver*: It receives the incoming calls at radio frequency.
- *A transmitter*: Which transmits the out going signal at radio frequency.
- *Synthesizer:* Provides the internal timing reference for the bit and frame clocks as also for the RF sources in the transmitter and receiver.
- *Voltage Controlled Oscillator*: It provides a stable frequency source to the transmitter, receiver, and various control and signaling units.
- *Control & Signaling Unit*: Performs all the control functions including power control, channels selection etc. signaling messages are generated, received and processed in this unit.
- *Channel Coder*: Encodes or decodes a bit sequence from the demultiplexer or to the multiplexer. It processes both signaling and speech channels.
- *Equalizer, Demodulator, Demultiplexer*: Compensates for distortions in received signals, extracts the bit stream and sorts the data into different time slots and frames into their appropriate individual logical channels.
- *Burst Building Unit, Multiplexer, Modulator*: Places the coded bits in the proper burst structure and add the other required bits. The multiplexer assigns each burst to a time slot in a numbered frame in which it is to be transmitted. The modulator modulates the voice signal on to the RF carrier.

The Base Station Subsystem (BSS):

The BSS is responsible for all functions related to radio resource management. Its functions include:

- Radio resource control.
- Frequency hopping and power control.
- Handoff management.
- Digital signal processing.

The BSS is composed of two parts, the base transceiver station (BTS) and the base station controller (BSC). They communicate across a standardized interface between BSC and MSC (Abis interface). The BTS provides the physical connection of an MS to the network in form of Air-interface. On the

other side, towards *network switching subsystem* (NSS), the BTS is connected to the BSC via the Abis-interface.

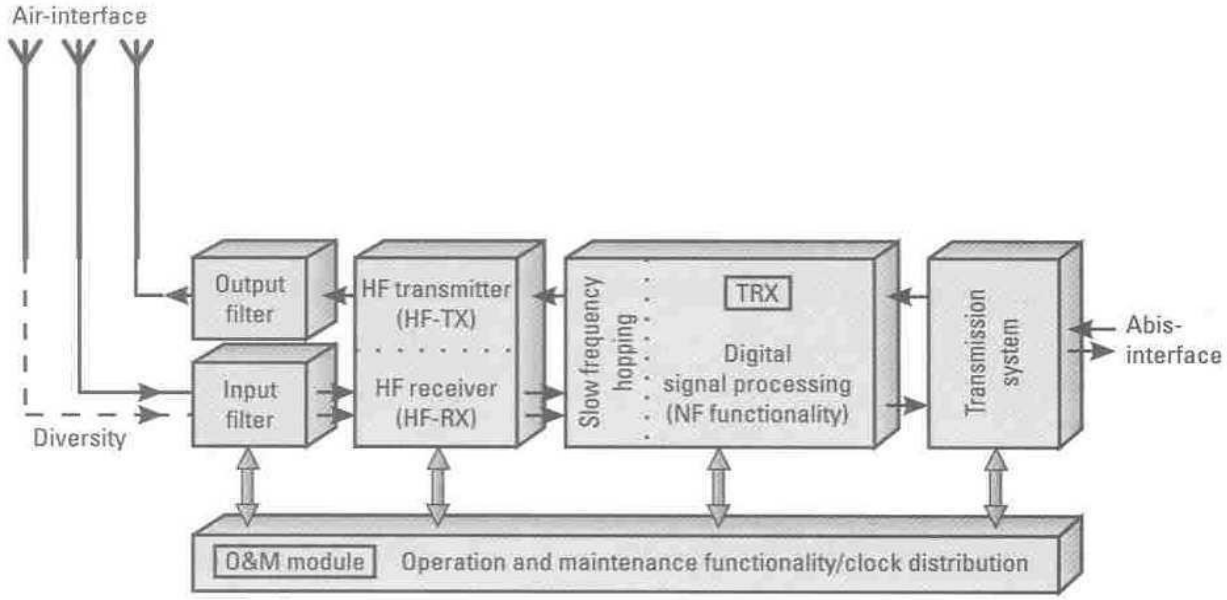


Fig: Block diagram of a BTS with oneTRX.

The base transceiver station houses the *radio transceivers* (TRXs) that define a cell and handle the radio link protocols with the mobile station. Fig above shows a block diagram and signal flow of one BTS with one TRX. The GSM recommendations allow for one BTS to host up to 16 TRXs.

In field, majority of the BTSs host between one and four TRXs. In a large urban area, they will be large number of BTSs. The base station controller manages the radio resources for one or more BTSs. It handles radio channel setup, frequency hopping and handovers as described below. The BSC is the connection between the mobile station and the mobile service-switching center (MSC). The TRX (transmit/receive) modules receive GMSK modulated carriers, demodulates them, do decryption, do signal processing, data formatting, measure signal strength, data encryption, burst formatting, and GMSK modulation of all downlink signals.

Many areas use sectorized BTSs. Where several BTSs are located in one site but their antenna covers only an area of 120 or 180 degrees. A cell used with 120^0 coverage allows reuse of frequencies in one sector. It also eases the demand of frequencies particularly in urban areas. BSC forms the centre of BSS. The BSC is in fact a small digital exchange with some mobile-specific extensions. BSC takes care of all the central functions and control of the subsystems (BSS). BTSs of an area are connected to the BSC via an interface called the Abis-interface. Large number of BSCs is connected to the MSC via the A-interface. It is also called Um interface. The MSC is only one sub-centre of a GSM network. Another sub-centre is HLR, which stores the data of a large number of subscribers. Every *public land mobile network* (PLMN) requires an at least one HLR. For a mobile-terminated (roaming) call, the network first establishes the current location area for the called mobile through signaling between the home location register (HLR) and the visiting location register (VLR). This process allows the call to be routed to the current serving MSC. When the subscriber moves out of the VLR area the HLR requests removal of the data related to a subscriber from VLR. The VLR represents a temporary data store, and there is one VLR per MSC. The temporary data stored in VLR includes:

- Features currently activated.
- Temporary mobile station identity (TMSI).
- Current location information about MS (e.g., location area and cell identity).

The equipment identity register (EIR) is a database that contains a list of all valid mobile equipment on the network, where each mobile station is identified by *its international mobile equipment identity*

(IMEI). An IMEI is marked as invalid if it has been reported stolen or is not type approved. Every SIM contains a unique identifier IMEI. The EIR checks for authenticated terminal equipment so that stolen, fraudulent, or non type-approved terminals can be identified and denied service (by analyzing the related SIM data).

The Network Subsystems:
The heart of the network subsystem is the mobile services switching center (MSC). It acts like a normal switching node of the PSTN or ISDN and additionally provides all the functionality needed to handle a mobile subscriber, such as registration, authentication, location updating, handovers, and call routing to a roaming subscriber. The MSC provides the connection to the fixed networks (such as the PSTN or ISDN). The network subsystem uses signaling system used for trunk Signaling in ISDN and widely used in current public networks.

A number of databases like:
- *Home Location register* (HLR).
- *Visitor Location Register* (HLR)
- *Authentication Centre* (AuC)
- *Equipment Identity Register* (EIR)

are available for call control and network management. They also keep track of the MS and continuously update the records of the mobile.

The home location register (HLR) and visitor location register (VLR), together with the MSC, provide the call routing and roaming capabilities of GSM. The HLR contains all the administrative information of each subscriber registered in the corresponding GSM network, along with the current location of the mobile. The location of the mobile is typically in the form of the signaling address of the VLR associated with the mobile station. There is normally one HLR per GSM network.

The visitor location register (VLR) contains selected administrative information from the HLR, necessary for call control and provision of the subscribed services, for each mobile currently located in the geographical area controlled by the VLR. Normally the VLR is implemented together with the MSC, simplifying the signaling requirements

The authentication center (AuC) is a protected database that stores a copy of the secret key stored in each subscribers SIM card, which is used for authentication and encryption over the radio channel.

11. Outline and describe the services offered by GSM.

GSM Services are defined as anything the end user explicitly sees as worth paying for.

Service Categories
Main type of telecommunication services:
- **Basic services:**
  Available to all subscribers to a mobile network. There are two main categories:
  - **Teleservices**
    Teleservice allows the subscriber to communicate (usually via voice, fax, data or SMS) with another subscriber. It is a complete system including necessary terminal equipment.
  - **Emergency calls**

The emergency call function enables a subscriber to make an emergency call by pressing a predefined button or by using the emergency number. (like 112 , 911).

- **SMS Cell Broadcast (SMSCB)**
  A text message with a maximum length of 93 characters can be broadcast to all mobiles within a certain geographic area.
  traffic congestion warnings, accident reports, weather announcements and advertisements.

- **Bearer Services**
  It transports speech and data as digital information within the network between user interfaces. e.g.- a bearer service associated with the speech telephony tele service is the timeslot assigned to a call on a TDMA frame over the air interface.

- **Supplementary services:** Additional services that are available by subscription only. These are value Added Services.
  - Call forwarding.
  - Calling line identification services: These cover both the presentation and restriction of the calling line identity.
  - Mobile Messaging
  - Mobile internet
  - Mobile intelligent Network Services