CHAPTER 2

Global System for Mobile Communication

2.1 GSM Overview

- GSM stands for **G**lobal **S**ystem for **M**obile Communication.
- It is a digital cellular 2G technology used for transmitting voice and data services.
- 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 is a circuit switched system that divides each 200kHz channel into eight 25kHz time-slot.
- GSM operates on the mobile communication bands 900 MHz, 1800 MHz and 1900 MHz in most parts of the world.
- GSM owned a market share of more than 70 percent of the world's digital cellular subscribers at one point.
- GSM was developed using digital techonlgy. UL and DL speed.
- GSM provides basic to advanced voice and data services including roaming service.
- GSM radio frequency carriers

	GSM 900	**GSM 1800**	**GSM 1800**
Uplink	890-915 MHz	1710-1785 MHz	1930-1990 MHz
Downlink	935-960 MHz	1805-1880 MHz	1850-1910 MHz

Carrier separation is 200 kHz, which provides:

- 124 pairs of carriers in the GSM 900 band
- 374 pairs of carriers in the GSM 1800 band

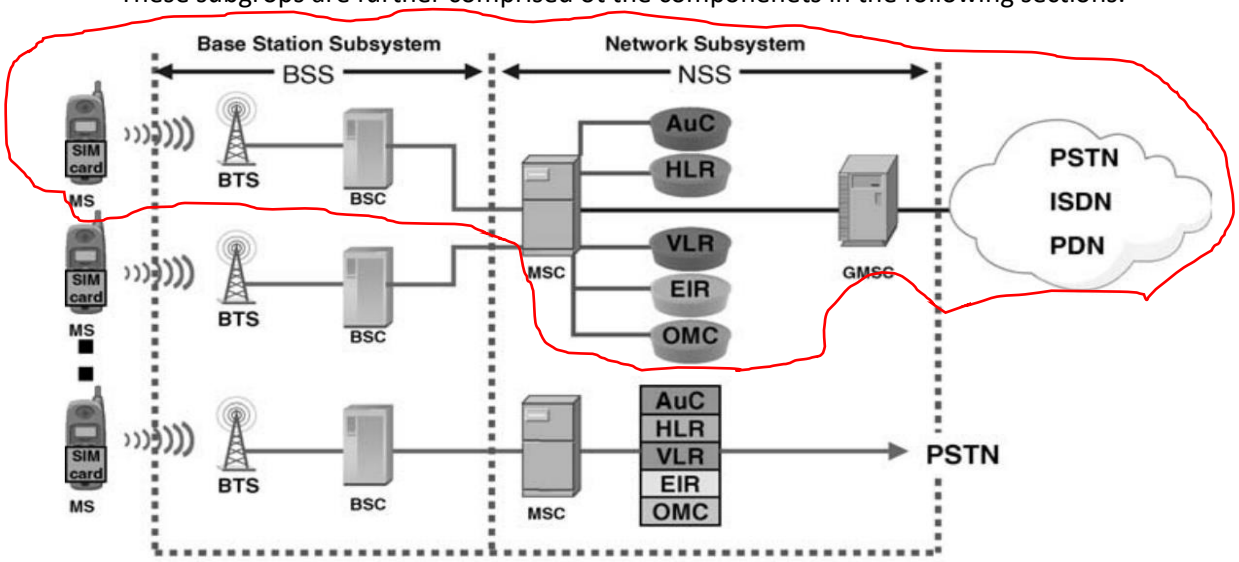
2.2 Why GSM?

- 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

2.3 GSM System Architecutre

- A cell containing a Mobile Station (MS) is formed by the radio coverage area of a Base Transceiver Station (BTS). Several BTSs together are controlled by one Base Station Controller (BSC). The BTS and BSC form the Base Station Subsystem (BSS). The combined traffic of the MSs in their respective cells is routed through the Mobile Switching Center (MSC). Several databases are required for call control and network management: the Home Location Register (HLR), the Visitor Location Register (VLR), the Authentication Center (AuC), and the Equipment Identity Register (EIR). The GSM system architecture comprised with a set of essential components is illustrated in Figure 1.1.

- The GSM system network can be divided into three subgroups that are interconnected using standardized itnerfaces:
  a. Mobile Station (MS)
  b. Base Station System (BSS)
  c. Network Switching System (NSS)
- These subgrops are further comprised ot the componenets in the following sections.

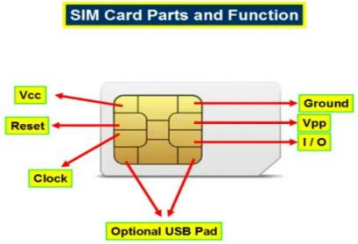


MS (Mobile Station)
SIM (Subscriber Identify Module)
BTS (Base Transceiver Station)
BSC (Base Station Controller)
MSC (Mobile Switching Center)
GMSC (Gateway Mobile Switching Center)
OMC (Operation and Maintenance Center)

HLR (Home Location Register)
VLR (Visitor Location Register)
AuC (Authentication Center)
EIR (Equipment Identify Register)
PSTN (Public Switched Telephone Network)
ISDN (Integrated Service Digital Network)
PDN (Packet Data Network)

1. Mobile Station (MS) [SIM + ME]

- The Mobile Stantion (MS) can refer to a handset or mobile equipment (ME).
- The subscriber Identity Module(SIM) card in a GSM handset is a microprocessor smart card that securely stores various critical information such as the subscriber's identity as well as the authentication and encryption algorithms responsible for providing legitimate access to the GSM network.
- Each SIM card has a unique identification number called the International Mobile Subcriber Identity (IMSI).
- In addition, each MS is assigned to a unique hardware identification called the International Mobile Equipment Identity (IMEI).
- It link between customer and wireless Network i.e. direct connection with Base Transceiver Station (BTS).
- It must be albe to digitize and process audio and other multimedia information.
- Transmit and receive RF signals..
- Tpyical output power is 500mW to 3 Watts.



2. Base Station Subsystem

It is also known as radio subsystem, provides and manages radio transmission paths between the mobile station and the Mobile Switching Centre (MSC). BSS also manages interface between the mobile station and all other subsystems of GSM. It consists of two parts.

1. Base Transceiver Station (BTS)
2. Base Station Controller (BSC)

1. Base Transceiver Station (BTS)

- The BTS contains the RF components that provide the air interface for a particular cell
- De-/Encodes, De-/encrypts, De-/multiplexes, De-/modulates and feeds the RF signals to the antenna.
- Communicates with the Mobile station and BSC.
- Consists of Transceiver units.
- Maintain synch with MS
- RF signal processing
- Diversity reception

2. Base Station Controller (BSC)

- Configure and manage Radio Resources
- Handover management: Signal quality, signal level, interference, power budget and distance
- Frequency hopping management
- Measurments and obserrvatiions: traffic, signaling and mobile tracing
- Control and supervise the BTSs
- Manage the paging operation
- The BSC is physically connected through leased lines or microwave links to the MSC.

3. Network Switching Subsystem (NSS)

It manages the switching functions of the system and allows MSCs to communicate with other networks such as PSTN and ISDN. It consists of

1. Mobile Switching Center (MSC)
2. Home Location Register (HLR)
3. Visitor Location Register (VLR)
4. Internetworking Location Register (ILR)
5. Authentication Center (AUC)
6. Equipment Identity Register (EIR)
7. Opreation and Maintenance Center (OMC)
8. Interworking Units (IWF)
9. Gateway MSC (GMSC)

1. Mobile Switching Center (MSC)

- It is a heart of the network. It manages communication between GSM and other networks.
- It manages call set up function, routing and basic switching.
- The basic functions performed by the MSC 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,
- Signalling to other network elements like BSC, HLR, PSTN, PLMN, etc.
- Performing of charging/accounting, statistical, and administrative input/output processing functions

2. Home Location Register (HLR)

- It is a permanent database about mobile subscriber in a large service area.
- Its database contains IMSI, IMSISDN, prepaid/post-paid, roaming restrictions, supplementary services.
- It stores permanent database about
    - The network's subscribers information
    - The subscribers teleservices or supplementary services
    - Dynamic data about the subscriber's present location
- It also plays a major role in the process of handling calls terminating at the MS.
- The HLR connects to the G-MSC for handling incoming calls, connects to SMSC for handling incoming SMS, connects to VLR for visitor subscribers, connects to AUC for authenticating and ciphering and exchange of data.

3. Visitor Location Register (VLR)

- It is a temporary database which updates when new MS enters into outside the home network.
- To inform the HLR that a subscriber has arrived in the particular area covered by the VLR.
- It reduces number of queries to HLR.
- Its database contains IMSI, TMSI, IMSISDN, MSRN, location, area authentication key.

4. Interworking Location Register (ILR)

- These are used to provide for intersystem roaming
- It allows a subscriver to roam in sevral different systems.

5. Authentication Center (AUC)

- It provides protection against intruders in air interface.
- It maintains authentication keys and algorithms and provides.
- It is a database that is connected to the HLR
- It provides the HLR with authentication parametes and ciphering keys for GSM systems.
- The use of encryption provides over the air security for the system.

6. Equipment Identity Register (EIR)

- It is a database used to validate the status of mobile equipment
- In GSM system, by use of EIR to check the current status of an MS through the global data maintained by the GSM association.

- The global database is updated daily to reflect the current status of an MS.
- The MS can be black listed indicating that it has been reported stolen or missing and thus not approved for network operation.
- The MS might be white listed and therefore registered and approved for normal operation.

7. Operation and Maintenance Center (OMC)

- Operation and Maintenenace Center (OMC) is used to monitor BSC MSC within a GSM system. The OMC has three main functions which are:
  - To maintain all telecommunications hardware and network operations with a particular market.
  - Manage all charging and billing procedures.
  - Manage all mobile equipment in the system.

8. Inter-working function (IWF)

- It is a method for interfacing a wireless telecommunication network with the public switched telephone network (PSTN).
- An interworking function (IWF) acts a gateway to enable 2G and 3G network elements to connect and communicate with 4G LTE network elements.

9. Gateway Mobile Switching Center (GMSC)

- It is a type of Mobile Switching Center (MSC) that is used to route calls outside the mobile network.
- Mobile Switching Center Servers (MSC-S) provide control of high-capacity switching in mobile circuit core networks for operators to control services and switching.

2.4 Interfaces used for GSM network

- UM Interface –Used to communicate between BTS with MS. It carries the GSM bursts carrying data and control information. Also referred as Air interface.
- Abis Interface— Used to communicate BSC to BTS. It supports two types of communication links viz. traffic channel at 64kbps and signaling channel at 16kbps.
- A Interface-- Used to communicate BSC and MSC
- Singling protocol (SS7)- Used to communicate MSC with other network .

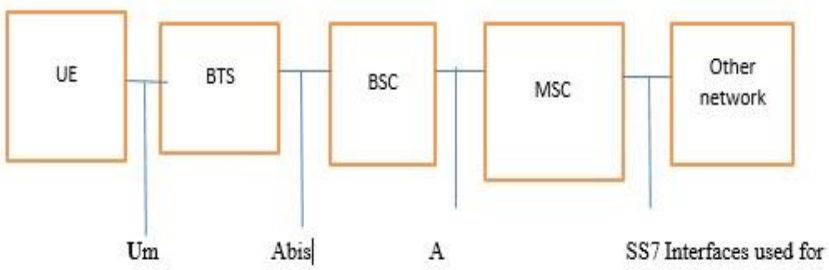
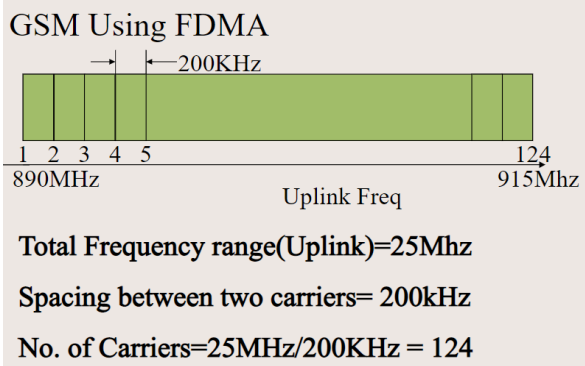
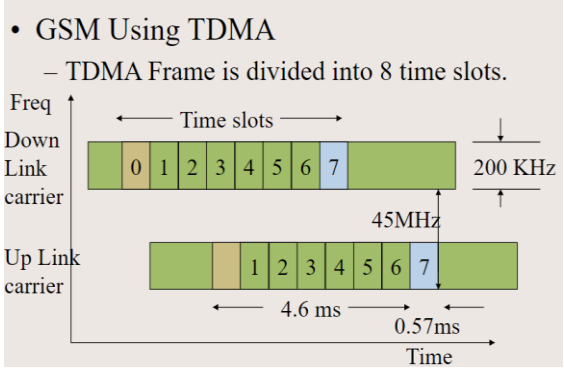


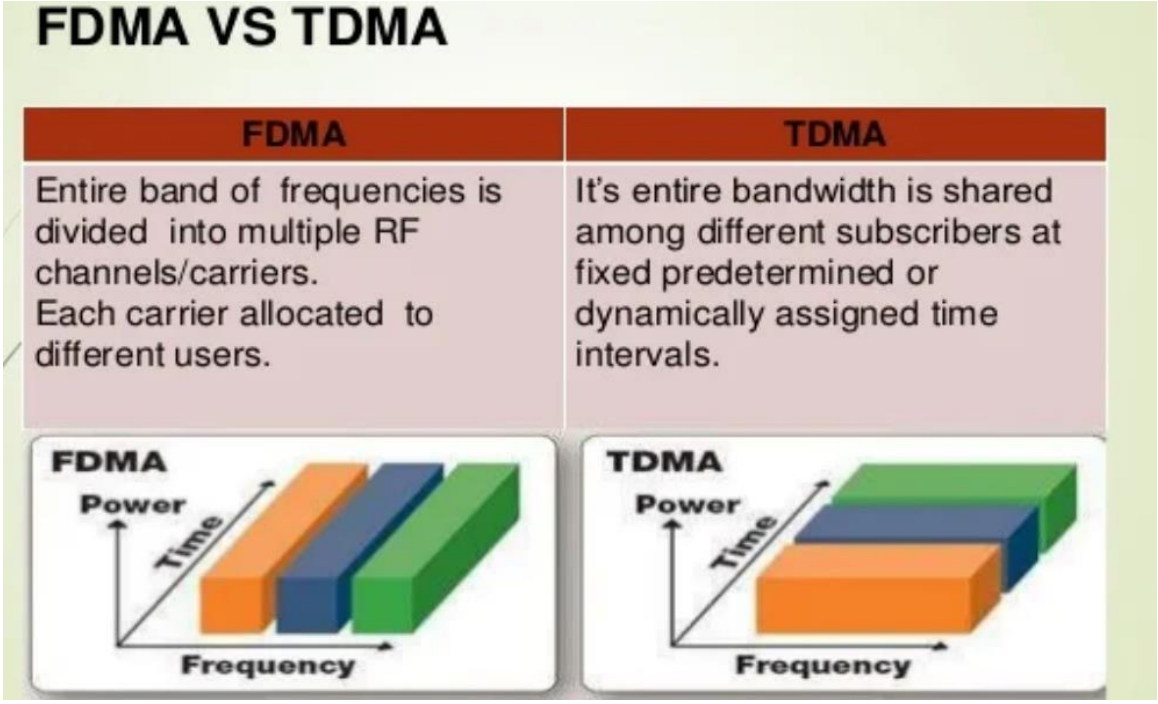
Fig 2 GSM network Interfaces

2.5 GSM Multiple Access Technologies

- GSM used two different multiple access technologies:
  1. **FDMA** – Frequency Division Multiple Access
  2. **TDMA** – Time Division Multiple Access

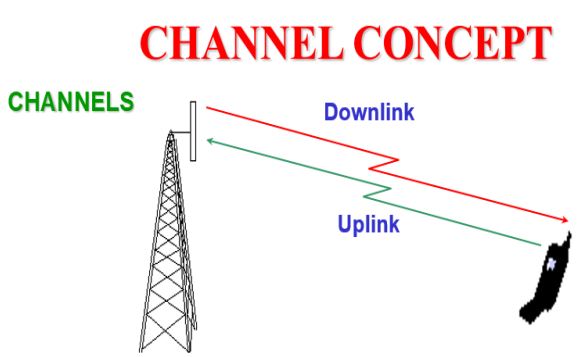


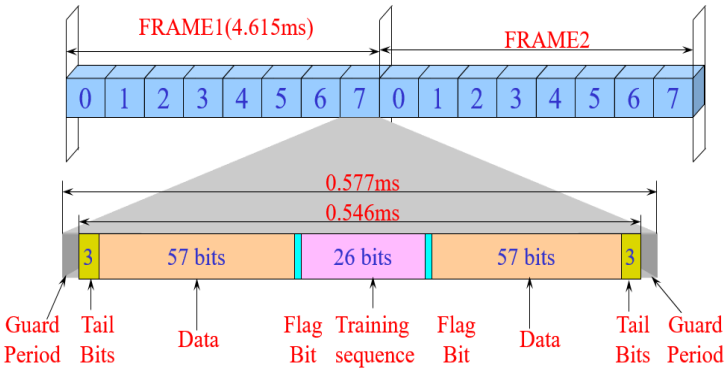




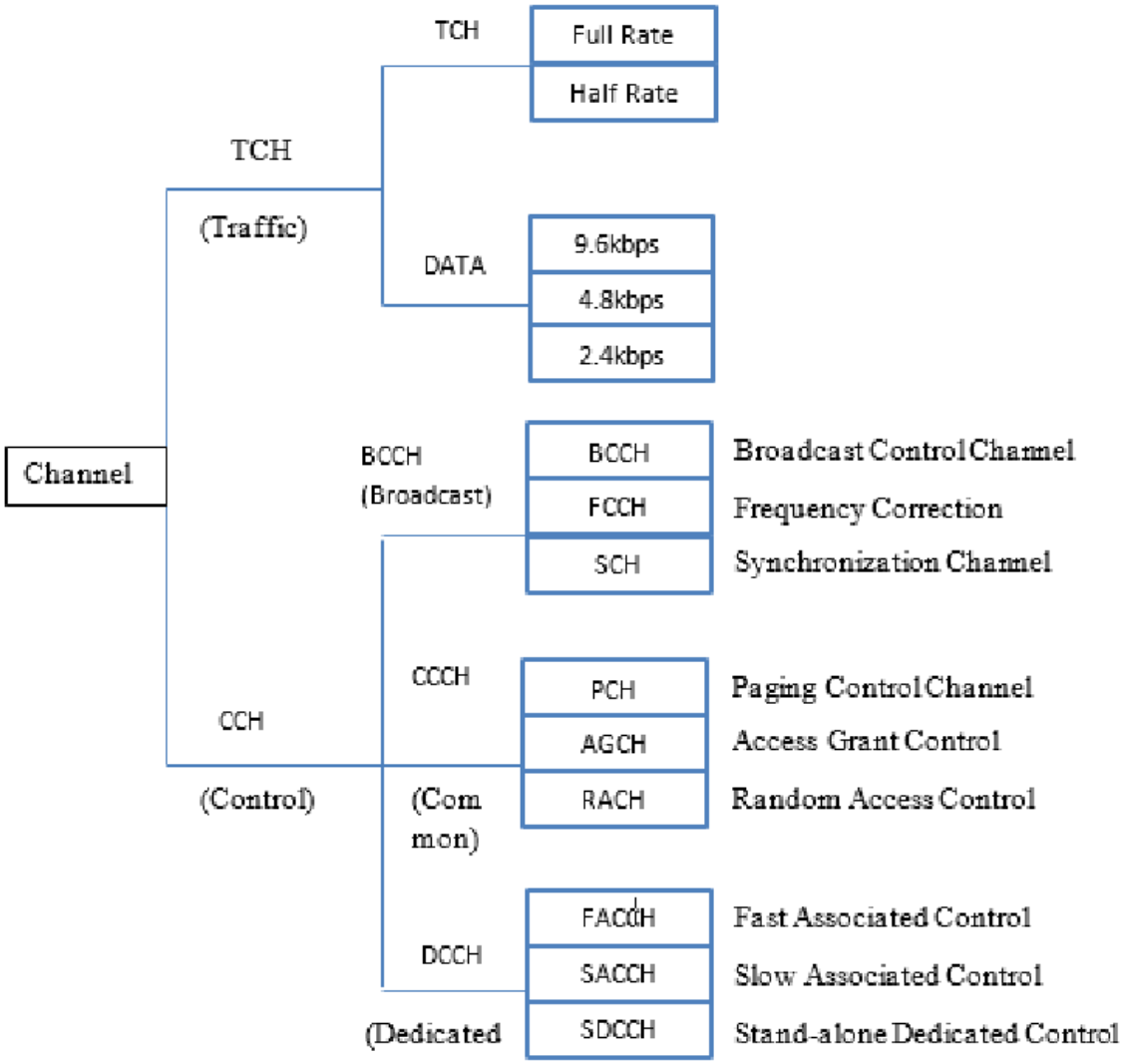
3. Using Time Division Multiple Access (TDMA) each of these carriers is divided into eight Time Slots (TS).

3.4 GSM Channel Concept





- Channels are used to carry speech, data and control information.
- Using Time Division Multiple Access (TDMA) each of these carriers is divided into eight Time Slots (TS).
- A veriety of information is transmitted between the BTS and the MS.
- The information is grouped into different logical channels.
- Each logical channel is used for a specific purpose such as paging, call set-up and speech.
- For example, speech is ent on the logical channel Traffic Channle (TCH).
- The logical channels are mapped into the physical channels.
- GSM uses a variety of channels in which the data is carries.
- These channels are separated into physical channels and logical channels.
- The Physical channels are determined by the timeslot, whereas the logical channels are determined by the information carried within the physical channel.



Logical Channels are divided into two categories: Traffic channels and control channels.

1. **Traffic Channels (TCH)**
   The traffic channels are intended to carry encoded speech or user data.
   - Full rate traffic channels(TCH/F) at a net bit rate of 22.8 Kbps
   - Half rate traffic channels (TCH/H) at a net bit rate of 11.4 Kbps

   Speech Channels: Speech channels are defined for both full rate and half rate traffic channels.
   Data Channels: Data channels support a variety of data rates (2.4, 4.8 and 9.6 kbps) on both half and full rate traffic channels.
2. **Control Channels (CCH)**
   - The control channels are intended to carry signaling and synchronization data between the base station and the Mobile station.
   - Control channels carry signaling information between an MS and a BTS. There are several froms of control channels in GSM, and they can generally be divided into three categories.

1. **Broadcast Control Channel**

   Broadcast control channels are transmitted in downlink direction only i.e. only transmitted by BTS.

   It has three types

   a. FCCH, Frequency Correction Channel
      Used for the frequency correction/synchronization of a mobile station.
   b. SCH, Synchronizaiton Channel
      Allows the mobile station to synchronization time wise with the BTS.
   c. BCCH, Broadcast Control Channel
      The broadcast control channel is used to broadcast control information to every MS witin a cell
      BCCH is transmitted on the downlink, point-to-multipoint.

2. **Common Control Channel**

   The common control channels are used by an MS during the paging and access procedures. Common control channels are following types

   a. Random Access Channel (RACH)
      Transmitted by the mobile when it wishes to access to the system.
   b. Paging Channel (PCH)
      Transmitte by the BTS when it wishes to contact a mobile. The reason for contact may be an incoming call or short message.
   c. Access Grant Control Channel (AGCH)
      It carries data which instructs the mobile to operate in a particular physical chnnel (Time Slot).
      The AGCH is used by the network to grant, or deny.

3. **Dedicated Control Channel**

   Signalling information is carrier between an MS and a BTS using associated and dedicated control channels during or not during a call.

   They are of following types:

   a. Standalone Dedicated Control Channel (SDCCH)
      The MS is on the SDCCH informed about which physical channel to use for traffic.

   b. Slow Associated Control Channel (SACCH)
      Conveys power control and timing information in the downlink direction
      Receive signal strength indicator and link quality report in uplink direction.
   c. Fast Associated Control Channel (FACCH)
      The FACCH is used to carry out user authentication and handover.

3.5 Handovers in GSM

- Handover or handoff refers to transfer of mobile connection from one resource (i.e. Base Station, BS) to another BS without disconnecting the ongoing voice or data call.
- In GSM, mobile continuously monitors signal quality and signal power level of serving/neighbor Basee Stations (BSs).
- It then sends the "measurement report" to serving BS. Based on the report BS initiates handover of mobile connection to its strongest neighbor BS.
- After new traffic channels are assigned with new serving BS, all the previous traffic channels are released.
- Within th GSM system thre are four types of handover that can be performed for GSM only systems:
    1. **Intra-BTS or Inter Cell handover:** Handover occurs between the two different sectors of the same BTS.
    2. **Inter-BTS Intra BSC handover:** Handover occurs between the two different BTSs i.e when a user move from one BTS to another BTS but within the same BSC.
    3. **Inter-BSC handover:** Handover occurs between the two different BSCs i.e when a user move from one BSC to another BSC but withing the same MSC.
    4. **Inter-MSC handover :** Handover occurs between the two different MSCs i.e when a user move from one MSC to another MSC.