Cellular Network

Base station
- Transmits to users on forward channels
- Receives from users on reverse channels

Mobile Switching Center
- Controls connection setup within cells & to telephone network

AC = authentication center
BSS = base station subsystem
EIR = equipment identity register
HLR = home location register
MSC = mobile switching center
PSTN = public switched telephone network
STP = signal transfer point
VLR = visitor location register
Base Transceiver Station (BTS)

- Establishes and maintains connections to the MS
- Interface between MS and BTS is called $U_m$ interface.
- Hosts the Antenna and Radio Frequency hardware
- Contain software for multiple access
- BTSs and the BS are either co-located or are connected together
Base Station Control (BSC)

- Has control Functionality
- Interface between BTS and BSC is called $A_{\text{bis}}$ interface
- Responsible for
  - channel assignment
  - Maintainace of link quality
  - Handover
  - Power Control
  - Coding
Mobile Switching Center (MSC)

- The MSC (mobile switching center) plays a central role in GSM
  - switching functions
  - additional functions for mobility support
  - management of network resources
  - interworking functions via Gateway MSC (GMSC)
  - integration of several databases

- Functions of a MSC
  - specific functions for paging and call forwarding
  - termination of SS7 (signaling system no. 7)
  - mobility specific signaling
  - location registration and forwarding of location information
  - provision of new services (fax, data calls)
  - support of short message service (SMS)
  - generation and forwarding of accounting and billing information
Databases

- Databases (important: scalability, high capacity, low delay)
  - **Home Location Register (HLR)**
    central master database containing user data, permanent and semi-permanent data of all subscribers assigned to the HLR (one provider can have several HLRs)
  - **Visitor Location Register (VLR)**
    local database for a subset of user data, including data about all user currently in the domain of the VLR
Operation subsystem

- The OSS (Operation Subsystem) enables centralized operation, management, and maintenance of all GSM subsystems

- Components
  - Authentication Center (AUC)
    - generates user specific authentication parameters on request of a VLR
    - authentication parameters used for authentication of mobile terminals and encryption of user data on the air interface within the GSM system
  - Equipment Identity Register (EIR)
    - registers GSM mobile stations and user rights
    - stolen or malfunctioning mobile stations can be locked and sometimes even localized
  - Operation and Maintenance Center (OMC)
    - different control capabilities for the radio subsystem and the network subsystem
Signaling & Connection Control

- **Setup channels** set aside for call setup & handoff
  - Mobile unit selects setup channel with strongest signal & monitors this channel

- **Incoming call to mobile unit**
  - MSC sends call request to all BSSs
  - BSSs broadcast request on all setup channels
  - Mobile unit replies on reverse setup channel
  - BSS forwards reply to MSC
  - BSS assigns forward & reverse voice channels
  - BSS informs mobile to use these
  - Mobile phone rings
Mobile Originated Call

- Mobile sends request in reverse setup channel
- Message from mobile includes serial # and possibly authentication information
- BSS forwards message to MSC
- MSC consults Home Location Register for information about the subscriber
- MSC may consult Authentication center
- MSC establishes call to PSTN
- BSS assigns forward & reverse channel
Handoff

- Base station monitors signal levels from its mobiles
- If signal level drops below threshold, MSC notified & mobile instructed to transmit on setup channel
- Base stations in vicinity of mobile instructed to monitor signal from mobile on setup channel
- Results forward to MSC, which selects new cell
- Current BSS & mobile instructed to prepare for handoff
- MSC releases connection to first BSS and sets up connection to new BSS
- Mobile changes to new channels in new cell
- Brief interruption in connection (except for CDMA)
Roaming

- Users subscribe to roaming service to use service outside their home region
- Signaling network used for message exchange between home & visited network
- Roamer uses setup channels to register in new area
- MSC in visited areas requests authorization from users Home Location Register
- Visitor Location Register informed of new user
- User can now receive & place calls
GSM Signaling Standard

- **Base station**
  - Base Transceiver Station (BTS)
    - Antenna + Transceiver to mobile
    - Monitoring signal strength
  - Base Station Controller
    - Manages radio resources or 1 or more BTSs
    - Set up of channels & handoff
    - Interposed between BTS & MSC

- **Mobile & MSC Applications**
  - Call Management (CM)
  - Mobility Management (MM)

- **Radio Resources Management (RRM)** concerns mobile, BTS, BSC, and MSC
Logical Channels

Traffic Channel (TCH)
- Full rate (/F)
- Half Rate (/H)
- One Eight (/8)

Control Channel (CCH)
- Broadcast Channel (BCH)
  - Frequency Correction channel (FCCH)
  - Synchronization Channel (SCH)
  - Broadcast Control Channel (BCCH)
- Common Control Channel (CCCH)
- Dedicated Control Channel (DCCH)
- Paging Channel (PCH)
- Random Access Channel (RACH)
- Access Grant Channel (AGCH)
- Slow Associated Control Channel (SACCH)
- Fast Associated Control Channel (FACCH)
- Cell Broadcast Channel (CBCH)
- Standalone Dedicated Control Channel (SDCCH)
Traffic Channels

- Traffic means voice transmission.
  - Full Rate:
    - 22.8Kbps, and speech coding 13Kbps.
  - Half Rate:
    - 11.4Kbps, and speech coding 6.5Kbps.
  - One Eight:
    - For signaling or SMS’s.
Broadcast Channels BCHs

- Found on the down link
- Serves as beacon signal
- MS uses signal from these channels to establish time and frequency synchronization
- Provide information about cell identity
- MS has to track information form these channels all the time for possible Hand Over
Broadcast channels

- **Frequency Correction Channel (FCCH)**
  - Provides the MS with a frequency reference
  - The MS tunes its frequency to this reference

- **Synchronization Channels (SCH)**
  - Define the frame number of the cell and Base Station Identification Code (BSIC)
  - The BSIC ensures that the MS synchronizes to the right network.

- **Broadcast Control Channel BCCH**
  Transmits cell specific information such as
  - Location Area Identity (LAI)
  - Maximum permitted signal power
  - Actual available traffic channel
  - Frequencies of the neighboring BSs that are permanently observed for possible Hand Over
Common Control Channels

Used by the BS to establish a connection to a specific MS

• Paging Channel (PCH)
  – Used to send the permanent international Mobile Subscriber Identity (IMSI) or the temporary Mobile Subscriber Identity when a connection arrives to a MS
  – May be used to broadcast local messages (street information and commercials)

• Random Access Channel (RACH)
  – Found only in the uplink
  – Used by MS to request Connection
    • To reply on PCH
    • Send request for dedicated channel (SDCCH)

• Access Grant Channel (AGCH)
  – Used to assign a standalone dedicated control channel in response to request via RACH
  – Found only in the uplink
  – Reply for the request of SDCCH with the time slot No.
Dedicated Control Channel (DCCHs)

- **DCCH**: 
  - **SDCCH**: standalone dedicated control channel (Downlink)
    - For call signaling setup. Operates at TCH/8 or TCH/4.
  - **SACCH**: Slow Association Control Channel
    - Downlink $\rightarrow$ to inform the MS power level.
    - Uplink $\rightarrow$ to inform the BS with the MS power level.
  - **FACCH**: Fast Association Control Channel
    - For handover by stealing 20 ms from the speech.

- **CBCH**: Cell Broadcast Channel (Downlink)
  - Each cell sends a short message to all MS’s every 2 ms to broadcast the users with information from a service center to mobile stations.
Dedicated Control Channel (DCCHs)

- **Standalone Dedicated Control Channel (SDCCH)**
  - Responsible for establishing a connection after a request acceptance.
  - Ensure that the MS and BS stay connected during Authentication.

- **Slow Associated Control Channel (SACCH)**
  - Regularly transmits radio link information such as:
    - MS informs BS about Strength and quality of the signal
    - BS informs MS about Power control and runtime of the received signal

- **Fast Associated Control Channel (FACCH)**
  - Used during handover for short time
  - Needs to transmit at high rate
  - Transmitted information similar to that sent by (SDCCH)