

Lecture 11: GSM Architecture and Specifications

GSM and CDMA Systems

DI05011011: Mobile Communication

Agenda for Today

- 1. Introduction to GSM
- 2. GSM Architecture Overview
- 3. Mobile Station (MS)
- 4. Base Station Subsystem (BSS)
- 5. Network and Switching Subsystem (NSS)
- 6. Operation and Support Subsystem (OSS)
- 7. Specifications of GSM 900
- 8. Summary and Next Steps

- **Global System for Mobile Communications (GSM)** is a 2nd Generation (2G) digital cellular network standard.
- Developed by the European Telecommunications Standards Institute (ETSI).
- Designed to replace 1G analog networks, providing better voice quality and security.
- Uses a combination of **TDMA (Time Division Multiple Access)** and **FDMA (Frequency Division Multiple Access)**.
- Offers services like voice telephony, Short Message Service (SMS), and basic data services.

- The GSM network is divided into four main subsystems:
- **1. Mobile Station (MS):** The user's mobile device.
- **2. Base Station Subsystem (BSS):** Manages the radio link with the MS.
- **3. Network and Switching Subsystem (NSS):** The core network managing switching and mobility.
- **4. Operation and Support Subsystem (OSS):** For network management and maintenance.

1. Mobile Station (MS)

- The Mobile Station consists of two main elements:
- **Mobile Equipment (ME):**
 - - The physical hardware (the phone).
 - - Identified by a unique IMEI (International Mobile Equipment Identity).
- **Subscriber Identity Module (SIM):**
 - - A smart card containing user account info and security keys.
 - - Identified by an IMSI (International Mobile Subscriber Identity).
- Separating ME and SIM allows users to change phones while keeping their number and network identity.

2. Base Station Subsystem (BSS)

- The BSS handles all radio-related functions. It connects the MS to the core network.
- It consists of two main components:
- **a. Base Transceiver Station (BTS):**
 - - The physical antennas and radio transceivers.
 - - Defines a single 'cell'.
 - - Handles radio-link protocols and modulation.
- **b. Base Station Controller (BSC):**
 - - Controls multiple BTSs.
 - - Manages radio resources, channel setup, and frequency hopping.
 - - Handles intracell and intercell handoffs.

3. Network and Switching Subsystem (NSS)

- The NSS (Core Network) performs call routing, mobility management, and switching.
- **Mobile Switching Center (MSC):**
 - - The central router of the GSM network.
 - - Sets up, routes, and tears down calls.
 - - Interfaces with the PSTN (Public Switched Telephone Network).
- **Gateway MSC (GMSC):**
 - - A special MSC that acts as a gateway to external networks (like landlines or other mobile networks).

- To manage user mobility, the NSS uses two crucial databases:
- **Home Location Register (HLR):**
 - - The central, permanent database of all subscribers.
 - - Stores IMSI, MSISDN (phone number), current VLR location, and service profiles.
- **Visitor Location Register (VLR):**
 - - A temporary, local database attached to an MSC.
 - - Stores data about MSs currently roaming in its specific area.
 - - Reduces lookup traffic to the HLR by keeping local copies of user data.

- **Authentication Center (AUC):**

- - Highly secure database connected to the HLR.
- - Generates security keys (triplets) used for user authentication and voice encryption.
- - Ensures only valid SIM cards access the network.

- **Equipment Identity Register (EIR):**

- - Database of mobile equipment (IMEI numbers).
- - White List: Valid devices.
- - Black List: Stolen or blocked devices (denied service).
- - Grey List: Tracked devices (e.g., malfunctioning).

4. Operation and Support Subsystem (OSS)

- The OSS is the central management layer for the network operator.
- **Functions include:**
 - - Network configuration and maintenance.
 - - Fault management (alarms and monitoring).
 - - Performance management and optimization.
 - - Billing and accounting collection.
- It connects to all other network elements (BSC, MSC, HLR, etc.) to ensure the entire system runs smoothly.

Specifications of GSM 900

- GSM was originally designed to operate in the 900 MHz band.
- **Frequency Bands:**
 - - **Uplink (MS to BTS):** 890 MHz to 915 MHz
 - - **Downlink (BTS to MS):** 935 MHz to 960 MHz
- **Bandwidth:**
 - - Total bandwidth per direction: 25 MHz
 - - Duplex Distance (separation between uplink and downlink): 45 MHz

GSM 900 Channels and Capacity

- **Carrier Separation:**

- - The 25 MHz band is divided into 124 radio frequency (RF) carrier channels.
- - Channel spacing (bandwidth of one carrier) is **200 kHz** (0.2 MHz).

- **Time Slots (TDMA):**

- - Each 200 kHz RF carrier is divided in time into **8 Time Slots (TS)**.
- - Therefore, one carrier can support 8 simultaneous voice calls.

- **Total Capacity:**

- - $124 \text{ carriers} \times 8 \text{ time slots} = \mathbf{992 \text{ physical channels}}$ per cell (theoretically).

- **Modulation Technique:**

- - GSM uses **GMSK (Gaussian Minimum Shift Keying)**.
- - GMSK is highly spectrum-efficient and power-efficient, making it ideal for mobile devices.

- **Data Rates:**

- - Raw bit rate on one RF carrier is **270.833 kbps**.
- - Voice encoding rate is **13 kbps** (using Regular Pulse Excitation - Long Term Prediction).

- **Frame Duration:**

- - A basic TDMA frame (containing 8 time slots) lasts **4.615 ms**.

- GSM architecture is composed of the MS, BSS, NSS, and OSS.
- MS includes the ME (hardware) and SIM (user identity).
- BSS manages the radio link via BTS and BSC.
- NSS acts as the core network with the MSC routing calls, and HLR/VLR managing mobility.
- GSM 900 uses the 890-915 MHz (Uplink) and 935-960 MHz (Downlink) bands.
- It employs a hybrid FDMA/TDMA scheme with 200 kHz spacing and 8 time slots per carrier.

- In the next lecture, we will look deeper into how communication actually happens over the air:
- **1. GSM Channels:** Logical vs Physical channels.
- **2. Traffic Channels (TCH):** For voice data.
- **3. Control Channels (CCH):** For signaling and setup.
- **4. GSM Call Procedure:** Step-by-step process of placing a Mobile-to-Mobile call.