Wireless Mobile Communication

Module IV
Standards of wireless communication systems – GSM, IMT- 2000, UMTS. GSM architectures, objectives, servicing frequency bands-GSM sub systems, Radio link features in GSM

GSM (Global System for Mobile)

- Global System for Mobile (GSM) is second generation cellular system standard that was developed to solve the fragmentation problems of the first cellular systems in Europe.
- GSM is the world's first cellular system to specify digital modulation and network level architectures and services.

  ❖ **GSM Services and Features**

- GSM services follow ISDN guidelines and are classified as either tele services or data services. Teleservices include standard mobile telephony and mobile-originated or base-originated traffic.
- Data services include computer-to-computer communication and packet-switched traffic. User services may be divided into three major categories:

  • **Telephone services**, including emergency calling and facsimile. GSM also supports Videotex and Teletex, though they are not integral parts of the GSM standard.
  
  • **Bearer services or data services** which are limited to layers 1, 2, and 3 of the open system interconnection (OSI) reference model. Supported services include packet switched protocols and data rates from 300 bps to 9.6 kbps. Data may be transmitted using either a transparent mode (where GSM provides standard channel coding for the user data) or nontransparent mode (where GSM offers special coding efficiencies based on the particular data interface).

  • **Supplementary ISDN services**, are digital in nature, and include call diversion, closed user groups, and caller identification, and are not available in
analog mobile networks. Supplementary services also include the short messaging service (SMS) which allows GSM subscribers and base stations to transmit alphanumeric pages of limited length, while simultaneously carrying normal voice traffic. SMS also provides cell broadcast, which allows GSM base stations to repetitively transmit ASCII messages with as many as fifteen 93-character strings in concatenated fashion.

- From the user's point of view, one of the most remarkable features of GSM is the Subscriber Identity Module (SIM), which is a memory device that stores information such as the subscriber's identification number, the networks and countries where the subscriber is entitled to service, privacy keys, and other user-specific information.
- A subscriber uses the SIM with a 4-digit personal ID number to activate service from any GSM phone.
- A second remarkable feature of GSM is the on-the-air privacy which is provided by the system.
- Unlike analog FM cellular phone systems which can be readily monitored, it is virtually impossible to eavesdrop on a GSM radio transmission.
- The privacy is made possible by encrypting the digital bit stream sent by a GSM transmitter, according to a specific secret cryptographic key that is known only to the cellular carrier.

**GSM System Architecture**

- The GSM system architecture consists of three major interconnected subsystems that interact between themselves and with the users through certain network interfaces.
- The subsystems are the Base Station Subsystem (BSS), Network and Switching Subsystem (NSS), and the Operation Support Subsystem.
- The Mobile Station (MS) is also a subsystem, but is usually considered to be part of the BSS for architecture purposes.
- Equipment and services are designed within GSM to support one or more of these specific subsystems.
- The **BSS**, also known as the radio subsystem, provides and manages radio transmission paths between the mobile stations and the Mobile Switching Center (MSC).
- The BSS also manages the radio interface between the mobile stations and all other subsystems of GSM.
- Each BSS consists of many Base Station Controllers (BSCs) which connect the MS to the NSS via the MSCs.
- **NSS** manages switching functions of the system and allows MSC to communicate with other networks such as the PSTN and ISDN.
- The **OSS** supports the operation and maintenance of GSM and allows system engineers to monitor, diagnose, and troubleshoot all aspects of the GSM system.
- This subsystem interacts with the other GSM subsystems, and is provided solely for the staff of the GSM operating company which provides service facilities for the network.
- Figure shows the block diagram of the GSM system architecture.
- The Mobile Stations (MS) communicate with the Base Station Subsystem (BSS) over the radio air interface.
- The BSS consists of many BSCs which connect to a single MSC, and each BSC typically controls up to several hundred Base Transceiver Stations (BTSs). Some of the BTSs may be co-located at the BSC, and others may be remotely distributed and physically connected to the BSC by microwave link or dedicated leased lines.
- Mobile handoffs (called *handovers*) between two BTSs under the control of the same BSC are handled by the BSC, and not the MSC. This greatly reduces the switching burden of the MSC.
The NSS handles the switching of GSM calls between external networks and the BSCs in the radio subsystem and is also responsible for managing and providing external access to several customer databases.

The MSC is the central unit in the NSS and controls the traffic among all of the BSCs. In the NSS, there are three different databases called the **Home Location Register (HLR)**, **Visitor Location Register (VLR)**, and the **Authentication Center (AUC)**.

The HLR is a database which contains subscriber information and location information for each user who resides in the same city as the MSC.

Each subscriber in a particular GSM market is assigned a unique **International Mobile Subscriber Identity (IMSI)**, and this number is used to identify each home user. The VLR is a database which temporarily stores the IMSI and customer information for each roaming subscriber who is visiting the coverage area of a particular MSC.

The VLR is linked between several adjoining MSCs in a particular market or geographic region and contains subscription information of every visiting user in the area.

Once a roaming mobile is logged in the VLR, the MSC sends the necessary information to the visiting subscriber's HLR so that calls to the roaming mobile can be appropriately routed over the PSTN by the roaming user's HLR.
The Authentication Center is a strongly protected database which handles the authentication and encryption keys for every single subscriber in the HLR and VLR.

The Authentication Center contains a register called the Equipment Identity Register (EIR) which identifies stolen or fraudulently altered phones that transmit identity data that does not match with information contained in either the HLR or VLR.

The OSS supports one or several Operation Maintenance Centers (OMC) which are used to monitor and maintain the performance of each MS, BS, BSC, and MSC within a GSM system.

The OSS has three main functions, which are

1) to maintain all telecommunications hardware and network operations with a particular market,

2) manage all charging and billing procedures, and

3) manage all mobile equipment in the system. Within each GSM system, an OMC is dedicated to each of these tasks and has provisions for adjusting all base station parameters and billing procedures, as well as for providing system operators with the ability to determine the performance and integrity of each piece of subscriber equipment in the system.

 Interfaces In GSM

![Diagram of Interfaces in GSM]
The **Um Radio interface** (between MS and base transceiver stations [BTS]) is the most important in any mobile radio system:

- interface which connects a BTS to a BSC is called the **Abis interface**.
- The Abis interface carries traffic and maintenance data, and is specified by GSM to be standardized for all manufacturers.
- The BSCs are physically connected via dedicated/leased lines or microwave link to the MSC. The interface between a BSC and a MSC is called the **A interface**, which is standardized within GSM.
- The A interface uses an SS7 protocol called the **Signaling Correction Control Part (SCCP)** which supports communication between the MSC and the BSS, as well as network messages between the individual subscribers and the MSC.
- The A interface allows a service provider to use base stations and switching equipment made by different manufacturers.

**GSM FREQUENCY BANDS**

- The GSM system is a frequency- and time-division system;
- each physical channel is characterized by a carrier frequency and a time slot number.
- GSM **system frequencies include two bands at 900 MHz and 1800 MHz** commonly referred to as the GSM-900 and DCS-1800 systems.
- For DCS-1800, there are two sub-bands of 75 MHz in the 1710–1785 MHz and 1805–1880 MHz ranges. GSM-1800 is also called DCS (Digital Cellular Service).
- **GSM-900 uses 890–915 MHz** to send information from the mobile station to the base station (uplink) and 935–960 MHz for the other direction (downlink), providing 124 RF channels (channel spacing of 45 MHz is used. Guard bands 100 kHz wide are placed at either end of the range of frequencies.
- **GSM-850 uses 824–849 MHz** to send information from the mobile station to the base station (uplink) and 869–894 MHz for the other direction (downlink). Channel numbers are 128.
- GSM-850 is also sometimes called GSM-800 because this frequency range was known as the "800 MHz band".
- **GSM-1900 uses 1,850–1,910 MHz** to send information from the mobile station to the base station (uplink) and 1,930–1,990 MHz for the other direction (downlink).
- **GSM-450** It operates in either 450.4–457.6 MHz paired with 460.4-467.6 MHz.
GSM RADIO LINK / CHANNELS:

1) Physical Channels:

One time slot on one carrier is called physical channel.

2) Logical Channels:

Information carried by physical channels is called logical Channels. Logical channels are: FCCH, SCH, BCCH, PCH, RACH, AGCH, SDCCH, SACCH, FACCH, TCH.

CONTROLS CHANNELS

1) Broadcast CHannel (BCH) (downlink only)

• Broadcast Controls Channels (BCCH)

  Broadcasts cell specific information to the MS.

• Frequency correction CHannel (FCCH)

  Used for frequency correction of MS.
• **Synchronization Channel (SCH)**
  Carrier information about TDMA frame number and the Base Station Identity code (BSIC) of the BTS.

2) **Common Controls Channel (CCH)**

  • **Random Access Channel (RACH)**
    Is used by the mobile when making its first access to the system. By making that access, the MS is requesting a signalling. The reason for the access could be a page response or initiation. RACH is sent uplink, point to point.

  • **Access Grant Channel (AGCH)**
    It is used to assign dedicate resource to MS. It is sent downlink, point to point and grandly access the network.

  • **Paging Channel (PCH)**
    Used on the downlink to page the MS.

  • **Cell Broadcast Channel (CBCH)**
    It is used to transmit common message to the cell MS

3) **ASSOCIATED CONTROLS CHANNELS (ACCH)**

  • **Slow Associated Controls Channel (SACCH)**
    It is used Measurement reports from the MS to BTS are sent on the uplink. On the downlink the MS receives information from the BTS on what transmitting power to use and also instruction on Timing advance (TA).It is also used for the transmission of short text message in call connected (busy) mode. Controls channel associated with a TCH.

  • **Fast Associated control Channel (FACCH)**
    Controls channel associated with a TCH.It is mainly used handover information used on uplink and downlink.

  • **Standalone Dedicated Controls Channel (SDCCH)**
    Used for system signaling during call setup or registration, uplink and downlink, as well as the transmission of short message in idle mode.

4) **TRAFFIC CHANNELS (TCH)**
• Half rate channels
  Used for half rate speech at 6.5kbps or data up to 4.8kbps.

• Full rate channels
  Used for full rate speech at 13kbps or data up to 9.6kbps.

**GSM ADVANTAGES:**

• It is a wireless system. So mobile equipment (cell phone) can be on move.

• High secrecy in the system. So information cannot be tapped easily.

• Easy to carry MS. And consumes less power.

• GSM provides more voice channels in limited bandwidth.

• Cellular is based on concept of trunking. This allows large number of channels.

**UMTS  Universal Mobile Telecommunication System**

• This is a system capable of providing variety of mobile services to wide range of Global Mobile Communication standards.

• UMTS is being developed by RACE (R&D in advanced Communication technologies in Europe) as 3rd the generation wireless system

• To handle mixed range of traffic, a mixed cell layout, that would consist of macrocells overlaid on micro and pico cells is one of architecture plan being considered.

• This type of network distribute the traffic with local traffic operating on Macro and Pico cells, while highly mobile traffic is operated on macro cells, thus reducing the number of handoff’s required for fast moving traffic.

• It is easily observed that Macro cells cover the spots not covered by other cells and also provide redundancy in certain areas.
• Thus, Macro cells also be able to avoid failures of overlapped cells.
• However major disadvantage of the overlaid architecture is the reduced spectral efficiency.
• The UMTS architecture will provide radio coverage with network of Base Stations interconnected to each other and to a fixed network exchange.
• A Metropoleitan Area Network (MAN) is one possible choices for network interconnections.

❖ **Network Reachability**

• The Network maintains a constant location information for each of the terminals.
• The Location will be updated by a terminal whenever it changes location area, which is determined whenever mobile terminal starts receiving a broadcast message.
• The network will also take advantage of distributed network database, for routing of calls one exact location of the mobile has been accessed.

![Cell Architecture Diagram](image)

❖ **IMT 2000**

➢ The ITU is on accelerated pace to specify the 3G mobile communication standards.
➢ The primary standard for 3G system is referred to as the International Mobile Telecommunications beyond the year 2000 (IMT-2000)-the goal of which is to support higher data rates that can support multimedia applications, provide a high spectral efficiency, makes as many of the interfaces standard as possible, and provide compatibility to services within the IMT-2000
➢ Although voice traffic will continue to be the main source of revenue, packet data for internet access, advanced messaging services such as multimedia email, and real-time multimedia for applications such as telemedicine and remote security are envisaged in IMT-2000.
The requirements for IMT-2000 include improved voice quality (wire line quality), data rates up to 384kbps everywhere and 2Mbps indoor, support for packet and circuit switched data services, seamless incorporation of existing 2G and satellite systems, seamless international roaming, and support for several simultaneous multimedia connections.

Most of the proposals were based on CDMA as CDMA provides a better voice quality and is more flexible for customized multimedia applications.

In order to avoid multiple standards, efforts were made to harmonize a single converged global standard.

Backward compatibility with legacy systems is also a major issue with support for the GSM-MAP and ANSI-41 (the core GSM and IS-41 backbone infrastructures) essential.

As far as the RTT's are concerned, there were two major competing proposals- the W-CDMA based on the UMTS Terrestrial Radio Access (UTRA) FDD and TDD proposals and the CDMA2000 proposal that is backward compatible with IS-95.

The main differences can be summarized as follows [ZEN00]:

1. Although CDMA2000 proposes multiples of 1.2288 Mcps chip rates to allow greater compatibility with IS-95 (in particular, 3.6864 Mcps is suggested). W-CDMA employs 3.84 Mcps.
2. In IS-95 and CDMA2000, the BSs operate synchronously by obtaining timing from GPS. W-CDMA advocates asynchronous operation to enable deploying picocells within aspects, and buildings where GPS is not available.
3. The frame length of W-CDMA is 10 ms to ensure small end to end delays, though it is 20 ms in CDMA2000.

The harmonization activities were initiated via a 3GPP that consisted of members from industry and standard bodies to work on the core network, the radio access network, service and system aspects, and the mobile terminal.

To include non-GSM technologies, a 3GPP2 was initiated in parallel by ANSI to prepare technical specifications for a 3G mobile system based on CDMA2000 and IS-41 based core network.

Both 3GPP and 3GPP2 are expected to cooperate in harmonization and consolidation.

An operators harmonization group (OHG) set up at the end of 1998 agreed on a further harmonized Global 3G (G3G) standard that has the following components:

1. Three air-interface standards-two frequency division duplex modes: a direct sequence (DS) mode based on W-CDMA at 3.84 Mcps chip rate, a multi carrier (MC) mode based on CDMA2000 with a chip rate of 3.6864 Mcps, and one time division duplex mode operating at 3.84 Mcps.
2. Support for both GSM-MAP and ANSI-41 with all air-interface modes
3. Support for functionality based synchronous operation
4. Seamless handoff between DS and MC modes, as well as interoperability of sorts between the UMTS core network and ANSI41.

- The idea is also to minimize the complexity of multimode terminals that include all of the standards.

**Forward Channels in WCDMA and CDMA2000**

- The primary requirements of 3G systems is that they should be able to support variety of application data rates (from 384 kbps circuit switched connections to 2Mbps in indoor areas) and operation environments.
- This means that there must be support for quality of service and operation from mega cells to picocells.
- The forward channels are referred to as transport channels in the UTRA W-CDMA standard proposed by 3GPP.

- The **forward channel modifications are as follows**.
  - In **W-CDMA**, the BSs can operate in a synchronous fashion that obviates the need of GPS availability to synchronize base stations.
  - **W-CDMA employs what is known as the orthogonal variable spreading factor (OVSF) codes**.
  - OVSF codes allow a variable spreading factor technique that maintains orthogonality between spreading codes of different lengths.
  - The **logical channels are called transport channels in W-CDMA**.
  - **CDMA2000 employs multiple carriers to provide a higher data rate compared with W-CDMA**.
  - Pilot channels are used for fast acquisition and handoff as before.
  - **QPSK modulation is employed before spreading with the Walsh codes to increase the number of usable Walsh codes**.
  - **To support QoS at different rates**, a fundamental channel (FCH) for signaling and a supplemental channel (SCH) for traffic can be made available.
  - **Turbo codes** are employed on the forward supplemental channels for high data rates.

**Reverse channels in W-CDMA and CDMA2000**

- Support for variable data rates and operation in a variety of environments
  - **In WCDMA Gold Codes and S(2) codes** are used for scrambling on the uplink.
The periodicity of Gold code is 38400 chips for using a Rake receiver and S(2) codes is 256 chips for employing multiuser detection.

In CDMA 2000, the reverse link is made more symmetrical with forward link in many aspects.

For instance, a reverse pilot channel is employed between each mobile and the BS for initial acquisition, time tracking, and power control measurement.

Turbo codes are employed on the reverse supplementary channels.

Variable rate spreading is supported to enable better error correction capability and variety of data rates.

**Handoff and power control in 3G system**

CDMA2000 is very similar to IS-95 in terms of power control and handoff procedures.

In W-CDMA, a fast power control scheme is used at 1,500 bps as compared with 800 bps with IS-95 and CDMA2000.

In W-CDMA, the handoff procedure is somewhat different.

Once again, different sets of pilots are maintained, and the active sets corresponds to the pilot channels being used for complete the call.

Relative threshold values are employed.