CS8601 –MOBILE COMPUTING

UNIT 2

MOBILE TELECOMMUNICATION SYSTEM

2.2. GSM [Global System for Mobile Communication]

GSM is the most successful digital mobile telecommunication system in the world today. It is used by over 800 million people in more than 190 countries. GSM permits the integration of different voice and data services and the interworking with existing networks. Services make a network interesting for customers. GSM has defined three different categories of services:

Bearer Services, Tele and Supplementary Services

Bearer services:

GSM specifies different mechanisms for data transmission, the original GSM allowing for data rates of up to 9600 bit/s for non-voice services. Bearer services permit transparent and non-transparent, synchronous or asynchronous data transmission.
Transparent bearer services only use the functions of the physical layer (layer 1) to transmit data. Data transmission has a constant delay and throughput if no transmission errors occur. Transmission quality can be improved with the use of forward error correction (FEC), which codes redundancy into the data stream and helps to reconstruct the original data in case of transmission errors. Transparent bearer services do not try to recover lost data in case of, for example, shadowing or interruptions due to handover. Non-transparent bearer services use protocols of layers two and three to implement error correction and flow control. These services use the transparent bearer services, adding a radio link protocol (RLP). This protocol comprises mechanisms of high-level data link control (HDLC), and special selective-reject mechanisms to trigger retransmission of erroneous data. Using transparent and non-transparent services, GSM specifies several bearer services for interworking with PSTN, ISDN, and packet switched public data networks (PSPDN) like X.25, which is available worldwide. Data transmission can be full- duplex, synchronous with data rates of 1.2, 2.4, 4.8, and 9.6 kbit/s or full-duplex, asynchronous from 300 to 9,600 bit/s.

Tele services:

GSM mainly focuses on voice-oriented tele services. These comprise encrypted voice transmission, message services, and basic data communication with terminals as known from the PSTN or ISDN (e.g., fax). The primary goal of GSM was the provision of high-quality digital voice transmission. Special codecs (coder/decoder) are used for voice transmission, while other codecs are used for the transmission of analog data for communication with traditional computer modems used in, e.g., fax machines. Another service offered by GSM is the emergency number (eg 911, 999). This service is mandatory for all providers and free of charge. This connection also has the highest priority, possibly pre-empting other connections, and will automatically be set up with the closest emergency center. A useful service for very simple message transfer is the short message service (SMS), which offers transmission of messages of up to 160 characters. Sending and receiving of SMS is possible during data or voice transmission. It can be used for "serious" applications such as displaying road conditions, e-mail headers or stock quotes, but it can also transfer logos, ring tones, horoscopes and love letters.

The successor of SMS, the enhanced message service (EMS), offers a larger message size, formatted text, and the transmission of animated pictures, small images and ring tones in a standardized way. But with MMS, EMS was hardly used. MMS offers the transmission of larger pictures (GIF, JPG, WBMP), short video clips etc. and comes with mobile phones that integrate small cameras. Another non-voice tele service is group 3 fax, which is available worldwide

Supplementary services:

In addition to tele and bearer services, GSM providers can offer supplementary services. these services offer various enhancements for the standard telephony service, and may vary from provider to provider. Typical services are user identification, call redirection, or forwarding of ongoing calls, barring of incoming/outgoing calls, Advice of Charge (AoC) etc. Standard ISDN features such as closed user groups and multiparty communication may be available.

GSM ARCHITECTURE

A GSM system consists of three subsystems, the radio sub system (RSS), the network and switching subsystem (NSS), and the operation subsystem (OSS).

Network Switching Subsystem[NSS]:

The NSS is responsible for performing call processing and subscriber related functions. The switching system includes the following functional units:

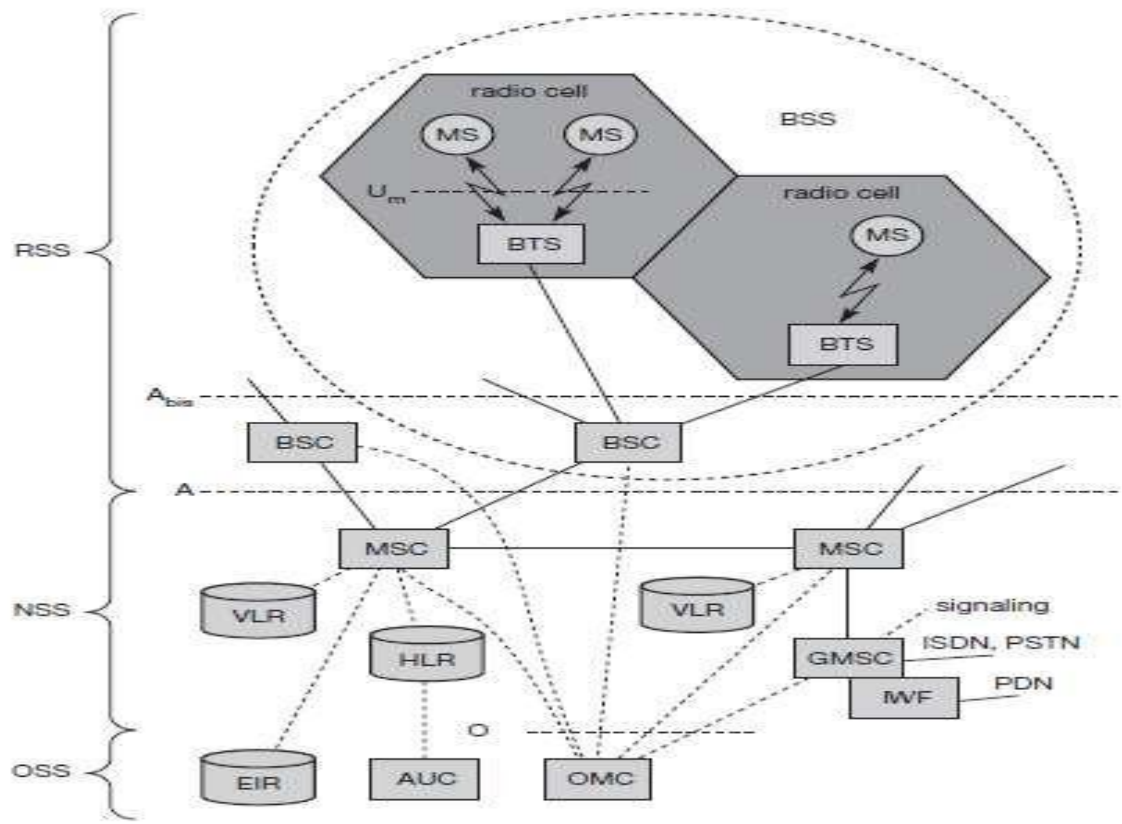
Home location register (HLR): It is a database used for storage and management of subscriptions. HLR stores permanent data about subscribers, including a subscribers service profile, location information and activity status. When an individual buys a subscription from the PCS provider, maintains temporary information about subscribers that is needed by the MSC in order to service visiting subscribers.

Visitor location register (VLR): The VLR associated to each MSC is a dynamic database which stores all important information needed for the MS users currently in the LA that is associated to the MSC (e.g., IMSI,MSISDN, HLR address). If a new MS comes into an LA the VLR is responsible for, it copies all relevant information for this user from the HLR. This hierarchy of VLR and HLR avoids frequent HLR updates and long-distance signaling of user information. Some VLRs in existence, are capable of managing up to one million customers.

Authentication center (AUC): A unit called the AUC provides authentication and encryption parameters that verify the users identity and ensure the confidentiality of each call.

Equipment identity register (EIR): It is a database that contains information about the identity of mobile equipment that prevents calls from stolen, unauthorized or defective mobile stations.

Mobile switching center (MSC): The MSC performs the telephony switching functions of the system. It controls calls to and from other telephone and data systems.



Radio Subsystem [RSS]:

The radio subsystem (RSS) comprises all radio specific entities, i.e., the mobile stations (MS) and the base station subsystem (BSS). The figure shows the connection between the RSS and the NSS via the A interface (solid lines) and the connection to the OSS via the O interface (dashed lines).

Base station subsystem (BSS): A GSM network comprises many BSSs, each controlled by a base station controller (BSC). The BSS performs all functions necessary to maintain radio connections to an MS, coding/decoding of voice, and rate adaptation to/from the wireless network part. Besides a BSC, the BSS contains several BTSs.

Base station controllers (BSC): The BSC provides all the control functions and physical links between the MSC and BTS. It is a high capacity switch that provides functions such as handover, cell configuration data, and control of radio frequency (RF) power levels in BTS. A number of BSC's are served by and MSC.

Base transceiver station (BTS): The BTS handles the radio interface to the mobile station. A BTS can form a radio cell or, using sectorized antennas, several and is connected to MS via the Um interface, and to the BSC via the Abis interface. The Um interface contains all the mechanisms necessary for wireless transmission (TDMA, FDMA etc.)The BTS is the radio equipment (transceivers and antennas) needed to service each cell in the network. A group of BTS's are controlled by an BSC.

Operation and Support system[OSS]:

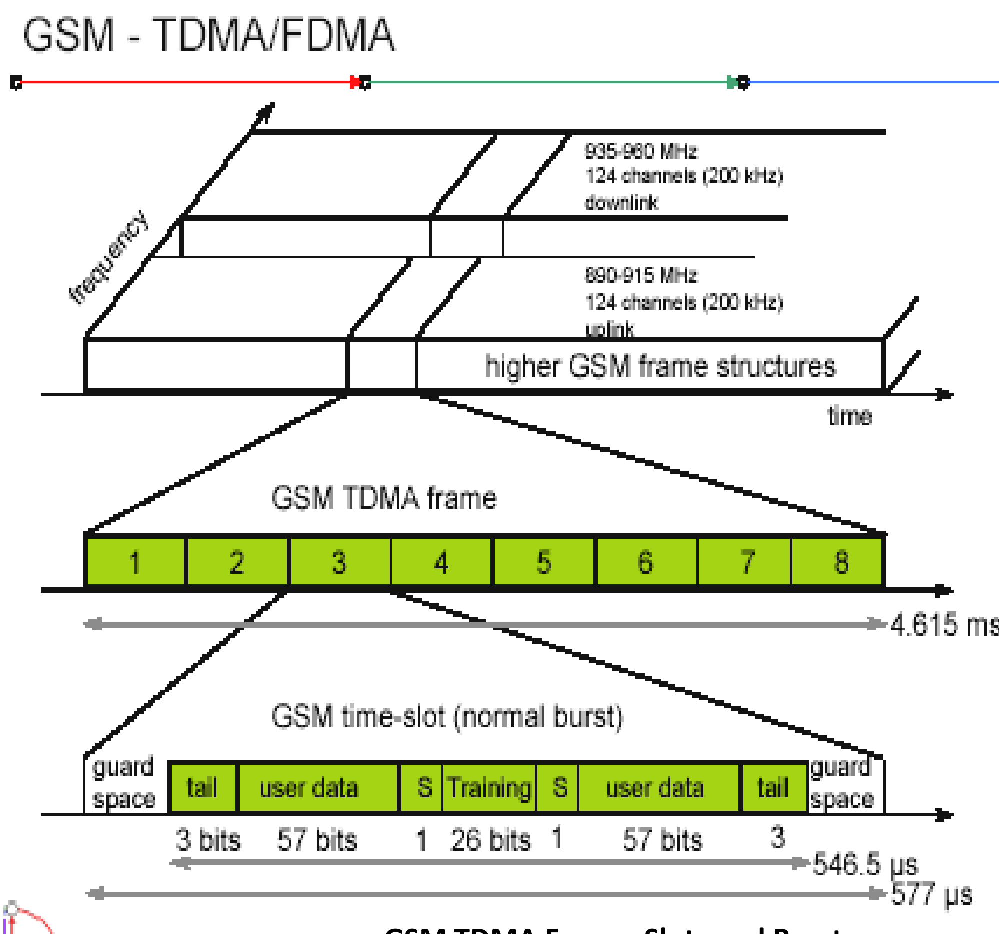
The operations and maintenance center (OMC) is connected to all equipment in the switching system and to the BSC. Implementation of OMC is called operation and support system (OSS). The OSS is the functional entity from which the network operator monitors and controls the system. The purpose of OSS is to offer the customer cost-effective support for centralized, regional and local operational and maintenance activities that are required for a GSM network. OSS provides a network overview and allows engineers to monitor, diagnose and troubleshoot every aspect of the GSM network.

The mobile station (MS) consists of the mobile equipment (the terminal) and a smart card called the Subscriber Identity Module (SIM). 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 that terminal, make calls identified by the International Mobile Equipement 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 and the IMSI are independent, thereby allowing personal mobility. The SIM card may be protected against unauthorized use by a password or personal identity number.

Each of the 248 channels is additionally separated in time via a GSM TDMA frame, i.e., each 200 kHz carrier is subdivided into frames that are repeated continuously. The duration of a frame is 4.615 ms. A frame is again subdivided into 8 GSM time slots, where each slot represents a physical TDM channel and lasts for 577 µs. Each TDM channel occupies the 200 kHz carrier for 577 µs every 4.615 ms. Data is transmitted in small portions, called bursts. The following figure shows a so called normal burst as used for data transmission inside a time slot. As shown, the burst is only 546.5 µs long and contains 148 bits. The remaining 30.5 µs are used as guard space to avoid overlapping with other bursts due to different path delays and to give the transmitter time to turn on and off. The first and last three bits of a normal burst (tail) are all set to 0 and can be used to enhance the receiver performance. The training sequence in the middle of a slot is used to adapt the parameters of the receiver to the current path propagation characteristics and to select the path propagation. A flag S indicates whether the data field contains user or network control data.

Apart from the normal burst, ETSI (1993a) defines four more bursts for data transmission: a frequency correction burst allows the MS to correct the local oscillator to avoid interference with neighbouring channels, a synchronization burst with an extended training sequence synchronizes the MS with the BTS in time, an access burst is used for the initial connection setup between MS and BTS, and finally a dummy burst is used if no data is available for a slot.



GSM TDMA Frame, Slots and Bursts

Logical channels and frame hierarchy:

Two types of channels, namely physical channels and logical channels are present.

Physical channel: channel defined by specifying both, a carrier frequency and a TDMA timeslot number.

Logic channel: logical channels are multiplexed into the physical channels. Each logic channel performs a specific task. Consequently the data of a logical channel is transmitted in the corresponding timeslots of the physical channel. During this process, logical channels can occupy a part of the physical channel or even the entire channel.

Each of the frequency carriers is divided into frames of 8 timeslots of approximately 577s (15/26 s) duration with 156.25 bits per timeslot. The duration of a TDMA frame is 4.615ms (577s x 8 = 4.615 ms). The bits per timeslot and frame duration yield a gross bit rate of about 271kbps per TDMA frame.

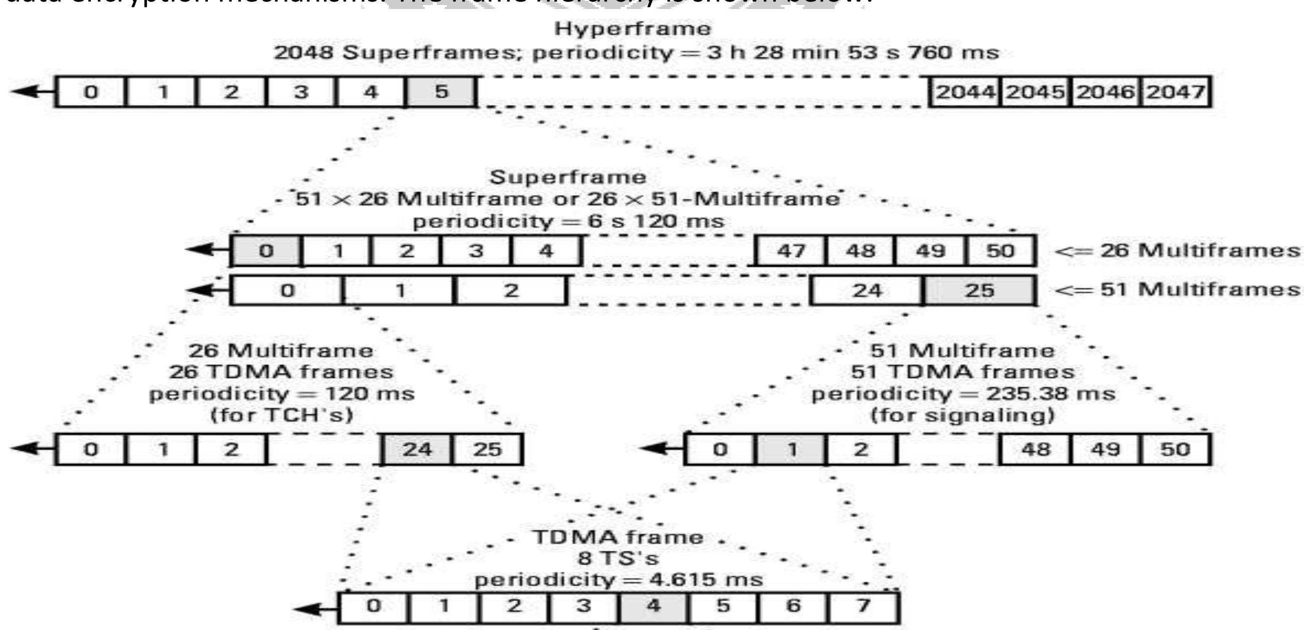
TDMA frames are grouped into two types of multiframes:

26-frame multiframe (4.615ms x 26 = 120 ms) comprising of 26 TDMA frames. This multiframe is used to carry traffic channels and their associated control channels.

51-frame multiframe (4.615ms x 51 ⍰ ⍰ 235.4 ms) comprising 51 TDMA frames. This multiframe is exclusively used for control channels. The multiframe structure is further multiplexed into a single superframe of duration of 6.12sec. This means a superframe consists of 51 multiframes of 26 frames.

26 multiframes of 51 frames.

The last multiplexing level of the frame hierarchy, consisting of 2048 superframes (2715648 TDMA frames), is a hyperframe. This long time period is needed to support the GSM data encryption mechanisms. The frame hierarchy is shown below:



GSM Frame Hierarchy

There are two different types of logical channel within the GSM system: Traffic channels(TCHs), Control channels (CCHs).

Traffic Channels:

Traffic channels carry user information such as encoded speech or user data. Trafficchannels are defined by using a 26-frame multiframe. Two general forms are defined:
i. Full rate traffic channels (TCH/F), at a gross bit rate of 22.8 kbps (456bits / 20ms)
ii. Half rate traffic channels (TCH/H), at a gross bit rate of 11.4 kbps.
Uplink and downlink are separated by three slots (bursts) in the 26-multiframe structure.

This simplifies the duplexing function in mobile terminals design, as mobiles will not need to transmit and receive at the same time. The 26-frame multiframe structure, shown below multiplexes two types of logical channels, a TCH and a Slow Associated Control Channel (SACCH).

However, if required, a Fast Associated Control CHannel (FACCH) can steal TCH in order to transmit control information at a higher bit rate. This is usually the case during the handover process. In total 24 TCH/F are transmitted and one SACCH.

Control Channels:

Control channels carry system signalling and synchronisation data for control procedures such as location registration, mobile station synchronisation, paging, random access etc. between base station and mobile station. Three categories of control channel are defined: Broadcast, Common and Dedicated. Control channels are multiplexed into the 51-frame multiframe.

Broadcast control channel (BCCH):

A BTS uses this channel to signal information to all MSs within a cell. Information transmitted in this channel is, e.g., the cell identifier, options available within this cell (frequency hopping), and frequencies available inside the cell and in neighboring cells. The BTS sends information for frequency correction via the frequency correction channel (FCCH) and information about time synchronization via the synchronization channel (SCH), where both channels are subchannels of the BCCH.

Common control channel (CCCH):

All information regarding connection setup between MS and BS is exchanged via the CCCH. For calls toward an MS, the BTS uses the paging channel (PCH) for paging the appropriate MS. If an MS wants to set up a call, it uses the random access channel (RACH) to send data to the BTS. The RACH implements multiple access (all MSs within a cell may access this channel) using slotted Aloha. This is where a collision may occur with other MSs in a GSM system. The BTS uses the access grant channel (AGCH) to signal an MS that it can use a TCH or SDCCH for further connection setup.

Dedicated control channel (DCCH):

While the previous channels have all been unidirectional, the following channels are bidirectional. As long as an MS has not established a TCH with the BTS, it uses the stand-alone dedicated control channel (SDCCH) with a low data rate (782 bit/s) for signaling. This can comprise authentication, registration or other data needed for setting up a TCH. Each TCH and SDCCH has a slow associated dedicated control channel (SACCH) associated with it, which is used to exchange system information, such as the channel quality and signal power level. Finally, if more signaling information needs to be transmitted and a TCH already exists, GSM uses a fast associated dedicated control channel (FACCH). The FACCH uses the time slots which are otherwise used by the TCH. This is necessary in the case of handovers where BTS and MS have to exchange larger amounts of data in less time.