MOBILE COMMUNICATION SYSTEMS

GSM is a **Global System for mobile communication**; it provides Voice, Messaging, Data and Multi Media services .GSM system is an open system, means it contains well defined interfaces between different system parts. GSM is a digital communication system.
There are several advantages of GSM.

1. GSM uses radio frequencies efficiently and due to the digital radio path, the system tolerates more intercell disturbances.
2. The average speech quality is better than an analog system.
3. Data transmission is supported throughout the GSM system.
4. Speech is encrypted and subscriber information security is guaranteed.
5. International roaming is possible within all countries using the GSM system.

1. System Architecture of GSM: A Network of Cells: The basic idea of a cellular network is to partition the available frequency range, to assign only part of that frequency spectrum to any base Transciever station and to reduce the range of a base station in order to reuse the scarce frequencies as often as possible. One of the major goals of the network planning is to reduce the interference between different base stations.

2. GSM Subsystems: A GSM Network comprises several elements: The Mobile station(MS), The Subscriber Identity Module(SIM), the base transciever station (BTS), the Base station controller(BSC), the Transcoder rate adapter unit(TRAU), the Mobile service switching centre(MSC). Together, they form the Public Land Mobile Network (PLMN).

3. Mobile Station: A Mobile Station consists of two main elements:

- The mobile equipment or terminal.
- The Subscriber Identity Module (SIM).
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4. The Terminal: There are different types of terminals distinguished principally by their power and application:

- The `fixed' terminals are the ones installed in cars. Their maximum allowed output power is 20 W.
- The GSM portable terminals can also be installed in vehicles. Their maximum allowed output power is 8W.
- The handhelds terminals have experienced the biggest success thanks to there weight and volume, which are continuously decreasing. These terminals can emit up to 2 W. The evolution of technologies allows decreasing the maximum allowed power to 0.8 W.

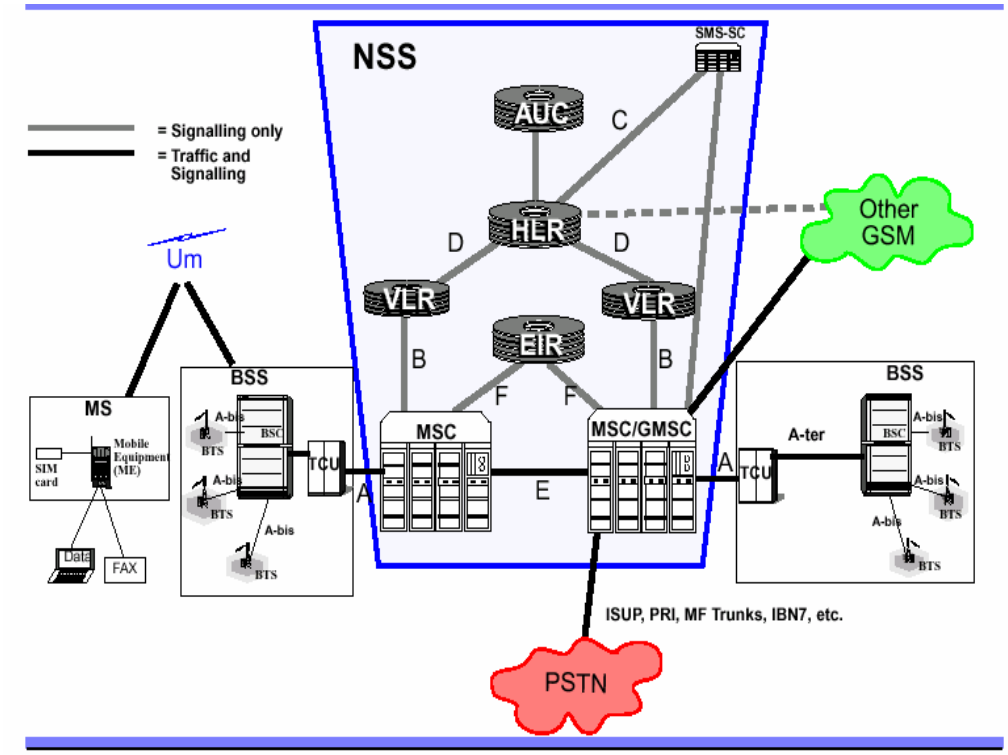

Fig: GSM Architecture

5. The SIM: The SIM is a smart card that identifies the terminal. By inserting the SIM card into the terminal, the user can have access to all the subscribed services. Without the SIM card, the terminal is not operational. The SIM card is protected by a four-digit Personal Identification Number (PIN). In order to identify the subscriber to the system, the SIM card contains some parameters of the user such as its International Mobile Subscriber Identity (IMSI). Another advantage of the SIM card is the mobility of the users. In fact, the only element that personalizes a terminal is the SIM card. Therefore, the user can have access to its subscribed services in any terminal using its SIM card.

6. The Base Station Subsystem: The BSS connects the Mobile Station and the NSS. It is in charge of the transmission and reception. The BSS can be divided into two parts:

- The Base Transceiver Station (BTS) or Base Station.
- The Base Station Controller (BSC).

7. The Base Transceiver Station: The BTS corresponds to the transceivers and antennas used in each cell of the network. A BTS is usually placed in the center of a cell. Its transmitting power defines the size of a cell. Each BTS has between one and sixteen transceivers depending on the density of users in the cell.

8. The Base Station Controller:The BSC controls a group of BTS and manages their radio resources. A BSC is principally in charge of handovers, frequency hopping, exchange functions and control of the radio frequency power levels of the BTSs.

9. The Network and Switching Subsystem: Its main role is to manage the communications between the mobile users and other users, such as mobile users, ISDN users, fixed telephony users, etc. It also includes data bases needed in order to store information about the subscribers and to manage their mobility. The different components of the NSS are described below.

10. The Mobile services Switching Center (MSC):It is the central component of the NSS. The MSC performs the switching functions of the network. It also provides connection to other networks.

11. The Gateway Mobile services Switching Center (GMSC) : A gateway is a node interconnecting two networks. The GMSC is the interface between the mobile cellular network and the PSTN. It is in charge of routing calls from the fixed network towards a GSM user. The GMSC is often implemented in the same machines as the MSC.

12. Home Location Register (HLR) :The HLR is considered as a very important database that stores information of the subscribers belonging to the covering area of a MSC. It also stores the current location of these subscribers and the services to which they have access. The location of the subscriber corresponds to the SS7 address of the Visitor Location Register (VLR) associated to the terminal.

13. Visitor Location Register (VLR): The VLR contains information from a subscriber's HLR necessary in order to provide the subscribed services to visiting users. When a subscriber enters the covering area of a new MSC, the VLR associated to this MSC will request information about the new subscriber to its corresponding HLR. The VLR will then have enough information in order to assure the subscribed services without needing to ask the HLR each time a communication is established. The VLR is always implemented together with a MSC; so the area under control of the MSC is also the area under control of the VLR.

14. The Authentication Center (AuC): The AuC register is used for security purposes. It provides the parameters needed for authentication and encryption functions. These parameters help to verify the user's identity.

15. The Equipment Identity Register (EIR): The EIR is also used for security purposes. It is a register containing information about the mobile equipments. More particularly, it contains a list of all valid terminals. A terminal is identified by its International Mobile Equipment Identity (IMEI). The EIR allows then to forbid calls from stolen or unauthorized terminals (e.g, a terminal which does not respect the specifications concerning the output RF power).

16. The GSM radio interface : The radio interface is the interface between the mobile stations and the fixed infrastructure. It is one of the most important interfaces of the GSM system. One of the main objectives of GSM is roaming. Therefore, in order to obtain a complete compatibility between mobile stations and networks of different manufacturers and operators, the radio interface must be completely defined. The spectrum efficiency depends on the radio interface and the transmission, more particularly in aspects such as the capacity of the system and the techniques used in order to decrease the interference and to

improve the frequency reuse scheme. The specification of the radio interface has then an important influence on the spectrum efficiency.

17. Frequency allocation: Two frequency bands, of 25 Mhz each one, have been allocated for the GSM system:

- The band 890-915 Mhz has been allocated for the uplink direction (transmitting from the mobile station to the base station).
- The band 935-960 Mhz has been allocated for the downlink direction (transmitting from the base station to the mobile station).

But not all the countries can use the whole GSM frequency bands. This is due principally to military reasons and to the existence of previous analog systems using part of the two 25 Mhz frequency bands.

18. Multiple access scheme: The multiple access scheme defines how different simultaneous communications, between different mobile stations situated in different cells, share the GSM radio spectrum. A mix of Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA), combined with frequency hopping, has been adopted as the multiple access schemes for GSM.

19. FDMA and TDMA: Using FDMA, a frequency is assigned to a user. So the larger the number of users in a FDMA system, the larger the number of available frequencies must be. The limited available radio spectrum and the fact that a user will not free its assigned frequency until he does not need it anymore, explain why the number of users in a FDMA system can be "quickly" limited.

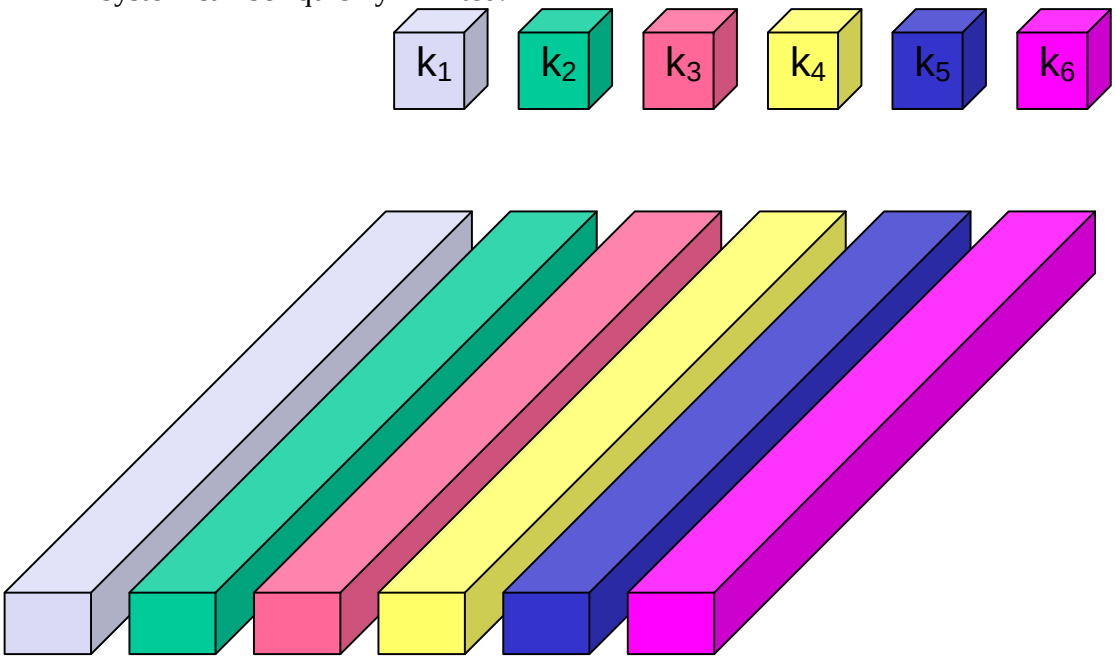

Fig: FDMA

On the other hand, TDMA allows several users to share the same channel. Each of the users, sharing the common channel, are assigned their own burst within a group of bursts called a frame. Usually TDMA is used with a FDMA structure.

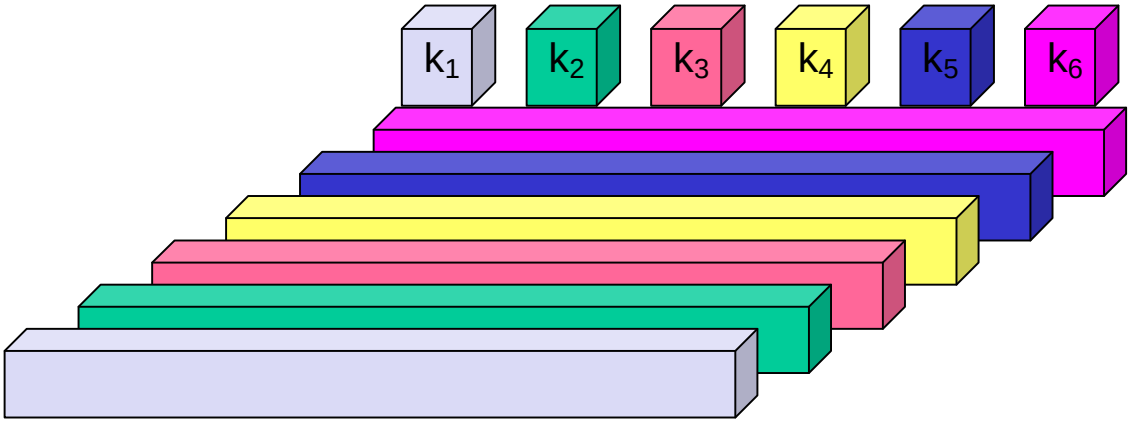

Fig: TDMA

In GSM, a 25 Mhz frequency band is divided, using a FDMA scheme, into 124 carrier frequencies spaced one from each other by a 200 khz frequency band. Normally a 25 Mhz frequency band can provide 125 carrier frequencies but the first carrier frequency is used as a guard band between GSM and other services working on lower frequencies. Each carrier frequency is then divided in time using a TDMA scheme. This scheme splits the radio channel, with a width of 200 khz, into 8 bursts. A burst is the unit of time in a TDMA system, and it lasts approximately 0.577 ms. A TDMA frame is formed with 8 bursts and lasts, consequently, 4.615 ms. Each of the eight bursts, that form a TDMA frame, are then assigned to a single user.

20. GSM services. It is important to note that all the GSM services were not introduced since the appearance of GSM but they have been introduced in a regular way. The GSM Memorandum of Understanding (MoU) defined four classes for the introduction of the different GSM services:

- E1: introduced at the start of the service.
- E2: introduced at the end of 1991.
- Eh: introduced on availability of half-rate channels.
- A: these services are optional.

Three categories of services can be distinguished:

- Teleservices.
- Bearer services.
- Supplementary Services.

21. Teleservices

- Telephony (E1® Eh).
- Facsmile group 3 (E1).
- Emergency calls (E1® Eh).
- Teletex.

Short Message Services (E1, E2, A). Using these services, a message of a maximum of 160 alphanumeric characters can be sent to or from a mobile station. If the mobile is powered off, the message is stored. With the SMS Cell Broadcast (SMS-CB), a message of a maximum of 93 characters can be broadcast to all mobiles in a certain geographical area.

Fax mail. Thanks to this service, the subscriber can receive fax messages at any fax machine.

Voice mail. This service corresponds to an answering machine.

22. Bearer services

A bearer service is used for transporting user data. Some of the bearer services are listed below:

- Asynchronous and synchronous data, 300-9600 bps (E1).
- Alternate speech and data, 300-9600 bps (E1).
- Asynchronous PAD (packet-switched, packet assembler/disassembler) access, 300-9600 bps (E1).
- Synchronous dedicated packet data access, 2400-9600 bps (E2).

23. Supplementary Services: Call Forwarding (E1). The subscriber can forward incoming calls to another number if the called mobile is busy (CFB), unreachable (CFNRc) or if there is no reply (CFNRy). Call forwarding can also be applied unconditionally (CFU). - Call Barring. There are different types of `call barring' services:

- Barring of All Outgoing Calls, BAOC (E1).
- Barring of Outgoing International Calls, BOIC (E1).
- Barring of Outgoing International Calls except those directed toward the Home PLMN Country, BOIC-exHC (E1).
- Barring of All Incoming Calls, BAIC (E1)
- Barring of incoming calls when roaming (A).

- Call hold (E2). Puts an active call on hold.

Call Waiting, CW (E2). Informs the user, during a conversation, about another incoming call. The user can answer, reject or ignore this incoming call.

- Advice of Charge, AoC (E2). Provides the user with an online charge information.
- Multiparty service (E2). Possibility of establishing a multiparty conversation.
- Closed User Group, CUG (A). It corresponds to a group of users with limited possibilities of calling (only the people of the group and certain numbers).
- Calling Line Identification Presentation, CLIP (A). It supplies the called user with the ISDN of the calling user.
- Calling Line Identification Restriction, CLIR (A). It enables the calling user to restrict the presentation.
- Connected Line identification Presentation, CoLP (A). It supplies the calling user with the directory number he gets if his call is forwarded.
- Connected Line identification Restriction, CoLR (A). It enables the called user to restrict the presentation.
- Operator determined barring (A). Restriction of different services and call types by the operator.

- Communication
  - mobile, wireless communication; support for voice and data services
- Total mobility
  - international access, chip-card enables use of access points of different providers
- Worldwide connectivity
  - one number, the network handles localization
- High capacity
  - better frequency efficiency, smaller cells, more customers per cell
- High transmission quality

  - high audio quality and reliability for wireless, uninterrupted phone calls at higher speeds (e.g., from cars, trains)
- Security functions
  - access control, authentication via chip-card and PIN

There are different equipment suppliers like **Ericsson, Nokia Siemens, Motorola, Alcatel, Lucent, Nortel, Huawei, ZTE** etc. Ericsson is the largest supplier of Transmission as well as BTS, BSC, and MSC.

In GSM SS7 protocols are used to establish the call between different users. SS7 protocol stack has 7 protocols. These are **MTP-1, 2, 3, SCCP, TCAP, ISUP and TUP.**

24. References:

1. An overview of the Global System for Mobile Communications by John Scourias http://ccnga.uwaterloo.ca/~jscouria/GSM/gsmreport.html
2. GSM World, the world wide web site of the GSM MoU Association http://www.gsmworld.com/
3. GSM information network http://www.gin.nl/
4. 'Overview of the Global System for Mobile communications' by John Scourias (University of Waterloo). Web document found in: *http://ccnga.uwaterloo.ca/~jscouria/GSM/index.htm*