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Global System for Mobile Communications

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Abstract **- The Global System for Mobile Communications - GSM. The Global System for Mobile Communications is a digital cellular communications system. It was developed in order to create a common European mobile telephone standard but it has been rapidly accepted worldwide. GSM was designed to compatible with ISDN services.**

It is a unique opportunity bestowed on us, to present the various techniques used in GSM, in this paper. The architecture of GSM is presented in this paper, which is widely in vogue today is comprised of The Mobile Station, The Base Station Subsystem, The Network and Switching Subsystem and The Operation and Support Subsystem. Our presentation also deals with the geographical areas of the GSM network, which is rarely dealt with. The functions such as Transmission, Radio Resources Management, Mobility Management, Communication Management and Operation, Administration and Maintenance are also vividly discussed in our paper. Last but not least, the presentation deals with the services provided by GSM such as Teleservices, Bearer Services and Supplementary Services.

I. INTRODUCTION

A. History of GSM

The idea of cell-based mobile radio systems appeared at Bell Laboratories in the early 1970s. But in the beginnings of cellular systems, each country developed its own system, which was an undesirable situation. In order to overcome these problems, the Conference of European Posts and Telecommunications (CEPT) formed, in 1982, the Group Special Mobile (GSM) in order to develop a pan-European mobile cellular radio system (the GSM acronym became later the acronym for Global System for Mobile communications). Unlike the existing cellular systems, which were developed using an analog technology, the GSM system was developed using a digital technology.

B. Cellular systems; the cellular structure

In a cellular system, the covering area of an operator is divided into cells. A cell corresponds to the covering area of one transmitter or a small collection of transmitters. The size of a cell is determined by the transmitter's power. The concept of cellular systems is the use of low power transmitters in order to enable the efficient reuse of the frequencies. The frequency band allocated to a cellular mobile radio system is distributed over a group of cells and this distribution is repeated in all the covering area of an operator. Frequencies used in a cell will be reused several cells away.

C. Clusters

The cells are grouped into clusters. The typical clusters contain 4, 7, 12 or 21 cells. The number of cells in each cluster is very important. The smaller the number of cells per cluster is, the bigger the number of channels per cell will be. The total number of channels per cell depends on the number of available channels and the type of cluster used. Different types of cells such as Macrocells, Microcells, Selective cells and Umbrella cells are used here.

D. Transition from analog to digital technology

Regarding the capacity of the system, analog systems were not able to cope with this increasing demand. In order to overcome this problem, new frequency bands and new technologies were proposed. But the possibility of using new frequency bands was rejected by a big number of countries because of the restricted spectrum (even if later on, other frequency bands have been allocated for the development of mobile cellular radio). The new analog technologies proposed were able to overcome the problem to a certain degree but the costs were too important. Viewing the compatibility of GSM with other systems such as ISDN In order to make GSM compatible with the services offered by ISDN, it was decide that the digital technology was the best option. Coming to the aspects of quality, analog systems pass the physical disturbances in radio transmission to the receiver. On the other hand, digital systems avoid the disturbing effects transforming the signal into bits.

II. THE GSM NETWORK

A. Architecture of the GSM network

The GSM technical specifications define the different entities that form the GSM network by defining their functions and interface requirements.
The GSM network can be divided into four main parts:

- The Mobile Station (MS).
- The Base Station Subsystem (BSS).
- The Network and Switching Subsystem (NSS).
- The Operation and Support Subsystem (OSS).

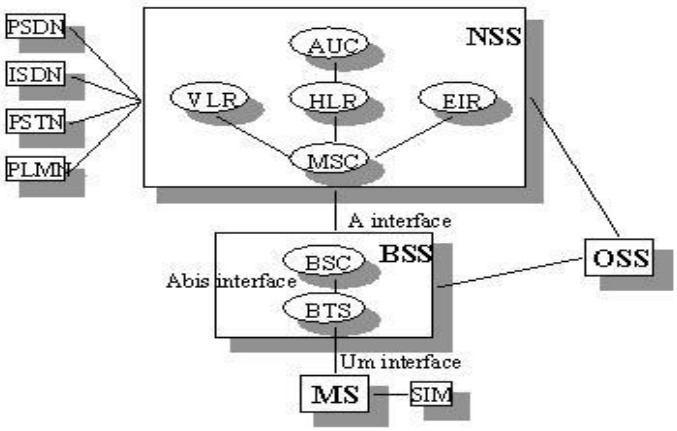

Fig. 1: Architecture of the GSM network

B. Mobile Station

A Mobile Station consists of two main elements:

- The mobile equipment or terminal.
- The Subscriber Identity Module (SIM).

C. 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 handless terminals have experienced the biggest success thanks to the weight and volume, which are continuously decreasing. These terminals can emit up to 2 W. The evolution of technologies allows to decrease the maximum allowed power to 0.8 W.

D. 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.

E. 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).

F. 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.

G. 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.

H. 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.

I. 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.

J. 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.

K. 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.

L. 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 is always implemented together with a MSC; so the area under control of the MSC is also the area under control of the VLR.

M. 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.

N. 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).

O. The GSM Interworking Unit (GIWU):

The GIWU corresponds to an interface to various networks for data communications. During these communications, the transmission of speech and data can be alternated.

P. The Operation and Support Subsystem (OSS):

The OSS is connected to the different components of the NSS and to the BSC, in order to control and monitor the GSM system. It is also in charge of controlling the traffic load of the BSS.

However, the increasing number of base stations, due to the development of cellular radio networks, has provoked that some of the maintenance tasks are transferred to the BTS. This transfer decreases considerably the costs of the maintenance of the system.

***Q.* The geographical areas of the GSM network:**

As it has already been explained a cell, identified by its Cell Global Identity number (CGI), corresponds to the radio coverage of a base transceiver station. A Location Area (LA), identified by its Location Area Identity (LAI) number, is a group of cells served by a single MSC/VLR. A group of location areas under the control of the same MSC/VLR defines the MSC/VLR area. A Public Land Mobile Network (PLMN) is the area served by one network operator.

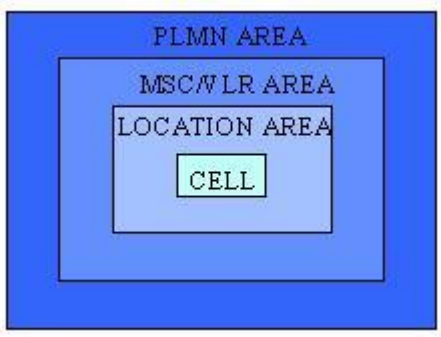

Figure 2: GSM network areas

III. GSM FUNCTIONS

In this paragraph, the description of the GSM network is focused on the different functions to fulfill by the network and not on its physical components. In GSM, five main functions can be defined:

A. *Transmission*

The transmission function includes two sub-functions:

- The first one is related to the means needed for the transmission of user information.
- The second one is related to the means needed for the trasnmission of signaling information.

B. *Radio Resources management (RR):*

The role of the RR function is to establish, maintain and release communication links between mobile stations and the MSC. The RR is also responsible for the management of the frequency spectrum and the reaction of the network to changing radio environment conditions. Some of the main RR procedures that assure its responsibilities are:

- Channel assignment, change and release.
- Handover.
- Frequency hopping.
- Power-level control.
- Discontinuous transmission and reception.
- Timing advance.

C. Mobility Management:

The MM function is in charge of all the aspects related with the mobility of the user, specially the location management and the authentication and security.

D. *Location management:*

When a mobile station is powered on, it performs a location update procedure by indicating its IMSI to the network. The first location update procedure is called the IMSI attach procedure.

The mobile station also performs location updating, in order to indicate its current location, when it moves to a new Location Area or a different PLMN. This location updating message is sent to the new MSC/VLR, which gives the location information to the subscriber's HLR.

E. *Authentication and security:*

The authentication procedure involves the SIM card and the Authentication Center. A secret key, stored in the SIM card and the AuC, and a ciphering algorithm called A3 are used in order to verify the authenticity of the user. The mobile station and the AuC compute a SRES using the secret key, the algorithm A3 and a random number generated by the AuC. If the two computed SRES are the same, the subscriber is authenticated. The different services to which the subscriber has access are also checked.

F. *Communication Management (CM):*

The CM function is responsible for:

- Call control.
- Supplementary Services management.
- Short Message Services management.

G. Call Control (CC):

The CC is responsible for call establishing, maintaining and releasing as well as for selecting the type of service. One of the most important functions of the CC is the call routing. In order to reach a mobile subscriber, a user dials the Mobile Subscriber ISDN (MSISDN) number which includes:

- a country code

- a national destination code identifying the subscriber's operator
- a code corresponding to the subscriber's HLR

The call is then passed to the GMSC (if the call is originated from a fixed network) which knows the HLR corresponding to a certain MISDN number. The GMSC asks the HLR for information helping to the call routing. The HLR requests this information from the subscriber's current VLR. This VLR allocates temporarily a Mobile Station Roaming Number (MSRN) for the call. The MSRN number is the information returned by the HLR to the GMSC. Thanks to the MSRN number, the call is routed to subscriber's current MSC/VLR. In the subscriber's current LA, the mobile is paged.

H. Short Message Services management:

In order to support these services, a GSM network is in contact with a Short Message Service Center through the two following interfaces:

- The SMS-GMSC for Mobile Terminating Short Messages (SMS-MT/PP). It has the same role as the GMSC.
- The SMS-IWMSC for Mobile Originating Short Messages (SMS-MO/PP).

I. Operation, Administration and Maintenance (OAM):

The OAM function allows the operator to monitor and control the system as well as to modify the configuration of the elements of the system. Not only the OSS is part of the OAM, also the BSS and NSS participate in its functions as it is shown in the following examples:

- The components of the BSS and NSS provide the operator with all the information it needs. This information is then passed to the OSS which is in charge of analyzing it and control the network.
- The self test tasks, usually incorporated in the components of the BSS and NSS, also contribute to the OAM functions.
- The BSC, in charge of controlling several BTSs, is another example of an OAM function performed outside the OSS.

IV. 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.

A. 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.

B. 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).

C. 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).

D. 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).

E. Call hold (E2)

Puts an active call on hold.

F. Call Waiting CW (E2)

Informs the user, during a conversation, about another incoming call. The user can answer, reject or ignore this incoming call.

G. Advice of Charge, AoC (E2)

Provides the user with an online charge information.

H. Multiparty service (E2)

Possibility of establishing a multiparty conversation.

I. 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).

J. Calling Line Identification Presentation, CLIP (A)

It supplies the called user with the ISDN of the calling user.

K. Calling Line Identification Restriction, CLIR (A)

It enables the calling user to restrict the presentation.

L. Connected Line identification Presentation, CoLP (A)

It supplies the calling user with the directory number he gets if his call is forwarded.

V. CONCLUSION

A latest technology in the present world that most individuals will find easy to use is GSM. The concept of GSM holds the potential for harmonizing many of today's organizational and managerial changes with the technological development. Though it has a very complex standard, it can be considered as the first serious attempt to fulfill the requirements for a universal personal communication system. It is used as a basis for the development of the Universal Mobile Telecommunication System (UMTS). Nowadays, most of the world's top companies like NOKIA, SAMSUNG use the GSM technology to produce their products.

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