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GSM and Mobile Telephony Trends

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ABSTRACT

GSM is an important technology to the world today, ensuring the connectivity of billions of individuals across the world. In this paper, the subject of mobile telephony is addressed, we look at the GSM technology detailing how it works and also look at the structure it is comprised of. Also, we see the trends experienced in then network system and see how due to technological advancement, the technology has grown to services billion of individuals today.

Keywords: GSM, Telephony, Technology, Connectivity, Trends

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Introduction

Communication is an important aspect of everyday life, the advantages of digital communication in today's society are endless. Technological advancements in field of telecommunications as brought about an information age where anyone can be connected to and have conversations in real time with anyone, anywhere in the world. The GSM communications network has made a huge contribution to the driving innovation and bringing the world into an information age. The Global System for Mobile Communications (GSM) can be described simply as a standard for digital communication, it is a digital system for mobile communication which was developed to serve as a common standard for European telecommunication systems but today has been accepted internationally (Pawar & Pawar, 2012).

At the dawn of the 1990s, the GSM technology revolutionized the way individuals communicate with one another, it was a significant transition from the analog systems which could only accommodate a certain number of subscribers and this limited the use of these analog systems. As at 2010 it was recorded that about out of a world population of 7.6 billion, 3 billion are active subscribers on various GSM networks and this number is expected to rise and surpass 5 billion by the year 2018 (GSMA , 2017). These achievement and popularity of the GSM technology can be attributed to the steady advancements in the field of digital telecommunication and also the gradual decline in the cost of acquiring both the infrastructural equipment for setting up the networks and also the reduction in price of getting mobile devices (Sauter, 2011).

What is GSM

The Global System for Mobile Communications (GSM) originally referred to has the *Groupe Spécial Mobile* is a communication standard which was developed by the European Telecommunications Standards Institute (ETSI) in order to have a common standard for mobile operators to communicate with throughout Europe (Olumide.O & Abiodun.A, 2014). The European Telecommunications Standards Institute (ETSI) created the protocols and communication standards for the second-generation (2G) digital communication cellular technology which is deployed for mobile phones. The 2G technology was first in July 1991 in Finland. As at 2014, it has become the main standard for mobile communication throughout the world, with about 90% of the worlds telecommunication market share and also its fully operational in over 219 countries (GSMA , 2017).

The GSM communication network architecture was developed to be compatible with Integrated Services Digital Network (ISDN) services. ISDN services are a combination of network protocols and also communication standards which allow for the simultaneous transmission of digital contents such as video, voice, text and other forms of digital contents and these contents are transmitted over the circuits of the public switched telephone networks which is called the Plain Old Telephone Service (POTS).

In the early 1970s, at Bells Laboratories in the United State of America, the concept of a mobile radio network system which could be divided into cells was conceived, but this idea would take another decade to be fully available for commercial use. Scandinavia and the United Kingdom were the two top nations in Europe that pushed the rapid development of the analog cellular telecommunication networks available, but towards the beginning of the 1990s it was seen that all these European nations operated using different standards and it was impossible for these standards to be able to share information among themselves. An example of this is that some one in the United Kingdom cannot communicate with an individual in Scandinavia, and the this was due to two main reasons which are:

1. The various telecommunication equipment at the time were not designed

to communicate outside the boundaries of the nation in which they occupy.

2. Also, the market for this telecommunication equipment was limited and not easily accessible to all.

These problems outline were needed to be solved in other for mobile telephony to achieve wide spread usage especially over international boarders, the Conference of European Posts and Telecommunications (CEPT) which was the continental regulatory board for telecommunication for the whole of Europe made a decision to form a pan-European mobile cellular radio system in 1980 which would make it possible for telecommunication operators across Europe to communicate across international borders (Selian, 2002). The radio system was initially called the Groupe Spécial Mobile (GSM) and years later, after it was commercially to operators across the world, it was renamed to Global System for Mobile communications. This new network cell-based (cellular) system had to met certain criteria, they include the following:

1. Maximized the available spectrum has efficiently has possible.
2. It had to support international roaming.
3. It had to support low cost availability of network equipment.
4. It had to provide quality voice services to the consumer.
5. It must be compatible with other existing network systems such as ISDN, PSTN.
6. It must also support new network services that would be developed.

How GSM Works

GSM was originally designed to be purely a circuit-switched network system which will create an exclusive and direct connection with two network users using a dedicated network channel. As technological advancement increased, many network nodes do not require dedicated channels, due to the fact that it reduces the amount of connections that can be made possible at any given time because there is a limited number of channels. Networks nodes are now connected via the IP-based broadband system. This is what is referred to has packet-switched networking (Willassen, 2003).

The GSM mobile network which was originally designed to perform as a circuit-switched network which acts similarly to the way a fixed telephone network acts. When a call is initiated, the network system connects the caller with the recipient via a network connection, this connection is exclusively for conversations. Before the call is passed through to the recipient, it first passes through a switching centre, the centre using a switching algorithm which sets up the connection and assign a dedicated channel to the call then the called parties are connected. Once the call ends, the switching algorithms simply clears the communication channel to allow for it to be available to other subscribers waiting to making a call (Alkharashi, 2016). This approach of connecting calls is very similar to the approach made by analogue fixed telephone line communication. It was not until the mid-1980s that digital technology replaces the analogue systems in the switching centre.

As a result of these shift from analogue to digital, today we no longer operate analogue network systems. Mobile calls are no longer sent via analogue lines, instead switching centres will convert analogue signals gotten from subscribers into digital signals and the digital signals are transmitted to the destination switching centre where it is converted back to analogue which is sent via cables and the destination subscriber. In some countries, the use of Integrated Services Digital Network (ISDN) is very much integrated to their GSM networks, this ensure that the transmission is digitally transferred and then reconverted to analogue is done by the mobile phones of the consumer.

GSM network operate with geo- anonymity allowing the user with flexible mobility. Thus, subscribers do not have a fixed dedicated line but rather a more dynamic network is operation offering a duplex network service. The GSM network is broken down into geographical cells

hence the name cellular network. Subscribers in a particular geo-cell communicate through the network element broadcasting in that cell. In other to ensure complete cellular coverage, with the application of handover services, subscribers can travel between cells with different broadcasting equipment during a call.

In order to have a completely global network system, an international body referred to as the International Telecommunication Union (ITU) is created in other to facilitate the standardization of various telecommunication network processes, interfaces and also procedures. This standardization ensure that subscribers are not only limited to communicate with other subscribers in their locality, it also ensures international roaming for subscribers. As a result of the standardization one of the most important protocol in GSM telecommunication was created. The Signalling System Number 7 (SS-7) is one of the most important protocols deployed by the ITU for the GSM network communication, it is used for call routing and international roaming.

Network Structure of GSM

The GSM network structure defines the various entities that form the GSM network. These components have defined functions which enables an efficient GSM network operation. The GSM network structure can be divided into 4 main parts:

1. The Mobile Station (MS).
2. The Base Station Subsystem (BSS).
3. The Network and Switching Subsystem (NSS).
4. The Operation and Support Subsystem (OSS).

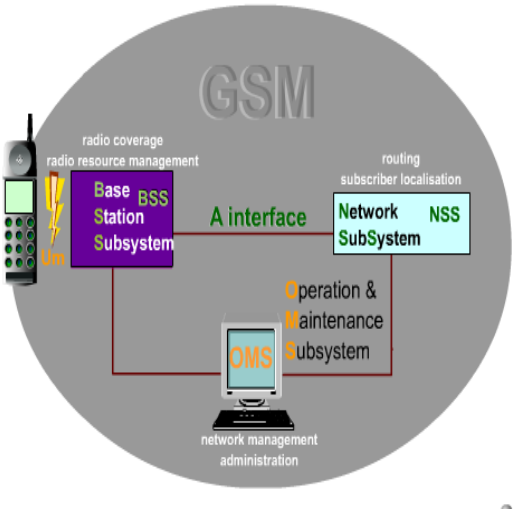


Figure 1: GSM Network Structure. (Source: GSM Interactive, 2001)

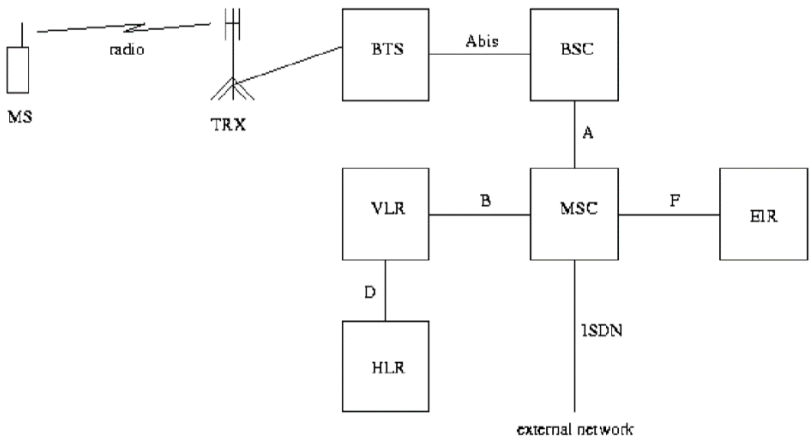


Figure 2: Logical Description of the GSM Network Structure. (Source: Willassen, 2003)

The Mobile Station (MS).

A mobile station consists of two main elements:

1. The Mobile Terminal: This is the mobile device used by the subscriber to access the network.
2. The Subscriber Identity Module (SIM): The SIM is a smart card which identifies the mobile terminal of the user. It is coded with the user information and this information is peculiar to just the user and it identifies individual users. Another benefit of using the SIM card is it ensures mobility of the user. The SIM card is the only network element that is encoded with user information. The user can change mobile terminal and also locations and still have access to the network via the SIM card.

The Base Station Subsystems (BSS)

The base station subsystem is the communication link between the mobile terminal and the core of the network. It acts basically has a repeater and transmit user information for the mobile terminal for processing at the core of the network. The BSS takes charge of the transmission of wireless signals and also the reception also. It is divided into two parts:

1. The Base Transceiver Station (BTS): The BTS is made up of various transceivers, antennas and radios. The BTS ensures the cellular coverage in the GSM network. A BTS is placed per cell and the BTS is at the centre. The coverage a BTS has in a particular cell is determined by its transmission power and this will also determine the size of the cell.
2. The Base Controller Station (BSC): The BSC controls a collection of BTS and it acts as the resource manager for these BTS. The BSC handles inter BSC communication, ensuring that the various BSCs are not in isolation of each other. Services such as handover, control frequency power levels, exchange functions are handled by the BTS.

The Network and Switching Subsystem (NSS)

The NSS is the core of the GSM network, it manages the communication between subscribers engaging in the communication. It also manages ISDN services and so on. It also incorporates the data required to run the entire network, it stores user information and manages the mobility of the users. The various components that make up the NSS include:

1. The Mobile Switching Centre (MSC): This is the core network element in the NSS. The MSC ensures connectivity between subscribers and it also handles communication between the parent network and other networks.
2. The Gateway Mobile Services Switching Centre (GMSC): This is a gateway network element that provide interconnectivity between two networks. It acts as an interface between the cellular mobile network and the PSTN, it also handles routing of calls between various networks.
3. Home Location Register (HLR): The HLR is a very important database to the network. All user information is stored in it. It also determines what services can be available to certain users.
4. Visitor Location Register (VLR): This is also a database on user information, it contains user information from the HLR. When a user enters into a new MSC coverage location, 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.
5. The Authentication Centre (AuC): The AuC is implemented for security reasons

in the GSM network. It is used as an encrypting and authenticating function in the network. It validates user integrity and identity of the users.

6. The Equipment Idesntity Register (EIR): The EIR contains information about the mobile equipment in the network. It sores information about all valid mobile terminals and SIM cards. It makes it possible to block certain mobile terminals in case they are stolen or unauthorized to access the network.
7. The GSMI Interworking Unit (GIWU): The GIWU offers the transmission of data communication (Tutorials Point, 2017).

The Operation and Support Subsystem (OSS)

The OSS is the control and monitoring system that monitors the GSM network. It controls the traffic load on the network ensuring that the network is not overloaded with traffic. It closely monitors the entire network, offering reports on the network operations.

Trends

The association between 2G and 3G can be seen in the migration process between these two standards of communication. The migration to 3G services from 2nd generation systems is a complex field, depending on the starting point of the study; for example, CDMA-based systems have a very different road to IMT-2000 than TDMA counterparts. Such systems point to 'CDMA 2000' systems as equivalent to '3G', while for TDMA systems (including GSM), the Ericsson-proposed W-CDMA standard represents attainment of '3G'. CDMA-based carriers believe that their migration path43 will be more inexpensive than that of GSM/TDMA-based carriers, because many will have only to change channel cards in the base stations and upgrade the network software as opposed to implementing entire network overlays.

The advancements of the 2nd generation GSM systems include HSCSD (High Speed Circuit Switched Data), GPRS (General Pack Radio Service), and EDGE (Enhanced Data Rate for GSM evolution) – all of which allow for higher data transmission rates. The objective of GSM advancements is to achieve UMTS, which is part of the ITU's 'IMT-2000' vision of a global family of 'third-generation' (3G) mobile communications systems.

All of these 2.5 generation systems are now well on their way to development and deployment – and the question now is which one will be most relevant, versatile, cost effective, and able to cope with the demands of a complex telecommunications service landscape? Which system will succeed in effectively offering which services? And, will these 'half-steps' toward elusive 3G-roll-out pre-empt the need for 3G itself, or just delay its introduction?

		Technology	Bandwidth (Kbit/s)	Features
First Generation Mobile	AMPS/ NMT	Advanced Mobile Phone System Nordic Mobile Telephony	9.6	• Analog voice service • No data capabilities
Second Generation Mobile	GSM	Global System for Mobile Communication	9.6 → 14.4	• Digital voice service • Advanced messaging • Global roaming • Circuit-switched data
	HSCSD	High-Speed Circuit Switched Data	9.6 → 57.6	• Extension of GSM • Higher data speeds

	GPRS	General Packet Radio Service	9.6 → 115	• Extension of GSM • Always-on connectivity • Packet-switched data
	EDGE	Enhanced Data Rate for GSM Evolution	64 → 384	• Extension of GSM • Always-on connectivity • Faster than GPRS
Third Generation Mobile	IMT-2000/UMTS	International Mobile Telecommunications 2000 / Universal Mobile Telecommunications System	64 → 2,048	• Always-on connectivity • Global roaming • IP-enabled

Trends in GSM Technology. (Source: Forrester Research)

Long Term Evolution (LTE) has propelled the world into an age of affordable, reliable and also efficient data services, user experience is greatly improved; also improving the Quality of Service (QoS), giving room for more sophisticated applications requiring huge bandwidth including streaming services, mobile video blogging, TV over IP, advanced gaming services and so on (ERICSSON, 2007). It can be described has the standard for high-speed data communication. This standard is based on the GSM/EDGE and UMTS/HSPA standards. The Long-Term Evolution technology brings about so many beneficial advantages over previous technologies to both users and the network administrators, these advantages can be categorized into three major points; which are performance and capacity; simplicity and a wide range of terminals (Khalil, 2015).

The standard is developed by the 3GPP (3rd Generation Partnership Project) and is specified in its Release 8 document series, with minor enhancements described in Release 9. LTE is the upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks. The different LTE frequencies and bands used in different countries mean that only multi-band phones are able to use LTE in all countries where it is supported (Salford, Brun, Eberhardt, Malmgren, & Persson, 2003).

5G technology is receiving lots of attention in the media even though the term 5G isn't formally defined yet; the formal definition will come from the International Telecommunications Union in the near future. There is, however, a significant amount of research on-going in the UK and elsewhere to develop candidate technologies to deliver the 5G vision of the future. (Sutton & Tafazolli, 2015). Mobile technology has been on a rapid journey since the launch of digital cellular systems in the UK some 20 years ago, Work on Global System for Mobile Communications (GSM) started in 1982, prior to the introduction of 1st generation analogue cellular in the UK (Khalil, 2015).

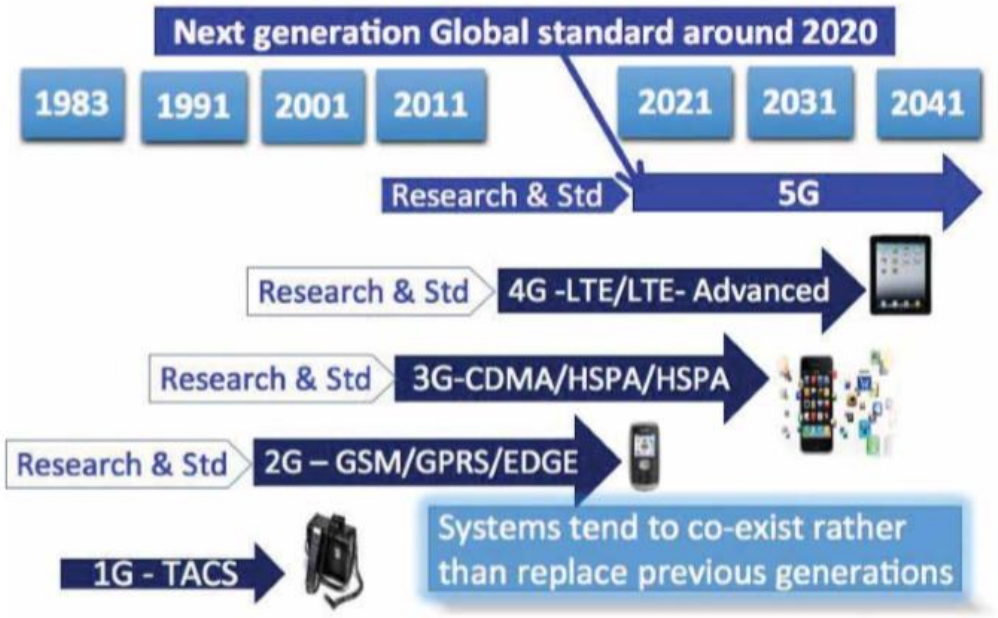
The goal of GSM was to provide a pan European system with international roaming between member states, something which wasn't possible with country-specific 1st generation technologies. GSM delivered a standard which, in the early 1990s, was widely adopted, not just in Europe. The early GSM standards supported Short Message Service and circuit switched data, enabling users to connect laptops to external data networks. The increasing demand for data, and in particular Internet access, led to the development of General Packet Radio Service which introduced packet-switching capability to GSM running in parallel with the existing circuit switched network.

The introduction of 3G was based on the same architecture as GSM/General Packet Radio Service although with a new radio interface to support higher data rates and greater capacity. This was subsequently enhanced with High Speed Packet Access technologies.

The big change to cellular network architecture came with 4G or Long-Term Evolution (LTE). LTE is an all-IP network with no circuit switching, voice is simply IP data with a high Quality of

Service applied and implemented. This move to an all-packet based system enables a much-simplified network architecture and the use of an advanced Quality of Service and policy control framework enables a wide range of new and innovative services to be delivered.

5G is expected to be standardised by the year 2020 and will be commercially deployed a few years later (Statista, 2018). Although 5G will introduce new technologies, much will be an evolution of 4G LTE-Advanced and WiFi both of which are developing to offer ever greater peak and average user data rates and new and innovative services.



Future Trends in GSM Technology. (Source: Sutton & Tafazolli, 2015)

Conclusion

The GSM network is the fastest growing network till date, having billions of individuals connected to it. In this paper we have been able to look at the GSM technology, give a detailed description on how it works and also see the trends currently experienced in this field. The GSM technology will continue to grow and develop due to the advancement experienced in the field of telecommunication.

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