A STUDY OF GSM TECHNOLOGY IN NIGERIA

AND ITS PLACE IN

THE INTERNATIONAL SCENE

BY

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DECLARATION

I hereby declare that this project was wholly conducted by me, Longrin Amos Wetten, under the able supervision of Engr. Musa D. Abdullahi of the Department of Electrical and Computer Engineering, Federal University of Technology, Minna, Niger State. The project report has not been presented elsewhere for the award of any degree, distinction or certificate.

SIGNATURE

12/10/2003

DATE

CERTIFICATION

This is to certify that Wetten, Longrin Amos carried out the project work presented in this report under my supervision.

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EXTERNAL EXAMINER

DATE

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DATE 12/10/2003

DEDICATION

To him: for pushing me when I needed pushing

To her; for letting me move at my own pace

To them; for moving with me every step of the way

What would I do without my family?

This one's for you.

AKNOWLEDGEMENTS

First and foremost, I am saying a big "Thank You" to Him who gave me the breath, the strength and the chance to be here. To my highly capable supervisor, Engr. M. D. Abdullahi; for fine-tuning my work with so much understanding; thanks for helping me extract the best in me. To my wonderful mother Mrs H. Wetten. To my beloved sister and her husband, Rev. and Mrs. Panya, who took me in and loved me like a son, and became my second parents. To my brother and his wife, Mr and Mrs N. Wetten, to my sister and her husband, Mr and Mrs B. Daje, and to Yoila, I appreciate all the love and support you gave me. To my gorgeous nephews and nieces who taught me how to be a good uncle; thanks for not disturbing me while I worked on this. To all my friends who shared my themes and my thrills, especially the inmates of "The Monastery", where my ideas were nurtured to maturity; To Wale; for your commendations and condemnations, To Kaase; for those astounding inputs that are heavy enough to impress, and for the use of your "workstation". To Chinnan, my understanding roommate for five years, for tolerating my idiosyncrasy in more ways than non. And to all those who supported me in one way or the other, whose names are too many to mention, I am eternally grateful to you all.

ABSTRACT

The GSM technology is a purely digital cellular telephone system that was introduced in 1982 by 26 European telecommunication administrators called the Conference of European Posts and Telegraphs and launched in 1991. It was a European standard that gained global acceptance after spreading in Europe to become the preferred system in over 190 countries around the world today. It is categorized as a 2nd generation (2-G) cellular telephony system with the 1st generation being the now obsolete analogue cellular telephone system. It also serves as the stepping stone to the next generation of cellular phones; the CDMA 3-G cellular phones. The GSM standard was carefully planned to cater for so many functions that were known at the time and also made flexible enough to accommodate future developments. This project gives a concise description of the GSM system from a technical point of view and culminates with a description of the various GSM network operators in Nigeria.

Commercial cellular systems have been in existence since the early 80s and the decision to adopt a global standard came with the need to agree on certain aspects of a new technology in order to foster greater trade relations and interaction between nations. The fact that the world is shrinking to become one global village is prominent. Nigeria, being the most populated country in sub-Saharan Africa, with a teledensity of about 0.4 in 1999, joined the race of the digital era in January 2001 when it embraced the Global System for Mobile Communications (GSM). The various operators of GSM technology in Nigeria are briefly described with the aim of giving an extensive view of the state of events in the telecommunication industry. A background view of telecommunications in Nigeria is presented to highlight the development of telecommunications in Nigeria in order to appreciate the state of the telecom industry at present, and possibly, in the future.

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1 INTRODUCTION

GSM technology in Nigeria can be considered to be in its infancy. The technology was launched in Nigeria in August 2001. Today, two years later, the technology has enjoyed a wide acceptance that is evident by improved telecommunication services in Nigeria. The GSM technology has aptly ushered Nigeria into the twenty-first century, counting Nigeria among the countries equipped to face the digital era. Before the advent of GSM, other forms of wireless telecommunications media existed. The old analogue cellular technology was being operated by NITEL (Nigerian Telecommunications Ltd.), Nigeria's national telecommunications services carrier company. Today, GSM technology has paved way for the introduction of other telecommunications companies including fixed wireless operators and most importantly, a second national telecommunications services carrier to work alongside NITEL.

The journey began in December 2000 with many local and foreign telecommunication companies competing for the much-coveted Nigerian Communications Commission (NCC) GSM licenses. By February 2001 after a competitive Digital Mobile License auction that was acclaimed as free, fair and legitimate, three firms emerged as GSM licensed operators in the country. These major players are ECONET WIRELESS (NIGERIA), MTN and Communication Investments Limited (CIL). The only indigenous firm at the time, CIL, was eased out of the race by the NCC after allegedly failing to meet up with the deadline for payment of the balance of the license fee by midnight of February 9, 2001.

Before August 2001, NITEL, the nations major telecom company had less than 500,000 landlines serving the 130 million Nigerians giving a teledensity of over 250 people to one telephone line

(0.4%). Nigeria's teledensity is reputed to be one of the poorest around the World in that it fell short of the International Telecommunications Union (ITU) recommendation of 4 people to a telephone line (25%). GSM offered an appropriate solution to this unfortunate situation because of its low cost, high capacity and relatively fast set up speed.

The GSM race started in earnest between the two digital mobile licensed operators – ECONET and MTN – who embarked on vigorous publicity stunts to catch the large market in the country. Private telephone operators (PTOs) such as Intercellular, ReITel, Multilinks, Cellcom and others also came on the scene and have deployed no more than 200,000 phone lines. At present, the Nigerian Communications Commission granted licenses to about 13 private companies to operate fixed wireless phone services. It also recently approved Globacom as the second national carrier. These, no doubt represent a major leap in the industry but a wide yawing gap still needs to be filled in the Nigerian telecoms sector. In spite of these developments, Nigeria's telephone services, GSM or otherwise, still remain the poorest and most expensive around the world.

This project is going to attempt to describe the GSM Technology for what it is – a twenty first century 2nd generation telephone system with a global coverage and world-wide acceptance. Its standards are going to be described in a simple and concise format, which I hope would be appropriate for the scope of this undergraduate project.

A description of cellular systems is included to give a background picture of the world of cellular telephony from inception. This was done in order to fit the GSM technology on the time scale of cellular telephony evolution.

The GSM system will be described in a brief and comprehensive approach. This is going to be a highly summarised version given that the GSM Specification document is over 8000 pages long.

Chapter 4 is going to look at the existing network operators in the country and try to give accurate information about them and the way they operate. This project will attempt to compare the various services available and weigh them on an international scale. The various operators in the country are going to be called upon to give a description of their networks based on the following criteria:

- Transmission equipment (types, technical specifications, distribution of base stations, switching centres, maintenance schedules)
- Coverage areas (coverage maps, consumer statistics, teledensity, future coverage plans)
- Set up (cost, ease, sources of power, problems encountered)
- Running/maintenance (what's involved, problems encountered)
- Billing (tariffs, interconnectivity)
- Statistics (teledensity, average call time)
- Future developments

2 CELLULAR SYSTEMS

2.1 *Definition*

A cellular mobile communication system uses a large number of low power wireless transmitters to create cells. The cell is the basic geographic area of a cellular system. The use of variable power levels allow cells to be sized according to the density of users and demand within a particular region. These cells are designed in such ways that, as mobile users travel from one cell to another, their conversations are "handed over" between cells in order to maintain seamless service. Since cells cover but a small area, frequencies used in one cell can be made available to another cell some distance away for as long as they are far enough from each other to avoid interference. Thus, the capacity of the system is greatly increased through the reuse of the available frequency bandwidth.

2.2 *The Evolution of Mobile Telephone Systems*

Cellular telephony is one of the fastest growing and most demanding telecommunications applications. It represents a continuously increasing percentage of all new telephone subscriptions around the world. There are more than 700 million cellular subscribers worldwide. And cellular systems using the digital technology have become the universal means of telecommunications that some countries have more mobile phones than fixed phones. Nigeria is one of such countries.

The concept of cellular service is the use of a large number of low-power transmitters to create cells – the basic geographic service area of a cellular communication system. As mobile users travel from cell to cell, there conversations are "handed off" between cells in order to maintain a seamless service. Frequencies used in one cell can be reused in another cell some distance away within a larger geographic area. The idea of cell-based mobile radio systems appeared at Bell Laboratories (in USA) in the early 1970s. However, mobile cellular systems were not introduced for commercial use until the 1980s. During the early 1980s, analogue cellular telephone systems experienced a very rapid growth in Europe, particularly in Scandinavia and the United Kingdom.

2.3 Cellular System Architecture

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. Cellular systems make use of low power transmitters in order to enable the efficient reuse of the frequencies. In fact, if the transmitters used are very powerful, the frequencies can not be reused for hundreds of kilometres as they are limited to the covering area of the transmitter.

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. The whole number of radio channels available can then be used in each group of cells that form the covering area of an operator. Frequencies used in a cell will be reused several cells away. The distance between the cells using the same frequency must be sufficient to avoid interference. The frequency reuse will increase considerably the capacity in number of users.

In order to work properly, a cellular system must verify the following two main conditions:

- The power level of a transmitter within a single cell must be limited in order to reduce the interference with the transmitters of neighbouring cells. The interference will not produce any damage to the system if a distance of about 2.5 to 3 times the diameter of a cell is reserved between transmitters. The receiver filters must also be very efficient.

- Neighbouring cells can not share the same channels. In order to reduce the interference, the frequencies must be reused only within a certain pattern.

In order to exchange the information needed to maintain the communication links within the cellular network, several radio channels are reserved for the signalling information.

2.4 Cells

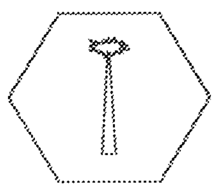

Fig. 2.0 A Hexagonal Representation Of A Cell

A cell is the basic geographic unit of a cellular system. The term *cellular* comes from the honeycomb appearance or cell-like structure of the areas in which a coverage region is divided. Cells are base stations transmitting over small geographical areas that are represented as hexagons. Each cell size varies depending on the landscape. Because of constraints imposed by natural terrain and man-made structures, the true shape of cells is not a perfect hexagon.

2.4.1 Types of cells

The density of population in a country is so varied that different types of cells are used:

- Macro cells
- Micro cells
- Selective cells
- Umbrella cells

2.4.1.1 Macro cells

The macro cells are large cells for remote and sparsely populated areas. They are mostly used in rural areas.

2.4.1.2 Micro cells

These cells are used for densely populated areas. These types are mostly found in large urban centres where the density of users is quite large. By splitting the existing areas into smaller cells, the number of channels available is increased as well as the capacity of the cells. The power level of the transmitters used in these cells is then decreased, reducing the possibility of interference between neighbouring cells.

2.4.1.3 Selective cells

It is not always useful to define a cell with a full coverage of 360 degrees. In some cases, cells with a particular shape and coverage are needed. These cells are called selective cells. Typical examples of selective cells are the cells that may be located at the entrances of tunnels where coverage of 360 degrees is not needed. In this case, a selective cell with coverage of 120 degrees is used.

2.4.1.4 Umbrella cells

A freeway crossing very small cells produces an important number of handovers among the different small neighbouring cells. In order to solve this problem, the concept of umbrella cells is introduced. An umbrella cell covers several micro cells. The power level inside an umbrella cell is increased comparing to the power levels used in the micro cells that form the umbrella cell. When the speed of the mobile is too high, the mobile is handed off to the umbrella cell. The mobile will then stay longer in the same cell (in this case the umbrella cell). This will reduce the number of handovers and the work of the network.

A too important number of handover demands and the propagation characteristics of a mobile can help to detect its high speed.

2.5 Clusters

The cells are grouped into clusters. No channels are reused within a cluster. The number of cells in a cluster must be determined so that the cluster can be repeated continuously within the covering area of an operator. 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 capacity of each cell will be therefore increased. However a balance must be found in order to avoid the interference that could occur between neighbouring clusters. This interference is produced by the small size of the clusters, which is defined by the number of cells per cluster. The total number of channels per cell depends on the number of available channels and the type of cluster used. Fig 2.1 illustrates a seven-cell cluster.

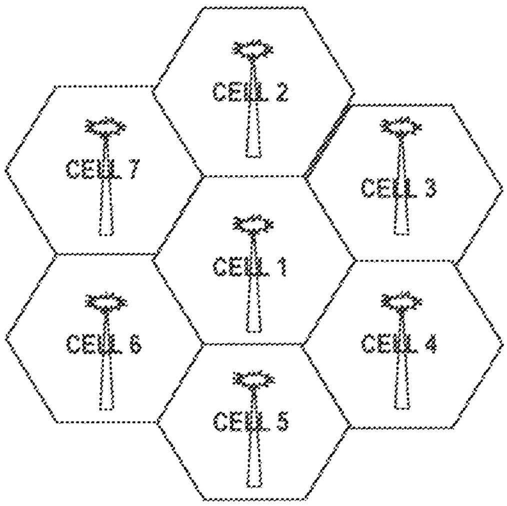

Fig 2.1 A Seven-Cell Cluster

2.6 Frequency Reuse

The concept of frequency reuse is based on assigning to each cell a set of radio channels that are completely different from that of neighbouring cells. The coverage area of cells is called the footprint. This footprint is limited by a boundary so that the same set of channels can be used in different cells that are far enough away from each other so that their frequencies do not interfere. Clusters facilitate the frequency reuse pattern when they are arranged in such a way that no two cells using the same set of frequencies share the same boundaries. Fig 2.2 below illustrates the use of clusters with seven cells to facilitate an effective frequency reuse arrangement. Cells with the same number have the same set of frequencies. Because the number of available set of frequencies is seven, the frequency reuse factor is 1/7. that is, each cell is using 1/7 of available cellular channels.

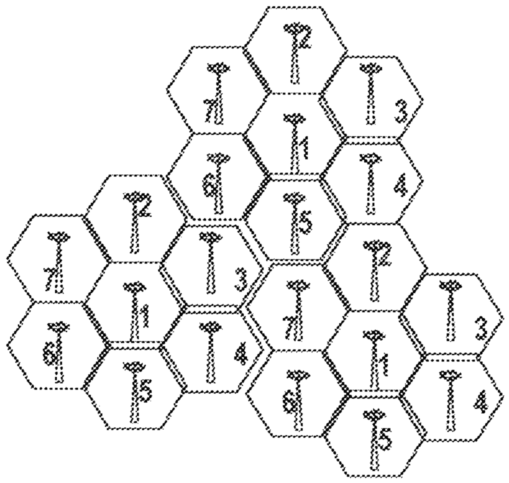

Fig. 2.3 A frequency reuse pattern based on a Seven-cell cluster arrangement.

2.7 Components of a Cellular System

The cellular system offers mobile and portable telephone stations the same service provided to fixed stations over conventional wired loops. It has the capacity to serve tens of thousands of subscribers in a major metropolitan area. The cellular communication system consists of the following components that work together to provide mobile services to subscribers.

- Public switched Telephone network (PSTN)

- Mobile telephone switching office (MTSO)

- Cell site with antenna system

➢ Mobile subscriber unit (MSU)

2.7.1 Public Switched Telephone Network (PSTN)

The PSTN is made up of local networks, the exchange area networks and the long-haul networks that interconnect telephones and other communication devices on a worldwide basis.

2.7.2 Mobile telephone switching office (MTSO)

The MTSO is the central office for mobile switching. It houses the mobile switching centre (MSC), field monitoring and relay stations for switching calls from cell sites to wire line central offices (PSTN). In analogue cellular networks, the MSC controls the system operation like calls, billing information, locations of cellular subscribers etc.

2.7.3 The Cell Site

The cell site refers to the physical location of radio equipment that provide coverage within a cell. Hardware located at a cell site include power sources, interface equipment, radio frequency transceivers and antenna systems.

2.7.4 Mobile Subscriber Unit

The mobile subscriber unit consist of a control unit and a transceiver that transmits and receives radio transmissions to and from a cell site. Three types of MSUs are available:

- The mobile telephone (used in cars, typical transmit power is 4.0 watts)

- The portable (typical transmit power is 0.6 watts)

- The transportable (typical transmit power is 1.6 watts)

The mobile telephone is installed in the trunk of a car and the handset is installed in a convenient location to the driver. Portable and transportable telephones are hand-held and can be used anywhere. The use of portable and transportable telephones is limited to the charge life of the internal battery.

2.8 The GSM Evolution

In the 1980s, most mobile cellular systems were based on analogue technology. As demand for mobile telephone services increased, service providers found that basic engineering assumptions borrowed from wire-line (landline) networks did not hold true in mobile systems. While the average landline phone call lasts at least ten minutes, mobile calls usually run ninety seconds. Engineers who expected to assign fifty or more mobile phones to the same radio channel found that by doing so they increased the probability that a user would not get dial tone -- this is known as call-blocking probability. As a consequence, the early systems quickly became saturated and the quality of service decreased rapidly. The critical problem was capacity.

The advantages of digital cellular technologies over analogue cellular networks include increased capacity and security. Technology options such as TDMA and CDMA offer more channels in the same analogue cellular bandwidth. These technologies have offered increased capacity and efficiency thereby allowing a greater number of simultaneous conversations per channel.

The GSM system can be considered as the first digital cellular system. It uses an advanced form of Time Division Multiple Access (TDMA) with a capacity of close to fifteen times that of analogue systems. The different reasons that explain the transition from analogue to digital technology are presented below.

2.8.1 The capacity of the system

As it is explained in above, cellular systems have experienced a very important growth. Analogue 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 analogue technologies proposed were able to overcome the problem to a certain degree but the costs were too important.

The digital system was, therefore, the best option to handle the capacity needs in a cost-effective way.

2.8.2 Compatibility with other systems such as ISDN

The decision of adopting a digital technology for GSM was made in the course of developing the standard. During the development of GSM, the telecommunications industry converted to digital methods. The ISDN network is an example of this evolution. In order to make GSM compatible with the services offered by ISDN, it was decide that the digital technology was the best option.

Additionally, a digital system allows, easily than an analogue one, the implementation of future improvements and the change of its own characteristics.

2.8.3 Aspects of quality

The quality of the service can be considerably improved using a digital technology rather than an analogue one. In fact, analogue systems pass the physical disturbances in radio transmission (such as fades, multipath reception, spurious signals or interferences) to the receiver. These disturbances decrease the quality of the communication because they produce effects such as fadeouts, crosstalk, hisses, etc. On the other hand, digital systems avoid these effects transforming the signal into bits. This transformation combined with other techniques, such as digital coding, improves the quality of the transmission. The improvement of digital systems comparing to analogue systems is more noticeable under difficult reception conditions than under good reception conditions.

2.8.4 Roaming

Roaming is defined as the ability for a cellular customer to automatically make & receive voice calls, send & receive data, or access other services when travelling outside the geographical coverage area of the home network, by means of using a visited network.

Roaming is technically supported by mobility management, authentication and billing procedures. Establishing roaming between network operators is based on Roaming Agreements.

If the visited network is in the same country as the home network, this is known as National Roaming. If the visited network is outside the home country, this is known as International or Global Roaming. If the visited network operates on a different technical standard than the home network, this is known as Inter-standard roaming.

GSM Roaming, which involves roaming between GSM networks, offers the convenience of a single number, a single bill and a single phone with world-wide access to over 190 countries. The convenience of GSM Roaming has been a key driver behind the global success of the GSM Platform.

GSM Coverage Map is a unique resource containing information supplied and approved by the members of the GSM Association.

Network, Services and Roaming information are continually updated to reflect the evolving situation world-wide. Interactive coverage maps, updated quarterly, allow you to navigate to see where exactly you can use your phone.

Today's second-generation GSM networks deliver high quality and secure mobile voice and data services (such as SMS/Text Messaging) with full roaming capabilities across the world.

3 THE GSM SYSTEM

3.1 History of GSM

In the beginnings of cellular systems, each country in Europe developed its own system, which was an undesirable situation for the following reasons:

- The equipment was limited to operate only within the boundaries of each country.
- The market for each mobile equipment was limited.

In order to overcome these problems, the Conference of European Posts and Telecommunications (CEPT) formed, in 1982, the ***Groupe Spécial Mobile (GSM)*** in order to develop a pan-European mobile cellular radio system. The GSM acronym later became the acronym for ***Global System for Mobile communications***. The standardized system had to meet certain criteria:

- Spectrum efficiency
- International roaming
- Low mobile and base stations costs
- Good subjective voice quality

- Compatibility with other systems such as ISDN (Integrated Services Digital Network)

- Ability to support new services

Unlike the existing cellular systems, which were developed using an analogue technology, the GSM system was developed using a purely digital technology.

In 1989 the responsibility for the GSM specifications passed from the CEPT to the European Telecommunications Standards Institute (ETSI). The aim of the GSM specifications is to describe the functionality and the interface for each component of the system, and to provide guidance on the design of the system. These specifications will then standardize the system in order to guarantee the proper inter-working between the different elements of the GSM system. In 1990, the phase I of the GSM specifications were published but the commercial use of GSM did not start until mid-1991. The developers of GSM chose the Narrow Band Time Division Multiple Access scheme (TDMA) which was yet to be proven at that time. They had faith the advancement in compression algorithms and digital signal processors would allow the fulfilment of the original criteria and the continual improvement of the system in terms of quality and cost.

The over 8000 pages of GSM recommendations provide functional and interface descriptions for each of the functional entities defined in the system.

The most important events in the development of the GSM system are presented in the table 1.

Year	Events
1982	CEPT establishes a GSM group in order to develop the standards for a pan-European cellular mobile system
1985	Adoption of a list of recommendations to be generated by the group
1986	Field tests were performed in order to test the different radio techniques proposed for the air interface
1987	TDMA is chosen as access method (in fact, it will be used with FDMA) Initial Memorandum of Understanding (MoU) signed by telecommunication operators (representing 12 countries)
1988	Validation of the GSM system
1989	The responsibility of the GSM specifications is passed to the ETSI
1990	Appearance of the phase 1 of the GSM specifications
1991	Commercial launch of the GSM service
1992	Enlargement of the countries that signed the GSM- MoU> Coverage of larger cities/airports
1993	Coverage of main roads GSM services start outside Europe
1995	Phase 2 of the GSM specifications Coverage of rural areas

Table 1: Events in the development of GSM

From the evolution of GSM, it is clear that GSM is not anymore only a European standard. GSM networks are operational or planned in over 170 countries around the world. The rapid and increasing acceptance of the GSM system is illustrated with the following figures:

➢ 1.3 million GSM subscribers worldwide in the beginning of 1994.

➢ Over 5 million GSM subscribers worldwide in the beginning of 1995.

➢ Over 10 million GSM subscribers only in Europe by December 1995.

Since the appearance of GSM, other digital mobile systems have been developed. The table 2 charts the different mobile cellular systems developed since the commercial launch of cellular systems.

Year	Mobile Cellular System
1981	Nordic Mobile Telephony (NMT), 450>
1983	American Mobile Phone System (AMPS)
1985	Total Access Communication System (TACS) Radio COM 2000 C-Netz
1986	Nordic Mobile Telephony (NMT), 900>
1991	Global System for Mobile communications> North American Digital Cellular (NADC)
1992	Digital Cellular System (DCS) 1800
1994	Personal Digital Cellular (PDC) or Japanese Digital Cellular (JDC)
1995	Personal Communications Systems (PCS) 1900- Canada>
1996	PCS-United States of America>

Table 2: Mobile cellular systems

3.2 Structure of the GSM network

The GSM network is divided into several funcional entities, whose functions and entities are specified. Fig. 3.1 shows the major components of a GSM Network. The GSM Network can be divided into three major parts:

- The mobile station (MS)
- The Base Station Subsystem (BSS)
- The Network Subsystem (NSS)

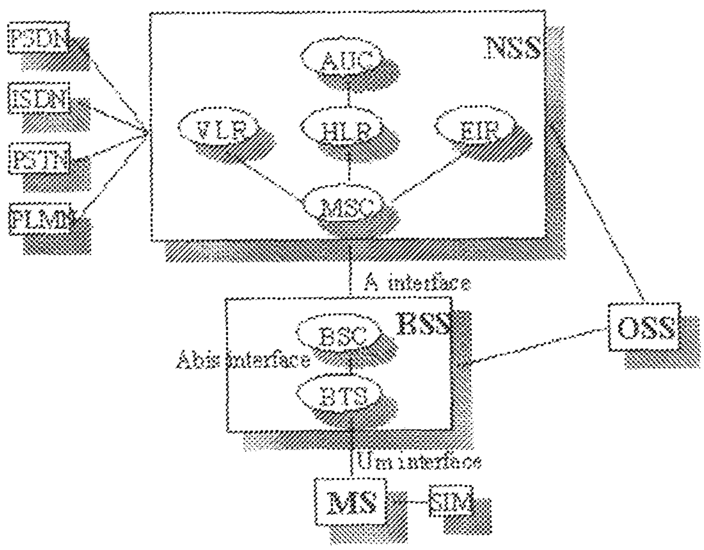

figure 3.1: Architecture of the GSM network

3.2.1 *Mobile Station*

The mobile station consists of the mobile equipment (the terminal) commonly known as the handset, and a smart card called the Subscriber Identity Module (SIM).

There are different types of terminals distinguished principally by their power and applications. Each terminal is identified by its unique International Mobile Equipment Identity number (IMEI). 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 handheld terminals have experienced the biggest success thanks to their 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.

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 personalises a terminal is the SIM card. Therefore, the user can have access to subscribed services in any terminal using his SIM card.

3.2.2 *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 and The Base Station Controller (BSC).

The BTS corresponds to the transceivers and antennas used in each cell of the network. A BTS is usually placed in the centre 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.

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.

3.2.3 *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.

3.2.3.1 *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 mobile cellular networks.

3.2.3.2 *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.

3.2.3.3 *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.

3.2.3.4 *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.

3.2.3.5 *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.

3.2.3.6 *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 unauthorised terminals (e.g., a terminal which does not respect the specifications concerning the output RF power).

3.2.3.7 *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.

3.2.4 *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.

3.3 *The geographical areas of the GSM network*

The figure 3.2 presents the different areas that form a GSM network.

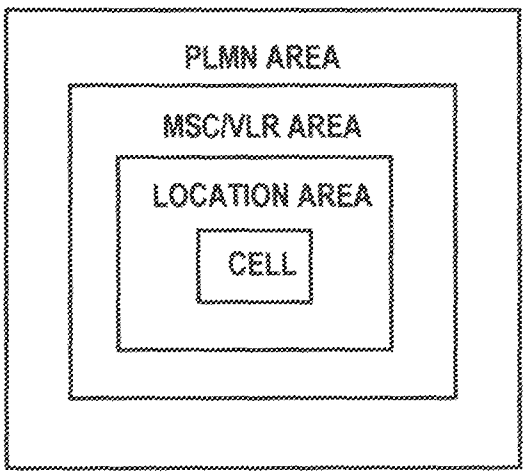

Figure 3.2: GSM network areas

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.

3.4 The GSM functions

In GSM, five main functions can be defined:

- Transmission.
- Radio Resources management (RR).
- Mobility Management (MM).
- Communication Management (CM).
- Operation, Administration and Maintenance (OAM).

3.4.1 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 transmission of signalling information.

Not all the components of the GSM network are strongly related with the transmission functions. The MS, the BTS and the BSC, among others, are deeply concerned with transmission. But other components, such as the registers HLR, VLR or EIR, are only concerned with the transmission for their signalling needs with other components of the GSM network.

3.4.2 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 elements that are mainly concerned with the RR function are the mobile station and the base station. However, as the RR function is also in charge of maintaining a connection even if the user moves from one cell to another, the MSC, in charge of handovers, is also concerned with the RR functions.

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, and Timing advance.

In this paragraph only the handover, which represents one of the most important responsibilities of the RR, is described.

3.4.2.1 Handover

The user movements can produce the need to change the channel or cell, especially when the quality of the communication is decreasing. This procedure of changing the resources is called handover. Four different types of handovers can be distinguished:

- Handover of channels in the same cell.
- Handover of cells controlled by the same BSC.
- Handover of cells belonging to the same MSC but controlled by different BSCs.
- Handover of cells controlled by different MSCs.

Handovers are mainly controlled by the MSC. However in order to avoid unnecessary signaling information, the first two types of handovers are managed by the concerned BSC (in this case, the MSC is only notified of the handover).

The mobile station is the active participant in this procedure. In order to perform the handover, the mobile station controls continuously its own signal strength and the signal strength of the neighbouring cells. The list of cells that must be monitored by the mobile station is given by the base station. The power measurements allow deciding which the best cell is in order to maintain the quality of the communication link. Two basic algorithms are used for the handover:

The `minimum acceptable performance' algorithm: When the quality of the transmission decreases (i.e. the signal is deteriorated), the power level of the mobile is increased. This is done until the increase of the power level has no effect on the quality of the signal. When this happens, a handover is performed.

The `power budget' algorithm: This algorithm performs a handover, instead of continuously increasing the power level, in order to obtain a good communication quality.

3.4.3 Mobility Management (MM)

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.

3.4.3.1 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 give detach procedure in order to tell the network that it is no longer connected.

3.4.3.2 Authentication and security

The authentication procedure involves the SIM card and the Authentication Centre. 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.

Another security procedure is to check the equipment identity. If the IMEI number of the mobile is authorised in the EIR, the mobile station is allowed to connect the network.

In order to assure user confidentiality, the user is registered with a Temporary Mobile Subscriber Identity (TMSI) after its first location update procedure.

3.4.4 Communication Management (CM)

The CM function is responsible for:

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

3.4.4.1 *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.

3.4.4.2 *Supplementary Services management*

The mobile station and the HLR are the only components of the GSM network involved with this function. The different Supplementary Services (SS) to which the users have access are presented below.

3.4.4.3 Short Message Services management

In order to support these services, a GSM network is in contact with a Short Message Service Centre 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).

3.4.5 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.

3.5 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.

3.5.1 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.

3.5.2 Multiple access schemes

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 scheme for GSM.

3.5.2.1 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.

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.

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.

3.5.2.2 Channel structure

A channel corresponds to the recurrence of one burst every frame. It is defined by its frequency and the position of its corresponding burst within a TDMA frame. In GSM there are two types of channels:

- The traffic channels used to transport speech and data information.
- The control channels used for network management messages and some channel maintenance tasks.

3.5.2.3 Traffic channels (TCH)

Full-rate traffic channels (TCH/F) are defined using a group of 26 TDMA frames called a 26-Multiframe. The 26-Multiframe lasts consequently 120 ms. In this 26-Multiframe structure, the traffic channels for the downlink and uplink are separated by 3 bursts. As a consequence, the mobiles will not need to transmit and receive at the same time which simplifies considerably the electronics of the system.

The frames that form the 26-Multiframe structure have different functions:

- 24 frames are reserved to traffic.
- 1 frame is used for the Slow Associated Control Channel (SACCH).
- The last frame is unused. This idle frame allows the mobile station to perform other functions, such as measuring the signal strength of neighbouring cells.

Half-rate traffic channels (TCH/H), which double the capacity of the system, are also grouped in a 26-Multiframe but the internal structure is different.

3.5.2.4 *Control channels*

According to their functions, four different classes of control channels are defined:

- Broadcast channels.
- Common control channels.
- Dedicated control channels.

- Associated control channels.

3.5.2.5 *Broadcast channels (BCH)*

The BCH channels are used, by the base station, to provide the mobile station with the sufficient information it needs to synchronise with the network. Three different types of BCHs can be distinguished:

- The Broadcast Control Channel (BCCH), which gives to the mobile station the parameters needed in order to identify and access the network

- The Synchronisation Channel (SCH), which gives to the mobile station the training sequence needed in order to demodulate the information transmitted by the base station

- The Frequency-Correction Channel (FCCH), which supplies the mobile station with the frequency reference of the system in order to synchronize it with the network.

3.5.2.6 *Common Control Channels (CCCH)*

The CCCH channels help to establish the calls from the mobile station or the network. Three different types of CCCH can be defined:

- The Paging Channel (PCH). It is used to alert the mobile station of an incoming cal

- The Random Access Channel (RACH), which is used by the mobile station to request access to the network

- The Access Grant Channel (AGCH). It is used, by the base station, to inform the mobile station about which channel it should use. This channel is the answer of a base station to a RACH from the mobile station

3.5.2.7 Dedicated Control Channels (DCCH)

The DCCH channels are used for message exchange between several mobiles or a mobile and the network. Two different types of DCCH can be defined:

- The Standalone Dedicated Control Channel (SDCCH), which is used in order to exchange signalling information in the downlink and uplink directions.

- The Slow Associated Control Channel (SACCH). It is used for channel maintenance and channel control.

3.5.2.8 *Associated Control Channels*

The Fast Associated Control Channels (FACCH) replace all or part of a traffic channel when urgent signaling information must be transmitted. The FACCH channels carry the same information as the SDCCH channels.

3.5.2.9 *Burst structure*

As it has been stated before, the burst is the unit in time of a TDMA system. Four different types of bursts can be distinguished in GSM:

- The frequency-correction burst is used on the FCCH. It has the same length as the normal burst but a different structure.
- The synchronization burst is used on the SCH. It has the same length as the normal burst but a different structure.
- The random access burst is used on the RACH and is shorter than the normal burst.
- The normal burst is used to carry speech or data information. It lasts approximately 0.577 ms and has a length of 156.25 bits. Its structure is presented in figure 3.

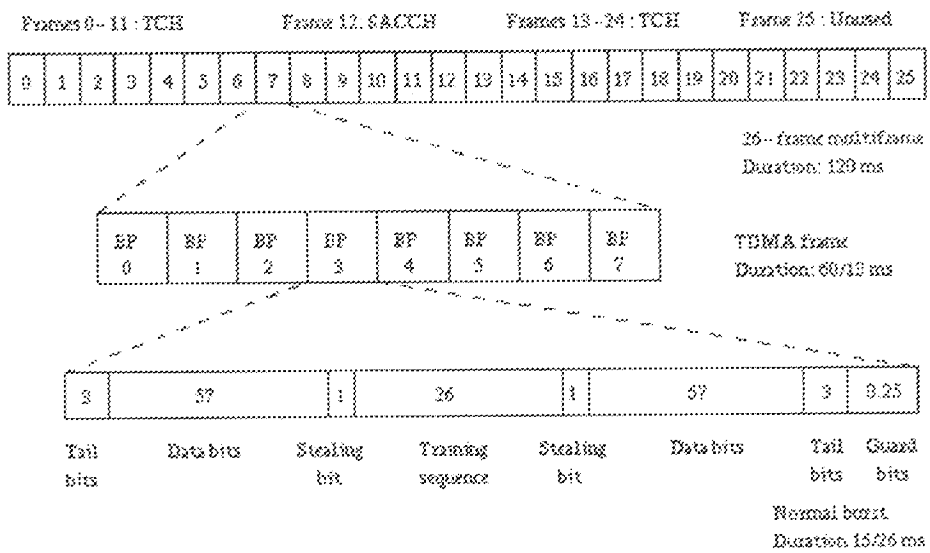

Figure 3.3: Structure of the 26-Multiframe, the TDMA frame and the normal burst

The tail bits (T) are a group of three bits set to zero and placed at the beginning and the end of a burst. They are used to cover the periods of ramping up and down of the mobile's power.

The coded data bits corresponds to two groups, of 57 bits each, containing signaling or user data.

The stealing flags (S) indicate, to the receiver, whether the information carried by a burst corresponds to traffic or signaling data.

The training sequence has a length of 26 bits. It is used to synchronize the receiver with the incoming information, avoiding then the negative effects produced by a multipath propagation.

The guard period (GP), with a length of 8.25 bits, is used to avoid a possible overlap of two mobiles during the ramping time.

3.5.2.10 Frequency hopping

The propagation conditions and therefore the multipath fading depend on the radio frequency. In order to avoid important differences in the quality of the channels, the slow frequency hopping is introduced. The slow frequency hopping changes the frequency with every TDMA frame. A fast frequency hopping changes the frequency many times per frame but it is not used in GSM. The frequency hopping also reduces the effects of co-channel interference.

There are different types of frequency hopping algorithms. The algorithm selected is sent through the Broadcast Control Channels.

Even if frequency hopping can be very useful for the system, a base station does not have to support it necessarily On the other hand, a mobile station has to accept frequency hopping when a base station decides to use it.

3.6 Converting source information to radio waves

The figure 3.5 presents the different operations that have to be performed in order to pass from the speech source to radio waves and vice versa.

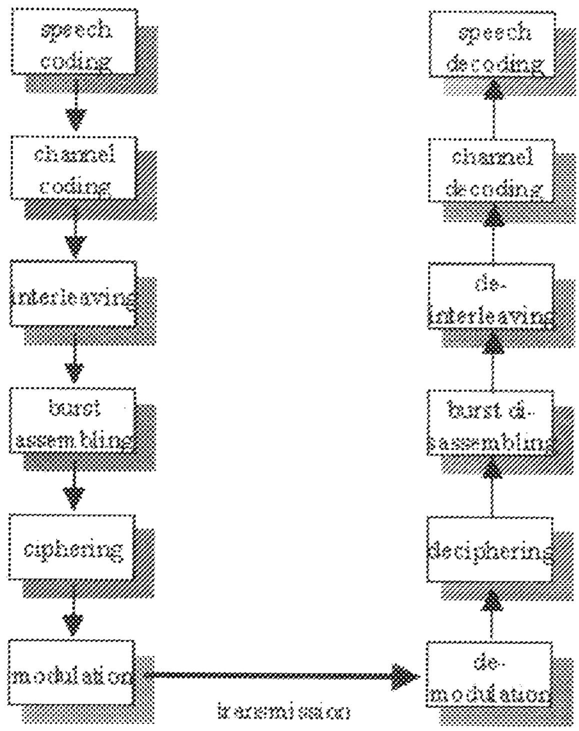

figure 3.5: From speech source to radio waves

If the source of information is data and not speech, the speech coding will not be performed.

3.6.1 Speech coding

The transmission of speech is, at the moment, the most important service of a mobile cellular system. The GSM speech codec, which will transform the analog signal (voice) into a digital representation, has to meet the following criteria:

- A good speech quality, at least as good as the one obtained with previous cellular systems.

- To reduce the redundancy in the sounds of the voice. This reduction is essential due to the limited capacity of transmission of a radio channel.

- The speech codec must not be very complex because complexity is equivalent to high costs.

The final choice for the GSM speech codec is a codec named RPE-LTP (Regular Pulse Excitation Long-Term Prediction). This codec uses the information from previous samples (this information does not change very quickly) in order to predict the current sample. The speech signal is divided into blocks of 20 ms. These blocks are then passed to the speech codec, which has a rate of 13 kbps, in order to obtain blocks of 260 bits.

3.6.2 Channel coding

Channel coding adds redundancy bits to the original information in order to detect and correct if possible, errors that occurred during the transmission.

3.6.3 Channel coding for the GSM data TCH channels

The channel coding is performed using two codes: a block code and a convolutional code.

The block code corresponds to the block code defined in the GSM Recommendations 05.03. The block code receives an input block of 240 bits and adds four zero tail bits at the end of the input block. The output of the block code is consequently a block of 244 bits.

A convolutional code adds redundancy bits in order to protect the information. A convolutional encoder contains memory. This property differentiates a convolutional code from a block code. A convolutional code can be defined by three variables: n, k and K. The value n corresponds to the number of bits at the output of the encoder, k to the number of bits at the input of the block and K to the memory of the encoder. The ratio, R, of the code is defined as follows: $R = k/n$. Let's consider a convolutional code with the following values: k is equal to 1, n to 2 and K to 5. This convolutional code uses then a rate of $R = 1/2$ and a delay of $K = 5$, which means that it will add a redundant bit for each input bit. The convolutional code uses 5 consecutive bits in order to compute the redundancy bit. As the convolutional code is a 1/2 rate convolutional code, a block of 488 bits is generated. These 488 bits are punctured in order to produce a block of 456 bits. Thirty two bits, obtained as follows, are not transmitted:

$$C(11 + 15j) \text{ for } j = 0, 1, \ldots, 31$$

The block of 456 bits produced by the convolutional code is then passed to the interleaver.

3.6.4 *Channel coding for the GSM speech channels*

Before applying the channel coding, the 260 bits of a GSM speech frame are divided in three different classes according to their function and importance. The most important class is the class

Ia containing 50 bits. Next in importance is the class Ib, which contains 132 bits. The least important is the class II, which contains the remaining 78 bits. The different classes are coded differently. First of all, the class Ia bits are block-coded. Three parity bits, used for error detection, are added to the 50 class Ia bits. The resultant 53 bits are added to the class Ib bits. Four zero bits are added to this block of 185 bits (50+3+132). A convolutional code, with r = 1/2 and K = 5, is then applied, obtaining an output block of 378 bits. The class II bits are added, without any protection, to the output block of the convolutional coder. An output block of 456 bits is finally obtained.

3.6.5 Channel coding for the GSM control channels

In GSM the signaling information is just contained in 184 bits. Forty parity bits, obtained using a fire code, and four zero bits are added to the 184 bits before applying the convolutional code (r = 1/2 and K = 5). The output of the convolutional code is then a block of 456 bits, which does not need to be punctured.

3.6.5.1 Interleaving

An interleaving rearranges a group of bits in a particular way. It is used in combination with FEC codes in order to improve the performance of the error correction mechanisms. The interleaving decreases the possibility of losing whole bursts during the transmission, by dispersing the errors. Being the errors less concentrated, it is then easier to correct them.

3.6.5.2 *Interleaving for the GSM control channels*

A burst in GSM transmits two blocks of 57 data bits each. Therefore the 456 bits corresponding to the output of the channel coder fit into four bursts (4*114 = 456). The 456 bits are divided into eight blocks of 57 bits. The first block of 57 bits contains the bit numbers (0, 8, 16, ...448), the second one the bit numbers (1, 9, 17, ...449), etc. The last block of 57 bits will then contain the bit numbers (7, 15, ...455). The first four blocks of 57 bits are placed in the even-numbered bits of four bursts. The other four blocks of 57 bits are placed in the odd-numbered bits of the same four bursts. Therefore the interleaving depth of the GSM interleaving for control channels is four and a new data block starts every four bursts. The interleaver for control channels is called a block rectangular interleaver.

3.6.5.3 *Interleaving for the GSM speech channels*

The block of 456 bits, obtained after the channel coding, is then divided in eight blocks of 57 bits in the same way as it is explained in the previous paragraph. But these eight blocks of 57 bits are distributed differently. The first four blocks of 57 bits are placed in the even-numbered bits of four consecutive bursts. The other four blocks of 57 bits are placed in the odd-numbered bits of the next four bursts. The interleaving depth of the GSM interleaving for speech channels is then eight. A new data block also starts every four bursts. The interleaver for speech channels is called a block diagonal interleaver.

3.6.5.4 *Interleaving for the GSM data TCH channels*

A particular interleaving scheme, with an interleaving depth equal to 22, is applied to the block of 456 bits obtained after the channel coding. The block is divided into 16 blocks of 24 bits each, 2 blocks of 18 bits each, 2 blocks of 12 bits each and 2 blocks of 6 bits each. It is spread over 22 bursts in the following way :

- The first and the twenty-second bursts carry one block of 6 bits each
- The second and the twenty-first bursts carry one block of 12 bits each
- The third and the twentieth bursts carry one block of 18 bits each
- From the fourth to the nineteenth burst, a block of 24 bits is placed in each burst

A burst will then carry information from five or six consecutive data blocks. The data blocks are said to be interleaved diagonally. A new data block starts every four bursts.

3.6.6 *Burst assembling*

The burst assembling procedure is in charge of grouping the bits into bursts. Section 3.5.2.9 presents the different bursts structures and describes in detail the structure of the normal burst.

Ciphering

Ciphering is used to protect signalling and user data. First of all, a ciphering key is computed using the algorithm A8 stored on the SIM card, the subscriber key and a random number delivered by the network (this random number is the same as the one used for the authentication procedure). Secondly, a 114 bit sequence is produced using the ciphering key, an algorithm called A5 and the burst numbers. This bit sequence is then XORed with the two 57 bit blocks of data included in a normal burst.

In order to decipher correctly, the receiver has to use the same algorithm A5 for the deciphering procedure.

3.6.7 Modulation

The modulation chosen for the GSM system is the Gaussian Minimum Shift Keying (GMSK).

The aim of this section is not to describe precisely the GMSK modulation as it is too long and it implies the presentation of too many mathematical concepts. Therefore, only brief aspects of the GMSK modulation are presented in this section.

The GMSK modulation has been chosen as a compromise between spectrum efficiency, complexity and low spurious radiations (that reduce the possibilities of adjacent channel interference). The GMSK modulation has a rate of 270 5/6 kbauds and a BT product equal to 0.3. Figure 5 presents the principle of a GMSK modulator.

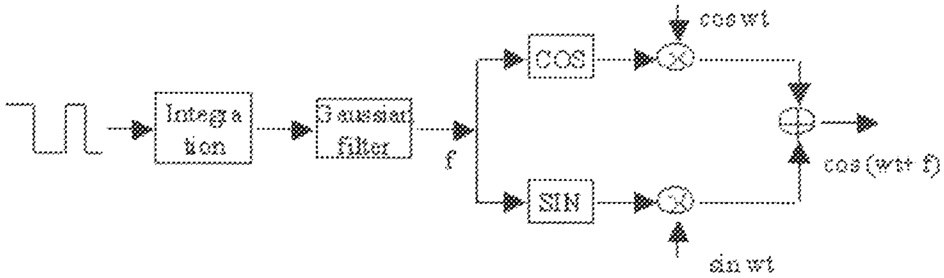

figure 3.4: GMSK modulator

3.6.8 Discontinuous Transmission (DTX)

This is another aspect of GSM that could have been included as one of the requirements of the GSM speech codec. The function of the DTX is to suspend the radio transmission during the silence periods. This can become quite interesting if we take into consideration the fact that a person speaks less than 40 or 50 percent during a conversation. The DTX helps then to reduce interference between different cells and to increase the capacity of the system. It also extends the life of a mobile's battery. The DTX function is performed thanks to two main features:

- The Voice Activity Detection (VAD), which has to determine whether the sound represents speech or noise, even if the background noise is very important. If the voice signal is considered as noise, the transmitter is turned off producing then, an unpleasant effect called clipping.

- The comfort noise. An inconvenient of the DTX function is that when the signal is considered as noise, the transmitter is turned off and therefore, a total silence is heard at the receiver. This can be very annoying to the user at the reception because it seems that

- 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 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.

4 GSM NIGERIA

4.1 INTRODUCTION

On August 8, 2001, there was much fanfare in Nigeria with the launch of the much-awaited 2G GSM cellular telephone service. Of three companies finally licensed earlier in January to provide the service, Zimbabwe-based ECONET Wireless was the first to come on board, beating by 24 hours the August 9 deadline set by Nigeria's telecommunications regulator, the National Communications Commission, NCC. The next day, the other licensee, South Africa's MTN, also launched its services. The third, the local incumbent, Nigerian Telecommunications Plc., NITEL, followed suit a day later. A few hours after the launch of the first service, when tariffs for the service were announced, hope turned into despair. Newspapers next day carried howling headlines: THE GSM TARIFF RIP-OFF; GSM NOT FOR THE POOR, etc. Even the Nigerian president showed concern, and asked for a review. However, having paid the sizeable sum of $285 million for a license, MTN, ECONET and NITEL had every reason to keep mute.

The tariffs so announced were that a Nigerian GSM cell phone subscriber would need about ₦70,000 to participate in cellular telephony, including about N50,000 for line activation and a monthly rental of about N3,000. Call charges of about N50 per minute for local calls plus VAT were also announced. Following the uproar over the tariffs, ECONET was to later marginally lower its tariffs from N50 per minute to N40 for peak periods, instead of its earlier advertised ₦ 24, for off-peak. Despite calls for further review in the tariffs, including from the president, the National Assembly and the nation's influential traditional leaders, the NCC Chief Executive, Ernest Ndukwe, said with a sense of resignation that there was little or nothing that his agency could do about the tariffs released by the operators. His only response was to hope that competition would drive down prices in due course. NITEL, the incumbent operator which runs the existing fixed lines, also reviewed upwards the tariffs for its services, up to one hundred percent in some cases. The media, which had raised the hopes of Nigerians so high on GSM, could only lament that what a one-time Nigerian communications minister (now a senator in the National Assembly) had said in the mid-1980s had come true: that telephones were not meant for the poor.

4.2 BACKGROUND ON TELECOMMUNICATIONS IN NIGERIA

The early telecommunications infrastructure in Nigeria was geared towards serving the colonial administration and economy. At Nigeria's independence in 1960 there were only 18,724 telephone lines for an estimated population of 45 million, giving a teledensity of 0.04 telephones per 100 people. Over the years, additional telephone lines were brought in, but the country's rapid population increase and other factors, such as fraud and inefficiency, cancelled any improvement in the teledensity. According to the International Telecommunication Union (ITU), by 1996, Nigeria's teledensity was a mere 0.36. It rose slightly to 0.4 by 1999, according to the NCC. Nigeria's teledensity is a far cry from the African average of 1.67 (ITU). Even the NCC admits that Nigeria has had a very limited telephone network for many years, and the waiting list is estimated at over ten million people who have applied to the incumbent network, NITEL (established in 1985) for services. NITEL had established a subsidiary, Mobile Telecommunications, or M-Tel, which is responsible for the analogue cellular service. Today, M-Tel is in charge of Nitel's GSM Network.

4.3 *THE FIXED ENVIRONMENT*

According to NITEL, there is a national network capacity of 700,000 fixed telephone lines in Nigeria and more than 400,000 are connected. The NCC, which is responsible for the regulation and restructuring of the telecommunications sector, falling under the Ministry of Communications, had in the middle of 1999, approved about 200 operating licenses for private providers of various telecommunications services across the country. This generated a lot of activities in the sector like demand for telecommunications equipment, accessories, consultancy and technical partnerships.

However, the civilian administration which took over from the military in May 1999 promptly cancelled the licences. In the following July, the new president announced plans to privatise NITEL, and authorised the NCC to issue yet another set of new licences, which it did. NITEL also approved eight private firms to be connected to its switching system in order to provide services to different Nigerian geo-political zones. Also in 1999, NITEL set up a packet switched X.25 service via Telkom SA's VSAT-based SpaceStream service to South Africa to link Nigeria's major cities for data communications. Most of Nigeria's telephone system is still analogue as only the major cities and university towns have become digital. Since 1986, the German company Siemens was given the contract to digitise the country's telecoms system in phases: a lot of the work is still ongoing.

Installing a fixed telephone line in Nigeria is no easy matter. In 1998, a line may cost over N100, 000, and could take several months and cumbersome paperwork. However, the new government has greatly reduced the official cost of applying for a new line; NITEL officially charges N9, 000.00 for a new land line. However, what this obtained was a new wave of applications for services, thus compounding the already miles-long waiting line. To compensate for its dismal performance in the residential sector, NITEL has for long been operating a payphone system.

Soon after NITEL's inception in 1985, ITT was contracted to supply and install payphone kiosks all over the country. This coincided with a downturn of events in the Nigerian economy, and the coin-boxes became easy prey for vandals. Therefore, due to vandalisation in the coin-operated system, it was soon withdrawn from service. Much later, the technologically more advanced card phone system was brought in. But due to the large population, the number of cards to satisfy demand would be enormous, and they were not forthcoming. This gave room for 'card vendors' who took advantage of the opportunity to do brisk business, charging for the use of their cards sometimes more than double the NITEL charge. And since the cards are usually too expensive for the common citizens, many had no choice but to use the services of the vendors.

Major African projects in which Nigeria is participating include the ECOWAS Telecommunications Project and the AT&T AfricaOne submarine cable project. Modern sectors of the Nigerian economy, typified by oil and banking are looking forward to changes in the telecoms sector.

4.4 THE GSM ENTRY

The Nigerian government has set out to achieve an essential goal through privatisation. It set up a National Council on Privatisation with the Vice President as chairman. The former Technical Committee on Privatisation and Commercialisation, TCPC, which had been set up by the military, was renamed the Bureau for Public Enterprises, BPE, and charged with the technical aspects of the privatisation programme. Other influencing quarters include the considerable Nigerian emigrants, who may want to invest at home. And also may want a more efficient telecoms service to contact relatives and friends. The substantial oil and banking industries are also keen.

To pave the way for the GSM licensing and other restructuring processes, the NCC had held conferences to fashion out modalities for a new telecoms policy and the liberalisation and privatisation regime. At a 1999 conference, experts suggested ways to achieving these ends. Many believe that deregulation has the advantage of bringing in new money, high penetration of telephone density and also bringing competition to the industry. Nevertheless, deregulation and privatisation should be approached with caution and necessary steps must be taken before divesting government assets.

Nigeria joined the world's digital cellular network in January 2001. The competing operators in Nigeria were selected through a public auction, which began on January 17 and ended on January 19, 2001. Four firms successfully concluded the auction but only three met the mandatory deadline for payment of the license fee of USD285 million each. The successful firms were Econet Wireless, originally from Zimbabwe, MTN owned by a South African company, and NITEL, the Nigerian government owned telecommunications parastatal. Communication Investments Limited (CIL), the only indigenous firm at the time, was eased out of the race by the NCC after allegedly failing to meet up with the deadline for payment of the balance of the license fee by midnight of February 9 2001. The race started in earnest between the two digital mobile licensed operators – ECONET and MTN. Econet Wireless launched its services on August 6, followed by MTN on August 8. NITEL took off the next day August 9. The mobile networks in Nigeria operate in the GSM900 MHz and GSM 1800 MHz frequencies.

..11 Discontinuous reception

It is a method used to conserve the mobile station's power. The paging channel is divided into sub channels corresponding to single mobile stations. Each mobile station will then only 'listen' to its sub channel and will stay in the sleep mode during the other sub channels of the paging channel.

3.6.12 Multipath and equalisation

At the GSM frequency bands, radio waves reflect from buildings, cars, hills, etc. So not only the 'right' signal (the output signal of the emitter) is received by an antenna, but also many reflected signals, which corrupt the information, with different phases.

An equalizer is in charge of extracting the 'right' signal from the received signal. It estimates the channel impulse response of the GSM system and then constructs an inverse filter. The receiver knows which training sequence it must wait for. The equalizer will then, comparing the received training sequence with the training sequence it was expecting, compute the coefficients of the channel impulse response. In order to extract the 'right' signal, the received signal is passed through the inverse filter.

Nigeria is pursuing an ambitious telecommunications expansion program expected to improve the national teledensity that was at 0.4 percent before the advent of GSM. Nigeria intends to increase its fixed wire lines from 800,000 to over 4 million within the next 2 years. 20 percent of these lines are expected to be installed in rural communities in compliance with ITU and the Nigerian government directives on universal access obligation.

The Nigerian government has said that it is committed to installing about 2 million mainlines and 1.2 million digital mobile lines before the end of 2002. Within this time frame, a second network career will be licensed to compete with NITEL. Nigeria has reviewed its telecommunications policy first published in October 1999 and has issued operating licenses to several private operators in the 350 MHz frequency range for zonal, regional and/or community telephony. A second national carrier, Globacom, was also licensed. Globacom has long started work on installation of equipment, erecting transmission masts and laying of transmission cables. As at August 2003, its services have not started yet despite the fact that it promised to start transmission by March, 2003.

4.5 THE GSM OPERATORS IN NIGERIA

The active operators in Nigeria are:

- MTN
- ECONET WIRELESS
- NITEL GSM
- GLOBACOM (Yet to launch)

The above-mentioned GSM operators have reached several stages in the execution of their duties as GSM service providers. MTN, Econet wireless and Nitel have since started operation and have been operational ever since despite periods of hitches and sometimes total shutdown. The incumbent network Nitel has the least number of lines and so far, its services have been described by many subscribers as grossly inefficient. The contract to increase the number of lines has been awarded and the public is still waiting for results. So far, Nitel's tariffs are the cheapest available followed by Econet and then MTN. Together, these three networks give a combined subscriber base of 2 million placing the teledensity of GSM phones only at about 1.6%. Combining this with the number of landlines and fixed wireless lines would give a combined teledensity of over 2.0%. This is a remarkable growth from a teledensity of a mere 0.4% in 1999. There's still a long way to go if Nigeria is to achieve the ITU recommended teledensity of 25%.

In terms of subscriber base, MTN has the highest with about 1.2 million subscribers as at August 2003. The extent of coverage achieved by MTN is quite remarkable given that it has exceeded its set target. On this note, MTN was described more vividly compared to the other networks. The general outlook is believed to be what is obtainable in the other networks. Many aspects of their operations are quite similar since they are all following the same specifications. Differences lie in modes of operations and publicity techniques. Nitel GSM, being an incumbent network is worthy of mention. This was done in order to give a picture of how things were and possibly how things would have been should Nitel be allowed to operate alone. The benefits of privatisation are clearly seen in this scenario and based on this observation, the role of private owned networks can best be appreciated.

Econet wireless and Globacom are briefly mentioned. A description of their networks as given by the GSM association is given. As at August 2003, Globacom has not started commercial operations yet although test transmissions have been carried out.

4.5.1 MTN NIGERIA

4.5.1.1 Background

MTN is a South African cellular network operator and is listed on the Johannesburg Stock Exchange under the umbrella of the M-Cell Group. Launched in 1994, MTN now has over five million subscribers. License awarded in 1993, MTN owns service provider M-Tel and has interests in I-Talk Cellular, Leaf Wireless and New Bucks Holdings.

MTN Nigeria Communications Limited is part of the MTN Group. Incorporated in Nigeria on November 8, 2000 as a private company, it secured a license to operate GSM telephony on February 9, 2001, from the Nigerian Communications Commission. MTN's GSM network is one of the largest in the world. It has approximately 4000 sites covering 19 200km of road, 900 000km^2 of land and providing access to 94.5% of South Africa's population.

On May 16 2001, MTN emerged as the first to make a call on its GSM network in the new dispensation in Nigeria. Thereafter, the company launched full commercial operations beginning with Lagos, Abuja and Port Harcourt.

MTN's products and services are available at its Friendship Centres and a nation-wide network of dealerships, banks and convenience channels including eateries, petrol stations and neighbourhood stores.

MTN leads the industry with service availability such as Pay As You Go (the pre-paid package), businessTime (post-paid or contract package), Booster Card, as well as an array of value added services that include Short Message Service, SMS, International Roaming, Wireless Application Protocol, WAP, MTN Funtones, MTN Directory Enquiries and Remote Interactive Voice Response, RIVR.

The company currently has a total of 14 mobile switching centres covering 35 cities with about 500 base stations. It has a subscriber base of about 1.2 million followed by Econet wireless, which has about 800,000 lines as at August 2003. This places MTN in the leading position in terms of coverage and subscriber base.

In January 2003, MTN celebrated the completion of a nation-wide microwave radio transmission backbone known as the "Y'Hello Bahn". The 'MTN Y'helloBahn', was constructed through an investment of US$120 million by MTN and can enable up to 1,900 voice calls at the same time. Nigerian President, Olusegun Obasanjo, formally commissioned the completion of the project in Lokoja, Kogi State.

MTN Nigeria's microwave backbone spans 3,400 kilometres, from Kano in northern Nigeria southwards, branching off towards the east and west respectively at Lokoja. In all, it traverses over 120 Nigerian towns and villages and many communities will have access to global information and

3.7 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.

3.7.1 *Teleservices*

- Telephony (E1® Eh).
- Facsimile 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. Through this service, the subscriber can receive fax messages at any fax machine.
- Voice mail. This service corresponds to an answering machine.

3.7.2 *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).

3.7.3 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) technology for the first time. In addition, the backbone will enable MTN Nigeria to provide coverage on a growing number of highways in Nigeria. Before the completion of this microwave link, MTN was using satellite links to interconnect most Nigerian cities. This was undesirable especially due to the long transmission delay associated with satellite transmissions.

MTN Nigeria is 77.6% owned by Mobile Telephone Networks International Limited, with the balance of 22.4% shareholding residing in the hands of Nigerian partners.

4.5.1.2 Network Description

MTN Nigeria Communications Limited - Network Information

Operator Name	➢	MTN Nigeria Communications Limited
Network Name	➢	MTN Nigeria
Network Type	➢	GSM 900/1800
Handset Code	➢	MTN-NG
Network Code	➢	621 30
Network Status	➢	Live August 2001

4.5.1.3 Products and Services

An **MTN starter pack** contains the items needed to establish a connection to the network except for a mobile handset which is optional. The following items are contained in a starter pack:

- A SIM card
- A Service Guide

- N500.00 worth of calls + 5 days access

A new subscriber pays a prescribed amount to get a starter pack, which contains the SIM, he loads this into his phone to gain access to the MTN network. There are bumper packages that come with cellphones so the customer doesn't bother about getting a mobile station.

4.5.1.3.1 Pay as you go

This is the easiest and fastest way to enjoy the benefits of cellular communication. It is suitable for customers who do not wish to enter into a contract or lay down deposits but want access to telecommunication services instantly. It's a versatile cellular package that gives the customer freedom of choice and freedom of movement. It offers immediate access to the MTN GSM network through an "All-in-one" access and airtime card. With a SIM card already loaded in the phone, Pay as you Go enables the subscriber to pay for his calls before making the calls. That way, the customer is in control of his call costs.

Loading a 12 digit secret code that is scratched off an all-in-one access card offers a means of paying for calls. The value of the loaded card is credited to the subscribers account and the subscriber can then make calls to the tune of the credited amount. Such cards are available from MTN friendship centres and authorised dealers. Fraudulent attempts to load a phone with false codes are prevented by blocking any user that makes three unsuccessful attempts. The mathematical chances of success in such an attempt are quite slim - 1: 10^{12}

MTN also offers a range of cellphones that includes world-famous brands such as Nokia, Ericsson, Alcatel, Motorola and Siemens. Buying an MTN cellphone gives the customer a full Manufacturers Warranty and Technical Warranty. If a fault develops during the warranty period, MTN takes responsibility for repairs or replacement of the phone. Repairs are carried out at the MTN Service Centre.

The MTN Booster Card is an additional option for the heavy user. This card provides a reduction of up to 50% on calls made for a period of 30 consecutive uninterrupted days from the time that the card is loaded on to the cellphone.

All-in-one-Card	Call Value	Access Period
N 1, 500	**N 1, 500**	15 days
N 3, 000	**N 3, 000**	30days
N 6, 000	**N 6, 000**	60days

* Access Period - means the number of days one can receive unlimited incoming calls.

Tariffs (N)

Pay as you GO		**With Boostercard**
Monthly Access	0	4,000
***Peak Rate**		
MTN to MTN	50	25
MTN to Other Networks	50	25
****Off Peak Rate**	40	20
*****Low Cost Rate**	30	15

Monday - Friday

Peak Period	-	07hrs:00 - 18hrs:59:59
Off Peak Period	-	19hrs:00:00 - 23hrs:59:59, 04hrs:00:00 - 06hrs:59:59
Low Cost Period	-	00hrs:00:00 - 03hrs:59:59

Off Peak Rates are applicable all day Saturday, Sunday and Public Holidays.

International Rates

Country		**With Boostercard**
Africa **Zone 1:** Zimbabwe, Zambia, Botswana, Malawi, Angola, Namibia, Dem Republic of Madagascar, South Africa, Swaziland, Kingdom of Lesotho, Mozambique	N100	N100
Zone 2 Algeria, Libya, Ghana, Gambia, Liberia, People's Rep. of Guinea, Egypt, Morocco, Benin, Cote d'Ivoire, Senegal, Mali, Sierra Leone, Mauritania, Guinea Bissau, Togo	N120	N120
Zone 3 Rest of Africa	150	150
Europe	115	115
Asia, North America	120	120
Middle East	130	130
South America	160	160
Inmrasat A	310	310
Inmrasat B	480	480

All calls are calculated and charged in units of 60 seconds for the first and subsequent minutes. In the event that the subscriber uses any part of a unit the subscriber shall be liable for the full charge in respect of that unit.

All prices and charges set out are inclusive of VAT.

4.5.1.3.2 Business Time

This is designed to offer the customer the cost saving benefit of low tariffs and the convenience of paying for calls at the end of every month. An itemized bill is sent each month, this allows for paying the monthly cellphone bill in arrears. Subscribers who stay on the businessTIME tariff plan for 12 consecutive months, will receive N6, 000 bonus airtime credited to their account.

To be a businessTIME subscriber, you will be required to complete an MTN Nigeria subscriber agreement. Once approved, this agreement is binding for a minimum period of 30 days, after which it will remain in place until you choose to cancel it by giving MTN 30 days notice. Together with your subscriber agreement, a one-off, refundable security deposit will be required.

The itemised monthly bill shows the numbers called the call duration and the call costs. Once the subscriber agreement is approved, the subscriber obtains a pack, which contains the SIM card and a service guide. The subscriber is given a chance to choose his own number known as the "Golden Number".

Tariffs

Business Time (TM)	
Monthly Access	N3,000
***Peak Rate**	
MTN to MTN	N24
MTN to Others	N29
****Off Peak Rate**	N20
*****Low Cost Rate**	N15
All SMS	N15

International call rates same as in Pay as you Go.

4.5.1.3.3 MTN proTIME

This is a contract package with a low access fee compared to businessTIME and a low tariff plan compared to Pay as You Go (PAYG). MTN proTIME customers have the opportunity of paying just **N1500** monthly access fee and **N33** at peak time for MTN to MTN calls.

Protime offers benefits of conversion from pay as you go without changing numbers or SIM, a credit limit facility and a dial in account balance check facility are also in place. This package is quite convenient, as there is no need to load an all-in-one scratch card.

Activation Requirements

The following activation requirements are necessary for subscribers who wish to take on this package.

- A form of identification, which could be a driver's license or International passport.
- Completion of a subscriber agreement form.
- Payment of the cost of the starter pack =N= 6, 490.00
- Payment of monthly access fee of =N=1,500.00
- Payment of security deposit of =N= 10,000.00

The completed forms are to be returned to the friendship centers, forms filled at the dealer outlets are also to be returned to the Friendship centers. Once the above requirements are met, the system would automatically allocate a randomly generated MSISDN to the **ProTime** SIM after verifying if the above amounts have been paid (Unless a Golden Number has been specified). Activation of **ProTime** SIMs would ONLY be done at the Friendship centers.

Any subscriber currently on MTN Pay as You Go that wishes to migrate to the MTN Protime package may do so provided the following criteria are met.

- A form of identification, which could be a driver's license or International passport.

* Completion of a migration form and handing in such at any Friendship center or dealer outlet. In the form, the subscriber would be required to write his/her current MSISDN and SIM number in the form.

* Payment of monthly access fee of =N=1,500.00

* Payment of security deposit of =N= 10,000.00

The subscriber would be automatically migrated after 48 hours.

Tariffs

ProTime (TM)		
Monthly Access		N1,500
***Peak Rate**		
MTN to MTN		N33
MTN to Others		N38
****Off Peak Rate**		N28
*****Low Cost Rate**		N20
All SMS		N15

4.5.1.3.4 ***MTN*** flexi

This is a pre-paid service with a tariff that decreases the more calls are made. The more calls are made within a month, the cheaper the call charges become.

It starts at N50 and can go as low as N30 depending on the amount of talk time. This means the more you talk, the less you pay.

MTN helps you ensure that your total call costs don't exceed the customer's personal budget. So, you buy the amount of call credit and access time you want and pay for it, before you make calls.

MTN ***pay as you Go*** or MTN ***boostercard*** subscriber can change to MTN ***flexi*** by dialing *517# and they will be automatically moved to MTN ***flexi***. Their airtime value and access time will be transferred immediately to MTN ***flexi***.

Tariffs

Calls made in Nigeria to all operators and selected Value Added Services. (ALL HOURS)

Level 1: 0 - 45 min	N50
Level 2: 46 - 120 mins	N40
Level 3: 121 - 240 mins	N35
Level 4: 241 mins and above	N30

SMS	
SMS (160 characters)	N15
Forwarding / Sending a ringtone	Up to N45
Forwarding / Sending a picture message	Up to N60
Customer Services	
All calls	N6
Voicemail, Using: 100, 111, 110, 120, 130 or 555 load-a-card	
All calls	Free
556 balance update	
All calls	N6
***556# OK balance update**	
All calls	Free
Tariff switch (to Standard *518# OK and/or flexi *517# OK)	
N300 for each change. (See below for details)	

	Option 1	Option 2	Option 3
Prepaid Option	***pay as you GO***	***boostercard***	***flexi***
Call costs	Peak: N50 Off Peak: N40 Low cost: N30	Peak: N25 Off Peak: N20 Low cost: N15	0-45mins: N50 46-120mins: N40 121-240mins : N35 240+mins: N30 All customers start at "N50" at the beginning of each month.
SMS	N15	N15	N15
How to switch to this option:	Call *518# OK (Each change: N300)	Load a ***boostercard***, cost: N4000 Lasts 30 days then another ***boostercard*** needs to be loaded or you shall be moved back to the MTN ***pay as you GO*** Option, automatically.	Dial: *517# OK (Each change: N300

4.5.1.3.5 MTN's Messenger

This is another contract package like business time. It offers a cost effective SMS tariff plan that caters for the needs of corporations and organisations using Short Message Service (SMS) based applications or customers using a high volume of text messages. Text messages are charged N8 per message at all times and all other conditions are the same as the business time package.

4.5.1.3.6 Value Added Services

MTN offers a wide range of value added services. Apart from making Voice Calls, you can do more. Below are some of the services.

- Voicemail
- Call Barring & Forwarding
- Call Waiting
- Call Line Identification
- Enhanced Voicemail
- Short Messages (SMS)
- Faxmail
- Internet
- International Roaming
- Closed User Groups
- Customer Services
- Emergency Services

4.5.1.4 Problems

The MTN network has performed quite remarkably as is evident from a comparison of the three GSM operators currently operating in Nigeria. Nevertheless, the users can best judge the quality of a telephone network whether or not it is a subjective judgement. The various complaints that come from subscribers are enumerated below:

- Calls get dropped while you are still speaking and MTN bills you.

- A call gets connected but the called party does not hear the caller. The caller gets billed.

- Difficulties in loading an all-in-one card due to network failures.

- Prolonged delay in transmission of text messages sometimes for days.

- Apparent free SMS that get billed later on.

- Difficulty in getting connected due to congestion.

4.5.2 NITEL GSM

4.5.2.1 Background

The mobile unit of Nigeria's incumbent network is Nitel GSM. It started transmission on the 9th of August 2001 and since then its performance has been described by many as highly epileptic. When the first anniversary of GSM was celebrated in August last year, Nitel GSM had 10,000 subscribers. During the celebration period, it was in the process of selling 100,000 lines. After selling off those lines, NITEL stopped rolling out lines. As at August 2003, Nitel was operating 118,000 lines.

One of the problems NITEL faced was that of interconnectivity. Nitel had difficulties in reaching an agreement with the other two GSM operators on tariffs. Econet wireless and MTN are demanding N18 per for all the calls they terminate. Nitel charges N21 per minute for Nitel to Nitel calls. Paying N18 out of N21 would spell loss for Nitel. The interconnectivity problem became a highly discussed problem but so far, nothing much has been done. The Nigerian Communications Commission (NCC) has tried to resolve the matter but failed.

After the failure of the attempt to sell-off Nitel to private investors, the Government gave the contract for the management of Nitel to Pentascope International. This gesture was done to put things in order before attempting to sell it again. Pentascope International is a privately owned telecommunications company that is based in Netherlands. Pentascope will be paid 4 million US dollars per year. They have supplied 3 key officers each to Nitel and Nitel GSM: CEO, Chief Finance Officer (CFO) and Chief Technical Officer (CTO). The company took over in March 2003 - amid strikes by the Nitel workers who have been against the privatisation process - and has since started work.

In March 2003, the Government awarded the contract for the expansion of Nitel by 1.2 million lines to three telecoms companies. The companies are LM Ericsson (Sweden), Motorola (USA) and ZTE (China). The contract was awarded at a total of 155 million USD.

The job was expected to be completed in 3 months, but the target has not been met three months later. The Chinese Company involved in the project was delayed by the SARS outbreak in Asia that prevented the Engineers from coming over to Nigeria. The other companies are being delayed by the Government's inability to pay them on time.

Between August 2002 and August 2003, the number of subscriptions grew from 10,000 to 118,000 and has remained so for the past 11 months. The number of cities covered grew from 4 to 13 and SMS was added into Nitel GSM's services.

In April 2003, the Nigerian Government split Nitel into two and Nitel GSM became a separate Company. It reverted to its old name of Nigerian Mobile-Telecommunications Ltd: M-TEL. M-TEL was initially in charge of Nitel's analogue cellular telecommunications.

4.5.2.2 Network Description

Operator Name	➢	Nigerian Telecommunications Limited (NITEL)
Network Name	➢	NITEL GSM
Network Type	➢	GSM 900/1800
Handset Code	➢	
Network Code	➢	621 40
Network Status	➢	Live October 2001

4.5.2.3 Problems

- NITEL is still not fully interconnected to Econet Wireless and MTN, and so Nitel GSM subscribers can't talk to a combined base of 2 million GSM subscribers.

- While it paid 1.7 billion Naira (12.5 million USD) to Econet Wireless and MTN for calls they terminated, Nitel GSM could not bill them back for the calls it terminated. The reason given was that Nitel GSM's equipment could not give accurate call data records.

- Nitel GSM being a government owned parastatal is heavily bound by the tenets of bureaucracy which, given the state of the nation, is a strong hindrance to efficient performance.

4.5.3 ECONET WIRELESS

4.5.3.1 Network Description

Operator Name	➢	Econet Wireless Nigeria Ltd
Network Name	➢	Econet Wireless Nigeria
Network Type	➢	GSM 900/1800
Handset Code	➢	ECONET
Network Code	➢	621 20
Network Status	➢	Live August 2001

4.5.4 GLOBACOM

4.5.4.1 Network Description

Globacom Ltd (Glo Mobile) - Network Information

Operator Name	➢	Globacom Ltd
Network Name	➢	Glo Mobile
Network Type	➢	GSM 900/1800
Handset Code	➢	glo
Network Code	➢	621 50
Network Status	➢	Provisional Member

5 COMMENTS/CONCLUSION

5.1 THE PRESENT

Telecommunications are evolving towards personal communication networks, whose objective can be stated as the availability of all communication services anytime, anywhere, to anyone, by a single identity number and a pocketable communication terminal. Having a multitude of incompatible systems throughout the world moves us farther away from this ideal. The economies of scale created by a unified system are enough to justify its implementation, not to mention the convenience of carrying just one communication terminal anywhere, regardless of national boundaries.

Another point where GSM has shown its commitment to openness, standards and interoperability is the compatibility with the Integrated Services Digital Network (ISDN) that is evolving in most industrialised countries, and Europe in particular (the so-called Euro-ISDN). GSM is also the first system to make extensive use of the Intelligent Networking concept, in which services like 800 numbers are concentrated and handled from a few centralised service centres, instead of being distributed over every switch in the country. This is the concept behind the use of the various registers such as the HLR.

The GSM system, and its sibling systems operating at 1.8 GHz (called GSM 1800 or DCS1800) and 1.9 GHz (called GSM1900 or PCS1900, and operating in North America), are a first approach at a true personal communication system. The SIM card is a novel approach that implements personal mobility in addition to terminal mobility. Together with international roaming, and support for a variety of services such as telephony, data transfer, fax, Short Message Service, and supplementary services, GSM comes close to fulfilling the requirements for a personal communication system: close enough that it is being used as a basis for the next generation of mobile communication technology in Europe, the Universal Mobile Telecommunication System (UMTS) which is the 3-G system.

5.2 THE FUTURE

As cellular systems reach maturity, many are looking to the future. While the PCS frequencies (1800 MHz – 2000 MHz) are still being built out, the next generation of cellular communication is being launched. To provide true homogeneous world-wide wireless coverage with no gaps, LEO (low earth orbit) satellites are being used. These LEO satellites orbit the earth in high speed, low altitude orbits with an orbital time of 70-90 minutes and an altitude of 400 – 700 miles. LEO's provide small coverage cells around the size Washington state. Since LEO's are not geosynchronous, they are forced to fly complete orbits, and thus many must exist to guarantee every area is covered by at least one satellite at all times. Therefore, call handoff is executed when the satellite moves, not when the person moves as it is with ground-based cellular systems.

5.3 LIMITATIONS

GSM is a broad topic that cannot be covered intensively with a 100-page document. The GSM specifications alone consume a whooping 8000 pages of recommendations and evaluations geared towards accomplishing a hitch free standard. In this project I have tried to give an overview of the GSM system. As with any overview, there are many details missing. However, I tried to give the general flavour of GSM and the philosophy behind its design.

The description of GSM in Nigeria was intended to cover the various network operators in the country. The information needed to give such a description needed to come from the operators themselves. On approaching the management of some of these establishments, they directed me to the Internet for all the information I need. Consequently, I found out that the Internet, albeit a rich source of information, is not enough to describe the state of affairs in these parastatals. The contents of these websites were found to be rather vague. I believe they have reasons to conceal some aspects of their operations for security reasons or possibly, economic reasons. Hence this project was mostly written with information from the Internet.

5.4 RECOMMENDATIONS

This undergraduate project has exposed me to so much in the world of telecommunications. The various aspects of a telecommunication system have been studied to gain a full background picture. One thing I noticed is the fact that Nigeria as a country is a pure consumer of all the telecommunication services offered. Nigeria cannot boast of producing a single microchip when the rest of the developed world is heading towards more advanced technologies. Most, if not all of the equipment used in the telecommunications industry today are imported. In fact, managing these companies, including our indigenous Nitel, is not without the help of foreign expatriates. I believe Nigerians have the capacity to handle these companies as well as their foreign counterparts. To this end, I recommend a different approach by the government in solving the problems associated with our technological backwardness. More resources should be channelled towards training indigenous Engineers even if it means training them abroad. The knowledge bought would be much more valuable than an equivalent amount of equipment bought. We should be more interested in the future not the present.

One of the ways I believe the government failed to consider future consequences is in the sale of the GSM licenses. The amount charged is quite exorbitant and every Nigerian that pays for his phone calls feels the effect. The tariffs in Nigeria still remain one of the highest in the world. And how cheap telecommunication services will get is greatly limited by these factors. The government should seriously ponder on issues that have far-reaching consequence before embarking on any project especially if it involves the rest of the world.

5.5 CONCLUSION

The state of the telecommunications industry in Nigeria has greatly improved in the past two years not only because of the GSM technology, but other sectors of the industry have enjoyed an un-abated growth. An example of such aspects is the Internet and computer telecommunications in general. Internetworking of computers has greatly enhanced productivity in the economy through efficient utilisation of facilities that can be accessed from remote locations. Banks have centralised networks that make transfer of funds faster and much easier. GSM networks have facilitated some of these functions by the use of wireless data transfer packages like HSDSC and GPRS with remarkably high data transfer speeds that can cater for internet connections on a wireless computer terminal like a laptop. The GSM handsets themselves can be used to gain access to the Internet. These days, the different modes of telecommunications can hardly be disassociated since the used of phones and the Internet are like two sides of the same coin. For instance, SMS or text messages can be sent to a GSM user from the Internet and vice-versa. E-mails can be sent and received on GSM phones without the use of a computer terminal.

Today's GSM platform is a hugely successful wireless technology and an exceptional story of global achievement. In less than ten years since the first GSM network was commercially launched, it became the world's leading and fastest growing mobile standard, spanning over 190 countries.

Today, GSM technology is in use by more than one in ten of the world's population and it is estimated that at the end of 2002 there were 787 million GSM subscribers across the 190 countries of the world.

The growth of GSM continues unabated with more than 160 million new customers in the last 12 months. Since 1997, the number of GSM subscribers has increased by a staggering 10 fold. During late 2003 or early 2004, it is predicted that global GSM subscribers will smash through the one billion mark.

Nigeria is not left behind in this turn of events. The teledensity increased from 0.4 in 1999 to 2.2 in 2003. This is a staggering 400% increase and with all things being equal, the teledensity is expected to rise to 10 percent by 2006.

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7 Glossary

ADC
American Digital Cellular

AMPS
Advanced mobile phone service

AoC
Advice of charge

AUC
Authentication center

bps
Bits Per Second

BSC
Base Station Controller

BSS
Base Station System

BTS
Base Transceiver Station

CGI
Cell Global Identity

CUG
Closed User Group

DCS
Digital Cellular System

DTMF
Dual-Tone Multifrequency

EIR
Equipment Identity Register

GIWU
GSM Interworking unit

GMSC

Gateway Mobile Services Switching Centre

GMSK
Gaussian minimum shift keying

GSM
global system for mobile communication

HLR
home location register

Hz
Hertz

ISDN
integrated services digital network

k
kilo

kbps
Kilobits per second

LA
Location area

LAI
Location-Area Identity

LPC
Linear Predictive Coding

MHz
Megahertz

MSC
Mobile Services Switching Center

MSN
Mobile Service Node

MXE
Message Center

NMT
Nordic Mobile Telephone

OMC
Operations and maintenance center

OSS
Operation and support system

PCS
Personal communications services

PDC
Personal digital cellular

PLMN
Public land mobile network

SS
Switching system

TACS
Total access communication system

TDMA
Time division multiple access

VLR
Visitor location register