RESEARCH AND DEVELOPMENT OF GSM SYSTEM. (CASE STUDY OF ZAIN NIGERIA LTD)

BY

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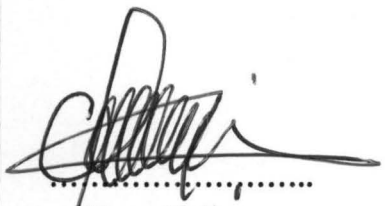
ATTESTATION

I UMAR HALIRU, I hereby declare that this project titled "Research and Development of GSM System (Case study of Zain Nigeria ltd) was carried out by me in the department of electrical and computer engineering under the supervision of Mr Enesi A. Yahaya. All the information utilized and their sources have been duly acknowledged.



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Date

CERTIFICATION

I hereby certify that this project work has been supervised and meets part of the requirement for the award of bachelors of engineering (B.Eng) Degree in the department of electrical and computer engineering, federal university of technology Minna, Niger state.

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DEDICATION

This work is dedicated first and foremost to God almighty, to my late Mum Hajiya Maryam,my Dad,my siblings,my In-law more like Brother(Daudu Attahiru) and my most treasured lover.

ACKNOWLEDGMENT

My thanks and gratitude goes to God almighty for his divine guidance and protection all through the course of my study. My special thanks go to my late Mum Hajiya Maryam for all the love, sacrifice and support. Also to my Dad, my siblings(Alhaji Ibrahim,Alhaji Aminu Noma,Bello Noma Aunty Ummah,Aunty Hannatu, Aunty Ladidi,Aunty Asma'u,Aunty Zulai,Aunty Jummai,Aunty Gwammah),my uncles(Baba Sa'idu Nabara, Baba Audu) my aunts, my friends and Engr. Gali Na'uzo who is genesis of this project, "thanks a million you". Many thanks to my supervisor Mr Enesi A Yahaya for his guidance, insightful support and contributions during the course of this project work.

ABSTRACT

This project was designed to provide an overview of Zain's Global system for mobile communication (GSM) system, Base Station Subsystem (BSS) and Network Subsystem. It will address BSS components, functions and features, as well as NSS components, functions and features. It also addresses basic challenges facing GSM industry in Nigeria and possible recommendation on how to improve the situations.

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(ABBREVIATIONS)

BTS	Base Transceiver Station
BSC	Base Station Controller
MCS	Mobile Switching Centre
EWN	Econet wireless Nigeria
VNL	Vodafone Nigeria Limited
MTC	Mobile Telecommunication Company
CAC	Cooperate Affairs Commission
ATC	Audio Teleconference
SMS	Short Message Service
SIM	Subscriber Identity Module
ITU	International Telecommunication union
MS	Mobile Station
PSTN	Public Switch Telephone Network
CDMA	Code Division Multiple Access
ISDN	Integrated Service Digital Network
DECT	Digitally Encoded Cordless Telecommunication
PLMN	Public Land Mobile Network
GMSC	Gate way Mobile Switching Centre

HLR	Home location Register
VLR	Visitor Location Register
EIR	Equipment identifier register
AUC	Authentication centre
SS.7	Signaling System No.7
MAP	Mobile Application Part
DTAP	Direct Transfer Application Part
BSSAP	Base Station System Application Part
BSSMAP	Base station System Mobile Application Part
LAPD	Link access Procedures on D-Channel
LAPDm	Modified Link Access Procedures on D-Channel
DSS.1	Digital Subscriber Signaling System No.1
MM	Mobility Management
CM	Connection Management
RR	Radio Resource Management
SCCP	Signaling Connection Control part

MTP	Message Transfer Part
RSL	Radio Signaling Link
OML	Operation and Maintenance Link
L2ML	Layer 2 Management Link
SS	Supplementary Service Support
CC	Call Control
TEI	Terminal Equipment Identifier
TRX	Transceiver Receiver
TCAP	Transaction Capability Application Part
ISUP	(ISDN User Part)
TUP	Telephone user Part
INAP	Intelligent Network Application Part
TRAU	Transcoder Rate Adapted Unit
OMC	Operation and Maintenance Centre
GSMC	Gate way Mobile Switching Centre
TCH	Traffic Channel

OSS	Operation and Support centre
NOC	Network Operation centre
OMT	Maintenance Software for BTS
MTTR	Mean Time To repair
CIC	Circuit Identification Code

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CHAPTER ONE

INTRODUCTION

1.1 COMPANY OVERVIEW

Zain Nigeria is formerly known as Celtel Nigeria. The company was established in the year 2000 as Econet Wireless Nigeria (EWN) Limited, by a group of institutional and private investors as well as three state governments. In August 5, 2001 she became the first telecoms operator to launch commercial GSM services in Nigeria [7].

EWN signed a management service agreement with Vodacom International of South Africa on April 1, 2004. The deal gave the continent's largest mobile operator the right to manage EWN network for five years. The company announced a change of its corporate name to Vee Networks Limited (VNL) trading as Vodacom Nigeria following an approval by the board of directors and endorsement of the change by the shareholders. The Corporate Affairs Commission (CAC) had earlier approved the new name and issued a certificate to that effect. Consequently, VNL changed its corporate brand to Vodacom Nigeria and its product brands: Buddie, Libertie and Business Partna to Vodago, Freedom and Business Call [7].

On June 30, 2004, the company changed its trading name to VMobile Nigeria following a mutual agreement between the boards of VNL and Vodacom to discontinue the management agreement.

The company became Celtel in 2006 following Celtel International's acquisition of majority stake in the company. Her operations then spanned through 14 African countries. On August 1, 2008 Celtel Nigeria was rebranded Zain Nigeria following the global acquisition of Celtel

International by MTC Group, which transformed to Zain Group, a leading emerging markets player in the field of telecommunications aiming to become one of the top ten mobile groups in the world by 2011.

Currently, Zain (formerly known as Mobile Telecommunication Company - MTC) is the pioneer mobile telecommunication company in the Middle East and a major player on the African continent. She began life in 1983 in Kuwait as the Middle East first mobile operator. Today she is a leading mobile and data services operator with a commercial footprint in 24 Middle Eastern and African countries with a workforce of over 15,000 providing a comprehensive range of mobile voice and data services to over 64.7million active individual and business customers.

Zain Nigeria has over 15million active subscribers on its network and has covered over 1500 towns and 14000 communities across the six geopolitical zones of the country. For effective management and maintenance of her network, Zain Nigeria runs a regional structure that comprises seven regions namely South South, South East, South West, Lagos, North Central, North West and North East. The regional structure was also designed to provide Zain's customers easy access to her products and services [7].

1.2 ZAIN IN AFRICA

Zain is the leading mobile operator in sub-Saharan Africa and operates in 16 countries serving more than 40 million customers. The countries in which Zain offers telecommunications services are Burkina Faso, Chad, Democratic Republic of the Congo, Republic of the Congo, Gabon, Ghana, Kenya, Madagascar, Malawi, Niger, Nigeria, Sierra Leone, Sudan, Tanzania, Uganda and Zambia.

Zain has invested over $12 billion on the African continent and is the market leader in 12 of the 16 countries in which it currently operates. She is committed to helping to open up an exciting world of new possibilities and opportunities, in culture, health and education, and acting responsibly in the communities where it operates is an integral part of its business. Zain has pioneered a range of education-based initiatives across Africa and is partnering with governments and communities to help them achieve the UN Millennium Development Goals.

Zain is also committed to supporting Africa's passions, be it in culture or music.

Zain's 10,000 experienced African staff is committed to the company's track record of profitable growth.

Notably for Zain, the acquisition of Celtel is the largest corporate transaction of African assets as well as being the Middle East's largest private sector transaction in the telecommunications industry [7].

1.3 ZAIN PHONE SERVICES

Zain offers a range of phone services some of which include:

Short Message Service (SMS) – SMS is a communication service standardized in the GSM mobile communication system, using standardized communications protocols allowing the interchange of short text messages between mobile telephone devices. Commonly referred to as text messaging, SMS is a service for sending short messages of up to 160 characters (224 characters if using a 5-bit mode) to mobile devices. It is similar to paging, however, SMS messages do not require the mobile phone to be active and within range and will be held for a

number of days until the phone is active and within range. Most SMS messages are mobile-to-mobile text messages, though the standard supports other types of broadcast messaging as well.

Voicemail – Voicemail is a computerized system for answering and routing telephone calls. Telephone messages can be recorded, stored and relayed. It is an easy-to-use answering service, available to both Prepaid and Postpaid subscribers.

As a subscriber, if you are not available to answer your phone (or it is switched off), voicemail will take a message. The caller will hear your recorded message, asking them to leave a message for you. Your phone will then alert you that you have messages to pick up. Just dial a number as may be given by your provider to hear your messages, example 122 for Zain. There is no charge to you when a caller leaves a voicemail message for you. The caller leaving you a voicemail message is charged at regular calling rates.

Roaming - In wireless telecommunications, roaming is a general term that refers to the extending of connectivity service in a location that is different from the home location where the service was registered. Traditional GSM Roaming is defined as the ability for a cellular customer to automatically make and receive voice calls, send and receive data, or access other services, including home data services, when travelling outside the geographical coverage area of the home network, by means of using a visited network. This can be done by using a communication terminal or else just by using the subscriber identity in the visited network. Roaming is technically supported by mobility management, authentication, authorization and billing procedure [1].

The convenience of roaming hinges on the fact that various countries in compliance with international GSM standards build mutually compatible networks. This enables foreign subscribers to connect to and use a foreign network while travelling, i.e. to "roam" in a given country. Since while roaming, you can use your SIM the same way you would at home, you can be reached at your own regular number when you are abroad. For this to happen, the two countries must sign a unilateral or bilateral roaming agreement. Zain Nigeria maintains such agreements with 296 operators in more than 142 countries, ensuring that you their subscribers remain in touch with families, friends, business associates, and they with you wherever they are [7].

Conference calls - A conference call is a telephone call in which the calling party wishes to have more than one called party listening to the audio portion of the call. The conference calls may be designed to allow the called party to participate during the call or the call may be set up so that the called party merely listens into the call and cannot speak. It is often referred to as an Audio Teleconference (ATC).

Conference calls can be designed so that the calling party calls the other participants and adds them to the call; however, participants are usually able to call into the conference call themselves by dialing into a special telephone number that connects to a "conference bridge" (a specialized type of equipment that links telephone lines).

Call Waiting - Call waiting is a feature that lets you know when someone else is trying to call you when you are already on a call. You can answer, reject or ignore this second call.

Call Forwarding - Call forwarding (or call diverting) in telephony, is a feature on some telephone networks that allows an incoming call to a called party, which would be otherwise[7]

unavailable, to be redirected to a mobile telephone or other telephone number where the desired called party is situated.

Call Barring - Enables you to restrict or bar certain or all types of calls to and from your mobile phone, i.e. outgoing calls, outgoing international calls and incoming calls.

Call line ID - Caller ID is a telephone service, available on GSM services that transmits caller number to the called party's telephone equipment during the ringing signal, or when the call is being set up but before the call is answered. Where available, caller ID can also provide a name associated with the calling telephone number. The information made available to the called party may be made visible on a telephone's own display or on a separate attached device.

International Dialing - With Zain, international direct dialing comes as standard. All Zain mobile phones are already set up to make international calls [7].

How to make an international call

Simply dial + (that's the Nigeria international access code) followed by these codes in this order:

(i) Destination country code

(ii) Area code

(iii) Telephone number

Here is an example of how you would make a call to Los Angeles, USA.

(i) Dial: + (the international access code)

(ii) Dial: 1 (the country code for the USA)

(iv) Dial: 213 (the area code for Los Angeles)

(v) Dial the telephone number of the person etc

1.4 AIMS AND OBJECTIVES

The aims and objectives of this project is to carry out research on how GSM system was developed (That it is, how GSM works) and also to address the basic challenges that lead to poor quality of GSM service in Nigeria .

1.5 SCOPE OF STUDY

This project will be limited to research and the development of GSM system in Nigeria.

1.6 METHODOLOGY

Visiting GSM service providers for vital information

General research from textbooks, Internet, journals and Lecture note.

CHAPTER TWO

GSM OVERVIEW

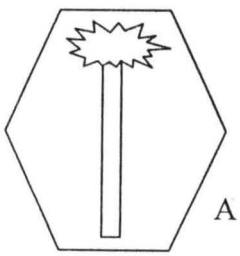
2.1 LITERATURE REVIEW AND THEORETICAL BACKGROUND OF GSM

GSM originally stood for Groupe Spécial Mobile when a technical committee for mobile communications was set up in 1982 in Europe to standardize a digital cellular mobile system for European countries. Today, GSM stands for Global System for Mobile Communication as it is now a global standard used by over 2 billion people across more than 212 countries and territories [1]. It is a typical second generation cellular mobile system which evolved from the analog cellular mobile system, the first generation. The frequency bands allocated to GSM900 by the International Telecommunication Union (ITU) are 890 – 915 MHz for the uplink (Mobile Station to Base Station) and 935 – 960 for the downlink (Base Station to Mobile Station). To provide additional capacity and enable higher subscriber densities two other systems were added later, GSM1800 (Previously DCS-1800) which has 1710 – 1785MHz on the uplink and 1805 – 1880MHz on the downlink and GSM1900MHz (Previously, PCS1900) with uplink spectrum of 1850 – 1910MHz and 1930 – 1990MHz on the downlink. GSM Technology was developed to address the problem of lack of standard specifications and compatibility experienced in the earlier mobile networks [2]. Although, different frequencies are defined at air interfaces, Mobile Station to Base Station, depending on locally available frequency bands, the system architecture and protocols, in particular, for user-network signaling and global roaming, are identical in all the networks. Thus, GSM enables worldwide development, manufacturing and marketing of innovative products.

2.2 GSM SPECTRUM ALLOCATIONS, MULTIPLE ACCESS AND CHANNEL STRUCTURE

The radio spectrum allocated to GSM as stated earlier is shared by all users. To serve as many users as possible, GSM system uses a combination of Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) in its operation. Using GSM900 as example, the FDMA part involves the division of the 25 MHz bandwidth into 124 carrier frequencies spaced 200 kHz apart. One or more carrier frequencies are assigned to each base station. Each of these carrier frequencies is then divided in time, using a TDMA scheme. The fundamental unit of time in this TDMA scheme is called a *burst period* and it lasts 0.577 ms. Eight burst periods are contained in a *TDMA frame*, which forms the basic unit for the definition of logical channels. One physical channel is one burst period per TDMA frame. Channels are divided into *dedicated channels and common channels. The latter are* used by mobile stations in idle mode [1]. Channel capacity = $2B\log_2 m$. where B is the bandwidth, m is the number of discrete signal[6]

2.2.1 CELL:- A cell is a basic geographical unit of a cellular system. Population in a country is so varied that different types of cells are use in different places. Such cells are macro cell, micro cell, selective cell and umbrella cell [1].



A hexagonal representation of cell.

Macro cell:- Are large cells used in remote and sparsely populated area. That is mostly in rural area.

Micro cell:- These are cell use in densely populated area mostly urban centre where the density of the users is quite large. By splitting the existing area into smaller cells. The number of channel available is increased as well as the capacity of the cell, the power level of the transmitter decreases, hence reducing the possibility of interference between the neighboring cells.

Selective cell:- It is not always useful to define a cell with full coverage of 360 degrees. In some cases, cell with particular shape and coverage is needed, these cells are called selective cell. Typical example is the cell use at entrance of tunnel where the coverage of 360degrees is not needed. In this case a selective cell of coverage of 120 degrees is used.

Umbrella cell:- A free way crossing very small cells produces an important number of hand over among different small neighboring cell, to solve this problem we concept of umbrella cell to cover several micro cells the power level is increase compared to the power in the micro cells that forms the umbrella cell. when speed of mobile is too high, the mobile is hand off to umbrella cell. The mobile will stay ionger in this umbrella cell. Hence reduce the hand off

2.2.2 CLUSTER:-Cells are grouped into cluster. No channel is reused within a cluster,the number of cells in cluster can be repeated continuously within the coverage area of an operator typical cluster contain4, 7, 12 or 31cells. The smaller the number of cells per cluster the bigger the number of channel per cell will be the capacity of each cell will therefore increase. However a balance must be form in order to avoid interference that could occur between the neighboring cluster.

2.2.3 FREQUENCY REUSE:- The concept of frequency reuse is based on assigning to each cell a set of radio channel that are completely different from that of the neighboring cells. The coverage area of a cell is called footprint is limited by a boundary so that the same set of

channels can be use in different cells that are far enough away from each other so that their frequency do not interfere[6].

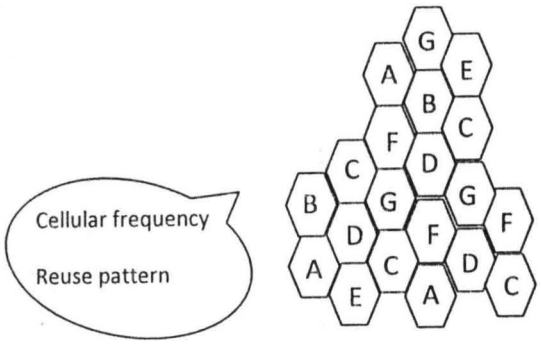


Figure 2.1 Frequency reuse pattern

2.2.4 MANAGING OF HAND OFF:- As a mobile travel through its coverage area, that is passes from one coverage zone of one base station into coverage of another while a call is on progress, the signal strength measurement by the mobile or by the base station trigger the base station controller(BSC) and switch to "hand off" the call and interfaces. Each wireless technology uses its own method to implement the hand off. CDMA can even "simulcast" to the mobile from multiple Base station to reduce fading effect (this is called soft hand off) [9]

2.3 GSM GENERAL SERVICES

Services supported by GSM technology include:

Telephony – Speech services in GSM can be between Mobile Station (MS) users or between MS users and fixed network users. Other services derived from telephony are emergency call services and voice messaging i.e. voicemail box facility.

Roaming – Roaming facility offers GSM users the ability to make and receive calls and access other services when outside the geographical area of their home network.

Data Services – GSM offer both asynchronous and synchronous data services. A unique feature of GSM is the Short Message Service (SMS) which is a bidirectional service for short messages.

It could be point to point or point to multipoint. It also offers access to packet data networks and telematic services such as fax and videotext.

Interworking Feature – Through the Gateway Mobile Switching Centres (GMSC), GSM networks are made compatible to interwork with other networks such as ISDN (Integrated Services Digital Network), PSTN (Public Switched Telephone Network, PLMN (Public Land Mobile Network and DECT (Digitally Enhanced Cordless Telecommunication.

Security Features – GSM offer extensive security functions, some of which include subscriber authentication, radio path ciphering, subscriber identity protection and distinction between user and device identification.

Supplementary services – GSM technology is rich in value added services such as call forwarding, call divert, multi-party conversations, call barring etc. Email and Internet connections are also provided by the technology.

Fax Services - Fax services enables you send and receive fax messages using your SIM card in a fax capable mobile device.

Toll Free Line - The Toll–Free line is a postpaid number in which the calling party is not charged for the call, rather the called party pays the charge for the calls. It is designed to help corporate organizations and Small-Medium Enterprises (SMEs) garner new customers and retain existing ones as well[7].

By utilizing the toll-free line, Large and Medium scale businesses provide their customers with a means of communicating with them at no charge. The toll-free line also makes these companies more accessible to customers and business associates.

2.4 SIGNALLING IN GSM NETWORK

Signaling refers to the exchange of information between call components required to provide and maintain services [4]. In the traditional Public Switch Telephone Network (PSTN), signaling is simply carried over the same path as that defined for the voice traffic and is known as In-band signaling. This is easy to enable as the various components of a fixed network have permanent connection to the network. In mobile networks such as GSM, signaling is more complex and demanding. This is due to the lack of fixed connection to the terminal mobile. For effective communication among all network elements, Out-of-Band signaling is used. Out-of-band signaling is signaling that does not take place over the same path as the conversation. It establishes a separate digital channel for the exchange of signal information. Specific channels are defined to carry signaling functions. These channels are called signaling links. They are used to carry all the necessary signaling messages between the nodes of the network.

Out-of-band signaling employs transport of data at high speeds of 56kbps. It allows for signaling at any time in the entire duration of the call. It also enables signaling to network elements to which there is no direct trunk connection [5].

2.5 SIGNALLING PROTOCOLS IN GSM NETWORK INTERFACES

Signalling System No.7 (SS7) is the signalling system required between the MSC and all the registers (HLR, VLR, EIR and AUC). The signalling protocol used for this purpose is known as Mobile Application Part (MAP). SS7 is also required between the MSC and the BSC. The signalling protocol used in this part of the network is called Base Station System Application Part (BSSAP) and it contains the Base Station System Mobile Application Part (BSSMAP) and the Direct Transfer Application Part (DTAP) protocols.

The signalling system used between the BSC and BTS as well as between the BTS and MS is based on the Digital Subscriber Signalling System No. 1 (DSS1) which is the same as that used in the access network for ISDN subscribers. The protocol used for transport of signalling messages between the BSC and BTS is the Link Access Procedure on D-channel, layer 2 (LAPD), which has the same structure as the corresponding layer 2 protocol in ISDN D-channel signalling.A modified LAPD protocol usually referred to as LAPDm is used on the air interface between the BTS and MS. The LAPDm protocol is based on the LAPD functionality but has been adapted to match radio requirements [5].

2.6 GSM SIGNALING PROTOCOL STRUCTURE

The signalling protocol in GSM is structured into three general layers, depending on the interface [5], as shown in Figure 2.2.

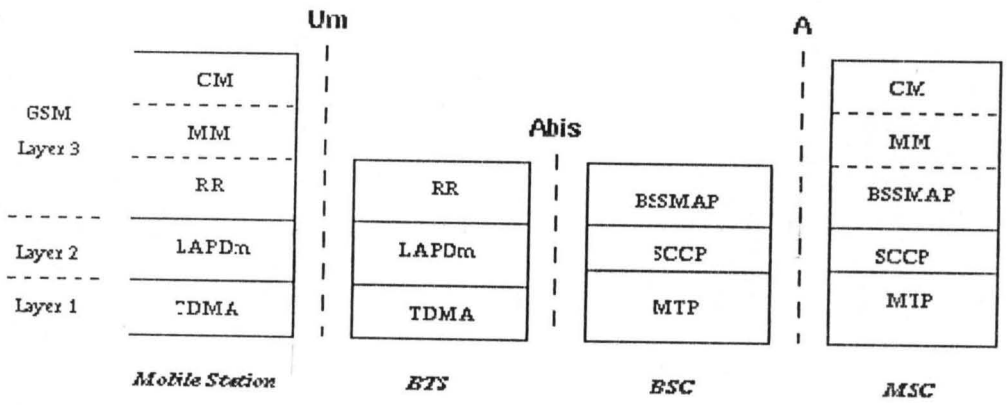


Figure 2.2 GSM signaling protocol structure

Um INTERFACE PROTOCOL LAYERS

Layer 1 – Physical Layer: Enables physical transmission of information using TDMA and FDMA access methods. It provides assessment of channel quality.

Layer 2 – Data Link Layer: Across the Um interface, the data link layer is a modified version of the LAPD protocol which is similar to ISDN LAP-D, called LAPDm. Its functions include:

(i) Connectionless transfer on point-to-point and point-to-multipoint signalling channels.

(ii) Set up and tear down of layer 2 connections on point-to-point signalling channels.

(iii)Connection-oriented transfer with retention of transmission sequence, error detection/correction and flow control.

Layer 3 – Network Layer: The network layer contains three sublayers which control signalling channel functions (RR, MM and CM):

(i) Radio Resources Management (RR) - Controls the setup, maintenance, and termination of radio and fixed channels and handovers between MS and MSC.

(ii) Mobility Management (MM) - Manages the location updating, Assignment of Temporary Mobile Subscriber Identity (TMSI) as well as security and authentication.

(iii) Connection Management (CM) – CM is used to set up, maintain and tear down call connections. It comprises three subgroups: Call Control (CC) for management of call connections, Supplementary Services Support (SS) for handling of special services and Short Message Service Support (SMS) for transfer of text messages.

MM and CM messages are not interpreted by the BTS and BSC. They are transferred transparently between the MS and MSC using the Direct Transfer Application Part (DTAP) on the A-interface. RR messages are mapped to or from the BSSAP protocols for exchange with the MSC.

Abis INTERFACE PROTOCOL LAYER

Layer 1 – Physical Layer: Enables PCM transmission (E1 or T1), Speech encoded at 16kbit/s and sub multiplexed in 64kbit/s time slots and Data which rate is adapted and synchronized.

Layer 2 – Data Link Layer: LAPD protocol is used as the transport mechanism for data messaging between the BTS and BSC.

Layer 3 – Network Layer: The network layer takes care of all BTS management (BTSM) functions. BTSM distinguishes three logical signaling connections with the Service Access Point Identifier (SAPI). SAPI0 is used by all messages coming from or going to the radio interface. SAPI62 provides operation and maintenance message transport between the BTS and BSC. SAPI63 is used for dynamic management of Terminal Equipment Identifiers (TEIs) as well as for layer 2 management functions. TEIs also provide addressing of the Transceivers and Receivers (TRXs) for the BTS. The TEIs that perform this function include:

Radio Signaling Link (RSL) – Traffic Management link; used for signaling between the BSC and BTS (non transparent messages e.g. RR) and transmission of signaling information on the air interface in the form of transparent messages (CM and MM messages).

Operation and Maintenance Link (OML) – Network Management Link; used to monitor the operating status of the TRXs or BTSs; OML messages have priority over other layer 2 messages.

Layer 2 Management Link (L2ML) – Layer 2 management; controls the TEI management and addressing procedures (allocation, de-allocation of BTS internal transceiver (TRX) addresses.

A-INTERFACE PROTOCOL LAYER

Layer 1 – Physical Layer: 2.048Mbit/s (ITU-T: E1) or 1.544Mbit/s (ANSI: T1) PCM Link.

Layer 2 – Data Link Layer: Across the A interface, SS7 based protocols are used. The Message Transfer Part (MTP) protocol responsible for transmission security between the BSCs and MSCs and the Signaling Connection Control Part (SCCP) protocol responsible for global addressing of network elements are used. MTP and SCCP also perform layer 3 functions. SCCP is used to transport DTAP and base station management application part (BSSMAP) messages on the A-interface, ensuring both connectionless and connection-oriented message flows. The connections can be related to a specific MS or radio channel and can be initiated by a mobile station (MS) or an MSC. When initiated by an MS, the SCCP will contain MM-CM service request, RR paging response, MM location updating request and MM-CM re-establishment request. When initiated by the MSC, the SCCP will contain, BSSMAP handover request and will also initiate other external handovers.

Layer 3 – Network Layer: The signalling on layer 3 uses the BSSAP protocol. The BSSAP provides BSSMAP and DTAP protocol functionalities.

BSSMAP functions include:

(i) Implementation of all procedures between the MSC and the BSS that require interpretation

(ii) Processing of information related to single calls, and resource management.

(iii) Control of BTS radio resources in response to instructions from the MSC.

(iii) Represents RR sublayer for the MSC

DTAP functions include:

(i) Used for the transparent transfer of MM or CM signaling messages between the MS and the MSC.

(ii) Provides the transport level protocol internetworking function for transferring layer 3 signaling messages from the MSC without any analysis

Signalling across the interfaces around the MSC use SS7 signalling based protocols (MAP, TCAP, ISUP, TUP and INAP) which are explained below:

MAP (Mobile Application Part): Used to control queries to the different databases in the mobile radio network (HLR, VLR and EIR). MAP responsibilities include access and location management (e.g. where is the called subscriber currently?), MSC-MSC handover, security functions, O&M, SMS and supplementary services.

TCAP (Transaction Capabilities Application Part): provides universal calls and functions for handling requests to distributed application processes.

ISUP (ISDN User Part): Controls interworking (e.g. call setup/take down) between PLMNs and other networks, and provides the same basic functionalities as TUP.

INAP (Intelligent Network Application Part): Implements intelligent supplementary services (e.g. free call, time-dependent routing functions in a central service centre).

ISUP (ISDN User Part): Controls interworking (e.g. call setup/take down) between PLMNs and other networks, and provides the same basic functionalities as TUP

TUP (Telephone User part): Implements interworking between PLMNs and other networks. TUP is normally used to provide international connections and slowly being replaced by ISUP.

Their functional interfaces include:

B interface: between MSC and VLR (MAP/TCAP)

C interface: between MSC and HLR (MAP/TCAP)

D interface: between HLR and VLR (MAP/TCAP)

E interface: between two MSCs (MAP/TCAP + ISUP/ TUP)

F interface: between MSC and EIR (MAP/TCAP)

G interface: between VLRs (MAP/TCAP)

The protocol used between MSC and Intelligent network (IN) is INAP.

Protocols used for connection with fixed networks are TUP and ISUP.

CHAPTER THREE

3.0 GSM NETWORK ARCHITECTURE AND INTERFACES

The GSM network can be divided into three broad parts. The Mobile Station (MS), the Base Station Subsystem and the Network Subsystem (NSS). The Mobile Station which is carried by the subscriber consists of the mobile equipment (the terminal) and a smart card called the Subscriber Identity Module (SIM). SIM cards are small chips carrying vital information about the subscription and the network. They provide personal mobility, so that the user can have access to subscribed services irrespective of a specific terminal. They also contain information on stored numbers and billing coordinates. Each SIM card has a unique identification number called International Mobile Subscriber Identity (IMSI), The Base station subsystem (BSS), consists of the Base Transceiver Station (BTS) and the Base Station Controller (BSC). The Network Subsystem (NSS) consists of the Mobile Switching Centre (MSC), Home Location Register (HLR), Visitors Location Register (VLR), Equipment Identification Register (EIR) and Authentication Centre (AUC) and the Operations and Maintenance Centre (OMC). A special switching centre called the gateway MSC (GMSC) connects the GSM network with other GSM networks and with other networks such as the PSTN [3]. The Transcoder Rate Adapter Unit (TRAU) converts PSTN PCM speech to GSM RELP (Residual Excited Linear Predictive) coded signal and vice-versa. TRAU may be located on the BSS side or NSS side of the network. It is the transport unit for a 16kbps traffic channel TCH on the Abis interface. It uses 13.6kbps for user data and 2.4 kbps for inband signalling, timing and synchronisation. It translates the 13kbps voice channel used over the radio link to the standard 64kbps channel used by the PSTN or ISDN.

The Mobile Station and the Base Transceiver Station communicate across the Um interface, also known as the air interface or radio link. It is the GSM equivalent of the ISDN user interface. The Air interface handles communication between MS and BTS using the LAPDm protocol.

The Base Transceiver Station (BTS) and the Base Station Controller (BSC) communicate across the Abis interface. The Abis permits the BSC to control a number of remote BTSs. The Abis interface handles communication between the BTS and BSC for radio traffic management and BTS exploitation and maintenance. It uses the LAPD protocol. The Base Station Subsystem communicates with the Mobile Switching Centre across the A interface. The A-interface handles communication for traffic management and uses BSSAP application protocol.

The Mobile Switching Centre communicates with the other network nodes such as HLR, VLR, AUC, and EIR across the B, C, D, E and F interfaces

3.1 BSS COMPONENTS, FUCTIONS AND FEATURES

All radio-related functions are performed in the BSS consists of the Transcoder Controller (TRC), Base Station Controller (BSC) and the Base transceiver Stations (BTSs).

Base Station Controller (BSC)

The Base Station Controller (BSC) manages all the radio-related functions of a GSM network. It is a high capacity switch that provides functions such as MS handover, radio channel assignment and the collection of cell configuration data. A number of BSCs may be controlled by each MSC.

Base Transceiver Station (BTS)

The Base Transceiver Station (BTS) handles the radio interface to the mobile station. One BTS can serve 1,2 or 3 cells. A group of BTSs is controlled by one BSC. Zain has two base station families, and they are BTS 200 and BTS 2000.

Transcoder Controller (TRC)

The Transcoder Controller (TRC) provides the BSS with rate adaptation capabilities. A device which performs rate adaptation is called a Transcoder. The bit rate per channel is decreased from 64 kbit/s to 16 kbit/s. This saves transmission links between the MSC to the BSCs.

TRC Functions

The primary functions of a TRC are to perform transcoding and to perform rate adaptation.

Transcoding

The function of converting from the PCM coder information (following A/D conversion) to the GSM speech coder information is called transcoding. This function is present in both the MS and the BSS.

Rate Adaptation

Rate adaptation involves the conversion of information arriving from the MSC/VLR at a rate of 64 kbits/s to a rate of 16 kbits/s for transmission to a BSC (for a full rate call). This 16 kbits/s contains 13 kbits/s of traffic and 3 kbits/s of inband signaling information. This is an important function. Without rate adaptation the links to BSCs would require four times the data rate capabilities. Such transmission capabilities form an expensive part of the network. *By reducing the rate to 16kbits/s, it is possible to use one quarter of the transmission links equipment nodes (MIN)*

3.2 NSS COMPONENNTS, FUNCTION AND FEATURES

Mobile Services Switching Center (MSC)

MSCs perform the telephony switching functions of the system. It controls calls to and from other telephone and data systems. It also performs such functions as: network interfacing, common channel signaling, and others.

Gateway MSC (GMSC)

A Gateway is a node to interconnect two networks. The gateway is often implemented in an MSC.

Home Location Register (HLR)

Is a database used for storage and management of subscriptions. The HLR is considered the most important database since it stores permanent data on subscribers; including subscriber's service profile, location information, and activity status. When an individual buys a subscription from an operator they are registered in the HLR of that operator. The HLR can be implemented with the MSC/VLR or as a stand-alone node.

Visitor Location Register (VLR) is a database containing temporary subscribers information needed by the MSC to service visiting subscribers. The VLR is always integrated

with the MSC. When a mobile station roams into a new MSC area the VLR connected to that MSC will request data about the mobile station from the HLR. Later, if the mobile station makes a call the VLR will have the information needed for call set-up without having to interrogate the HLR each time.

Authentication Center (AUC)

Provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each call. The AUC protects network operators from different types of fraud found in today's cellular world. AUC can be implemented in the HLR

Equipment Identity Register (EIR)

is a database containing information about the mobile equipment identities that prevents calls from stolen, unauthorized, or defective mobile stations. The AUC and EIR are implemented as standalone nodes or as a combined AUC/EIR node.

Additional (SS) Functional Elements

There are additional optional elements that can be configured with the Switching System (SS).

OPERATION AND SUPPORT SYSTEM (OSS)

Operation and Support System (OSS) is zain`s implementation of OMC. OSS provides a way of supporting the centralized, regional, and local operations and maintenance activities required by a cellular network. OSS is the functional entity from which the network operator monitors and controls the system. OSS can be viewed as a two-level management function. The NMC staff can concentrate on system-wide issues; whereas local personnel at each OMC can concentrate on short-term, regional issues. The OMC and NMC functionality can be combined inthe same physical installation or implemented at different locations. The OSS is designed to provide a coherent management system that supports a number of network elements. Examples of these network elements are:

(i) Mobile Switching Center (MSC)

(ii) Base Station Controller (BSC)

(iii) Radio Base Station (RBS)

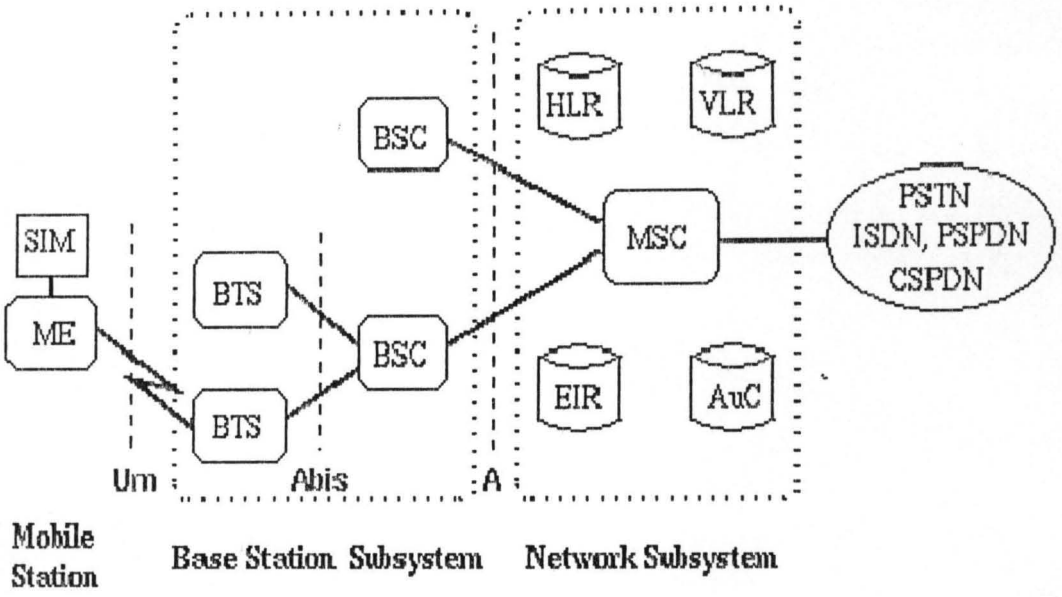
(iv)Visitor Location Register (VLR)

(v) Home Location Register (HLR)

(vi) Equipment Identity Register (EIR)

(vii) Authentication Center (AUC)

(viii) Mobile Intelligent Network



SIM Subscriber Identity Module
ME Mobile Equipment
BTS Base Transceiver Station
BSC Base Station Controller
HLR Home Location Register
VLR Visitor Location Register
MSC Mobile services Switching Center
EIR Equipment Identity Register
AuC Authentication Center

Figure 3.1 General GSM Architecture

3.3 SIGNALLING IN A SIMPLE CALL SETUP

A simple call set up scenario between A GSM user and PSTN subscriber is described below: After calling up the number to be called, the subscriber, on pressing the "send" key initiates a "channel request" message from the MS to the BSS. The BSS on getting this request assigns a dedicated control channel to the MS and the DSS1 signaling link is established between the MS and the BSS. A "request for service" is passed to the MSC by the MS using the DTAP protocol; the MSC relays the message to the VLR. The VLR will carry out authentication process if the MS has been previously registered on the VLR, but if not, the VLR will have to obtain authentication parameters from HLR. After a successful authentication of the MS, the message "Set-up" is sent by the MS to the MSC accompanied by the call information (number being called, type of call etc.). This message is forwarded from the MSC to the VLR. The interaction between the MSC and VLR is via the SS7 signalling link using the MAP protocol. In response to the message "Set-up", the VLR sends the message "Complete Call" to the MSC, which subsequently notifies the MS with "Call Proceeding". The MSC then assigns a traffic channel to the BSS with the message "Assignment Command', which in turn assigns an air interface traffic channel to the MS. The MS responds to the BSS with "Assignment Complete" message. The BSS responds in-turn to the MSC with the complete assignment message via the SS7 signalling link using the BSSAP protocols. An "Initial and Final Address Message" is sent to the PSTN from the GMSC. Ring tone is applied at the MS in response to "Alerting", which the MSC sends to the MS when the PSTN responds with an "Address Complete Message". When answered, the message "Connect" from the PSTN is forwarded to the MS by the MSC, stopping the MS ring tone. The MSC then connects the GSM traffic channel to the PSTN circuit, thus completing the end-to-end traffic connection. Conversation takes place for the duration of the call.

SIMPLE CALL SET UP STRUCTURE

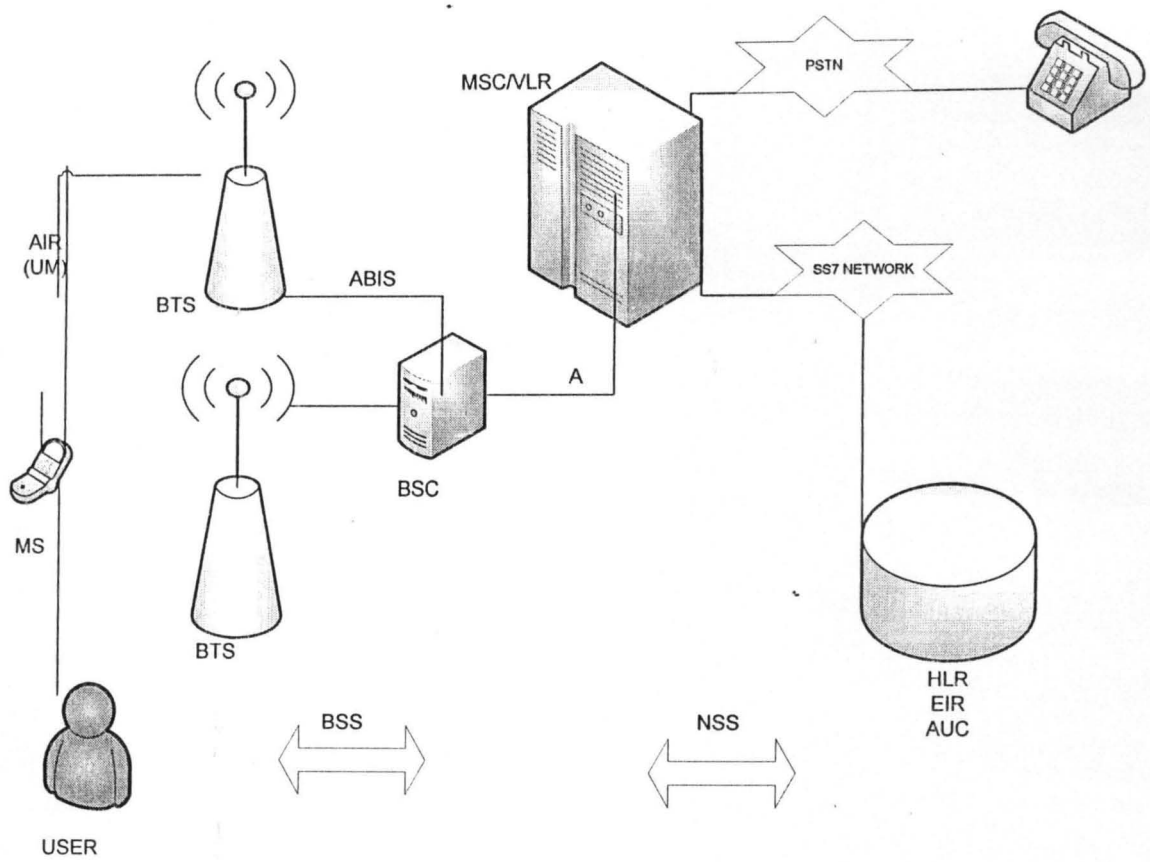


Figure 3.2 Simple call set up structure

CHAPTER FOUR

4.0 BASIC PROBLEMS / CHALLENGES FACING GSM IN NIGERIA

(1) **EXPENSIVE LINCENSE:-** This result to high operational cost

(2) **NON AVAILABILITY OF POWER SUPPLY:-** This makes the operators to engage in 100% use of power generator, as well the cost of maintenance and fueling of these generators consequently makes GSM services to be provided at a very high cost.)

(3) **SECURTY CHALLENGES**:-Regular steal of equipment like back up battery, Generators and others essential components of the base station

(4) **CONGESTION**:-This simply means over concentration of subscribers on the network due to increase in number of subscribers and additional promotional activities that increase the chances of block calls (i.e. high rate of access deny).

(5) CROSS TALK:-This occurs when a "Foreign conversation appear to interfere with the primary call which is highly common in Nigeria wireless telecommunication system. These happen as result of CIC mismatch (circuit identification code mismatch)

(6) **MTTR** (Mean time to repair)

(7) HIGH RATE **OF DROPPED CALLS**:- Means termination of already establish

(8) **ECHO:-** Which means reflection of transmitted signal within the communication tract, due to error or interference on the voice channels called

(9)MULTIPLE TAXATION:- That is federal, state and local governments tax on a particular thing, this go along way threaten the mobile operators in Nigeria

(10) GOVERNMENT POLICIES:- In rolling out their networks, operators order equipment from infrastructure vendors and because of the equipment are not manufacture in Nigeria, the vendor need a letter of credit to enforce manufacturing of needed equipment(i.e payment for the equipment). The control Bank policy on equipment procurement affected the network roll out as regard to time constrained since it takes a lot of time to process. Also the equipment takes a lot of time in clearing because of custom's policies and the port congestion in the country.

(11)INTERCONNECTIVITY PROBLEMS:- this problem frustrate the effort of service providers and also render great dissatisfaction in the mind of their customer.

4.1 BSS NETWORK MAINTENANCE

Maintenance procedure in the BSS Network can generally be divided into preventive and corrective maintenance.

Preventive maintenance - Preventive maintenance is a set of activities directed to prevent failures and ensure that the system remains in its optimal functional status. This is achieved by systematic inspection to detect and prevent incipient failure before this causes serious system consequence.

Corrective maintenance - Corrective maintenance refers to those maintenance activities directed to bring the system back to its original functional status after a failure. It is responding to actual faults by repairing their immediate causes [7].

In Zain network, BSS maintenance covers the following network elements:

(i) Power Systems

(ii) Access Transmission

(iii)Base Transceiver Stations (BTS)

4.1.1 POWER SYSTEMS

The power system comprises: The national grid – PHCN Power Supply, Air conditioners, stand-by power Generators, Voltage regulators, Uninterrupted power supplies and battery backups

PHCN SUPPLY – Routine preventive maintenance of PHCN power supply is mainly referring to the maintenance of the operational transformer and the PHCN meter.The energy consumption is checked monthly and verified with bills to ensure that the readings are the same. The records of the checks are kept for future reference.

Voltage Regulator - The voltage regulator is checked regularly in accordance with the manufacturer's manual. Relays and electronic cards are regularly inspected for damage.

Generator Maintenance – Only qualified technicians are allowed to carry out maintenance and service of generators in Zain network. The Network Maintenance Technical Officer only checks the generators for any visible alarm and report to the appropriate personal for correction.

UPS and Battery back-up – UPS and back-up batteries are checked once every month for proper functioning. The UPS batteries are checked to ensure that they are fully charged.The bypass supply is checked to ensure that it is at the correct level. Battery back-up test are performed by cutting off the input power of the rectifier and allow the site to run on battery for at least an hour. If it can stand the load for this period then it is confirmed that the battery bank is in good working condition but if not the information supplied by the manufacturer is checked for correction and replacement interval.

Air-Conditioner Maintenance - The maintenance cycle for the air conditioners in Zain BTS site is once every month. The maintenance and servicing is carried out by only qualified technicians and the function is contracted out.

4.1.2 ACCESS TRANSMISSION

Access transmission refers to the transmission between the BTS en-route to the Hub-sites up to the BSC. Mainly, lower capacity radios like Mini-link radio / Nera Cellink / Harris / Microstar are used to implement this interface. The Network Maintenance personnel is responsible for the maintenance of the access transmission links. The following checks are carried out during routine preventive maintenance of the links:

Received Signal Level (RSL) – The RSL of transmission equipment is checked for deviation or changes from the reference value. Usually such changes may occur if there is change in antenna position, failure of any component of the radio frequency unit or if there is obstruction in the line of site as a result of new buildings or towers blocking the line of site after installation.

Bit Error Rate (BER) - The BER check is carried out to check the percentage availability of the link within a specified period usually one month. The BER is high when there is interference on the link. The results are recorded and kept for future reference. Any observed anomalies are also corrected.

In the event that the transmission link fails, corrective maintenance is carried out to restore the link. At such times the technical officer will visit the site and carry out a thorough investigation of the fault. He will take with him, basic spare radio units for replacement in case the link failure was as a result of failed component. He will also be on the lookout for any deviations in values of transmission link parameters or alarms such local (near end) or remote (far end), TX output power, RX level, frequency. If there is any change in value of the parameters when compared with reference values, a correction of the affected element is carried out to restore the link.

4.1.3 BASE TRANSCEIVER STATIONS (BTS)

The BTS comprises of the radio transceivers (TRX), the combiners, the processor boards, clocking boards, radio frequency (RF) cables & feeder cables, TRX power supply units, fan units and the interconnecting cables. The following checks are carried out during the preventive maintenance of the BTS: Feeder cable insulation, clamps, grounding points, antenna assembly and mounting. If there are observed loose bolts, they are tightened. The fan unit is checked to ensure that air is circulating properly inside the BTS cabinet.

Network Operations Centre (NOC) monitors the BTS sites and reports on any fault that occurs on the BTS. Usually they will provide the necessary information that will facilitate in identifying the cause of the fault, the affected network node and resolution method. Information such as the site number, cabinet or cell number, reference number, the suspected faulty hardware unit and history for example, whether the same type of fault has been detected and repaired a few weeks earlier will be provided. The technical officer usually visits the site with a spare part of the unit that is suspected to be faulty for replacement after confirming the unit is bad.

On getting to the site, the technical officer will localize the fault by the use of OMT (maintenance software for BTS). When the faulty hardware has been confirmed bad the Technical officer will inform the NOC before replacing it. After replacing the faulty unit the technical officer then must test the functionality of the hardware unit and ensure that it is working properly before leaving the site. When a maintenance procedure or repair has been completed, the technical officer then calls the NOC so that they can verify the functionality of the new hardware and all the detailed description of actions taken before leaving the site.

Whenever Voltage Standing Wave Ratio (VSWR) alarm is encountered on the system the VSWR and DTF of feeder cables is checked and the appropriate correction is effected.

4.1.4 BSS NETWORK MAINTENANCE REPORT

Reports are feedback mechanism that enables a system to have a grip of what that nature of the output is and take corrective actions to resolve the day to day problems arising. The efficiency of a system and the quality of improvement is directly proportional to the quality of the feedback. If the feedbacks are not accurate then the improvement actions can then not be accurate.

It is mandatory for every technical officer to provide management with reports of network maintenance activities within his/her cluster. The technical officer ensures that documentations and reports are accurate and timely as much as possible so that the purpose of such will not be defeated.

The following reports are prepared and presented to management by technical officers in Zain field operations:

Fault Log – This Report contains details of the faults recorded that are reported to and handled by the technical officer covering a set of BTS in a sub-region. The fields included in the report gives a snap shot of the kind of faults that was encountered, equipment affected, dates and time at which the fault was reported as well as date and time of resolution; it also details the action taken to resolve the problem. By completing this on a weekly basis, the technical officer indirectly gives account of his activities for the week.BSS Spares Management

The BSS Spares management report -gives an account of what BSS spare equipment was utilized during that week in question and on what site the equipment was used. This will help in track of spare equipment in the custody of the technical officer for reconciliation purposes.

TX Access Radio Spares Management - The Transmission Access Radio Spares management report gives an account of what Access radio spare equipment was utilized during that week in question and on what site the equipment was used. This will help in track of spare equipment in the custody of the field officer for reconciliation purposes.

Major Outages - Major Outages are outages that affect more than 30% of the network availability in the sub region where the field officer is covering. This also includes major Hub site failure as well. This report is sent through the Network Maintenance Manager to the Head of

Operation and Maintenance after such report must have been approved by the Head of Region. Major outage report is supposed to be sent within 24 hours after the fault has been rectified.

Site Routine Maintenance Status – This report covers the preventive maintenance activities on the network by the technical officer. Usually a stipulated time is given for the technical officer to carry out the maintenance for different network nodes. The exercise is carried out based on a preventive maintenance checklist that will be given to the technical officer.

CHAPTER FIVE

CONCLUTION AND RECCOMMENDATIOIN

5.0 CONCLUSION

From this research work, I am able to find out the electronic evolution of GSM from mobile switching centres(MSCs) to Base station controllers(BSCs), from BSCs to Base transceivers stations(BTSs),from BTSs to mobile stations(our hand sets). All these components brought together and established mobile system.

5.1 RECOMMENDATION ON HOW TO IMPROVE THE QUALITY OF GSM SERVICE AND INCREASE SUBSCRIBERS SATISFACTION IN NIGERIA

(1) **CONGESTION**:-This simply means over concentration of subscribers on the network due to increase in number of subscribers and additional promotional activities that increase the chances of block calls (i.e. high rate of access deny). I recommend that the operating companies should be able to expand the capacities of their network fast enough to meet up with the ever growing demand by subscribers and also to effectively accommodate any form of promotional activities engage by the operators and this can be done with use of WIMAX as an over lay to increase the capacity because WIMAX gives better carriage capacity that reduce the chances of block calls and enhance the GOS.

(2) **HIGH RATE OF DROPPED CALLS**:- Means termination of already establish called, which is mainly cause by handover failure, and sometimes due to influence of high speed on a mobile system. I recommend that optimization unit should ensure that Hand Over Parameters are

properly define by high skilled personnel and ensured the use of WIMAX/ umbrella cells on high ways, this will help to reduce frequent handoff and reduced chances of call drops due it is wide coverage area..

(3) **CROSS TALK**:-This occurs when a "Foreign conversation appear to interfere with the primary call which is highly common in Nigeria wireless telecommunication system. These happen as result of CIC mismatch (circuit identification code mismatch) or to say circuit failure due to wrong connection during expansion and most a times it happens accidentally due to system malfunction. I recommend that, Daily Health Check as routine preventive maintenance should be adapted.

(4) **HIGH TARRIFF**:-Non availability of power supply in Nigeria, which makes the GSM operators to majorly depend on power generators in order to power their Base stations, is one of the basic reason that brings about high operational cost (High Tariff). Diesel is very expensive in Nigeria; Example 18KVA power generator consumes approximately 18,000 litres of diesel in a month.500KVA power Generator used in powering major Hubs like switches consume approximately about 36,000 litres in a month. Like in Niger state Zain have about 107 Base stations, majority of which are 18KVA Generator. The monthly cost of these Base stations is given as fallows: ₦ 120×107 Base stations× ₦18,000 = ₦231,120,000. Not to talk of maintenance and other related expenses, as such it leads to high operational cost (High tariff).I recommend that if the federal Government will make available of power supply at least 12hours in a day, it will help to reduce the consumption by half, another option is if the Federal Government will have special discount for GSM operators, so that operators buy directly from the government, will help to reduce the tariff and increase customer satisfaction.

(5) **MTTR** (Mean time to repair):- In situation where we have network outage, The MTTR high or low affect network quality, due to unavailability of spares parts within the country. To address this problem, I recommend that the GSM operators should subscribe with spares and logistic management company that makes available the unavailable resource within the shortest period of time.

(6) **SECURTY CHALLENGES**:-Regular steal of equipment like back up battery, Generators and others essential components of the base station. Example, a lot of Base station are situated in remote areas and high ways to give road coverage and community coverage as such, such Base station are vulnerable to theft due their location in idle places and if stolen it takes time to replace must of which have to be imported, in such situation, the mean time to repair become excessively high. I recommend that the Government of the country should tighten up their general security most especially on high ways and remote areas, because to employed the service of skilled security by the GSM operators may makes the service unaffordable to an average Nigerian.

(7) **LICENSES** :-GSM operators paid high amount of money, about 128million U.S Dollars acquire licenses with the agreement that the Federal Government would provide the basic amenities required, stuffs like :Good road network, Electricity supply.

Bad road network affect quality of service: For instance if a site is located 100Km distance, on the average a technical officer is expected to get to the site in an hour time, but due to the influence bad road network in Nigeria it takes him more than an hour to get to the site and this increase the MTTR .I recommend that the Government of the country should try as much as

possible to meet up with the licenses agreement by providing the basic amenities involved in the agreement.

(8) **ECHO:-** Which means reflection of transmitted signal within the communication tract, due to error or interference on the voice channels. I recommend that in addition to the echo corrector that is put on Transcoder, a Daily Health Check as routine preventive maintenance should be employed

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