EVALUATION AND COMPARATIVE ANALYSIS OF THE QUALITY OF SERVICE OF GSM AND CDMA CELLULAR NETWORKS IN ZARIA

BY

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DEDICATION

I dedicate this work to my late mother, Mrs Celestina Wirnkar who departed from this world some years back. She could not stay to reap the fruits of her labour. May her gentle soul rest in perfect peace. Amen

DECLARATION

I hereby declare that this thesis titled "**Evaluation and Comparative Analysis of the Quality of Service of GSM and CDMA Cellular Networks in Zaria** "was performed by me in the Department of Mathematics, under the supervision of Dr. S. E. Abdullahi and Dr. D.N Choji. The Information derived from the literature has been presented for another degree or diploma at any institution.

CERTIFICATION

This thesis titled "Evaluation and Comparative Analysis of the Quality of Service of GSM and CDMA Cellular Networks in Zaria" by Celinus Kiyea meets the regulations governing the award of the degree of Masters of Science (M.Sc) of Ahmadu Bello University, Zaria and it is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

The research was focused on evaluation and comparative analysis of the QoS of some selected GSM (Globacom and Zain) and CDMA (Starcomms and Visafone) networks in Zaria. Data for the purpose was collected for both intra and inter calls from ten different areas in Zaria by call centre Operators and the researchers, where a total of eight thousand nine hundred and sixty (14 days x 10 different areas x 4 times x 16 call combinations) calls were made. The averages of each day were found and recorded in tables and used for analysis. The daily trend for each KPI for each network type and data collection site was shown using line graphs while the comparison of GSM inter and intra networks as well as CDMA inter and intra network for the KPIs (Key Performance Indicators) under study was shown using bar charts. The work therefore revealed that GSMs operators' performance in Zaria is better than the CDMAs and at the same time Globacom's performance is better than Zain's while Starcomms is better than Visafone. It also showed the most preferable network for each data collection site. Mean while the values gotten for the KPIs were just closer or very slightly above most of those of the set standards. The conclusion was drawn and recommendations made. All the works of other authors were fully referenced.

DEFINITION OF TERMS

QoS: Quality of Service

GSM: Global System for Mobil-telecommunication

CDMA: Code Division Multiple Access

CCITT: United Nations Consultative Committee for International Telephony and Telegraphy

MANET: Mobile Ad Hoc Network

QoE: Quality of End-user Experience

KPIs: Key Performance Indicators

BTS: Base Transciever Station

4G: Fourth Generation

MAC: Media Access Control

IP: Internet Protocol

TCP: Transmission Control Protocol

iQoS: Individual Quality of Service

CAC: Call Admission Control

CSSR: Call Setup Success Ratio

SCCR: Successful Call Completion Rates

TE: Terminal Equipment

MT: Mobile Terminal

CN: Core Network

UMTS: Universal Mobile Telecommunication System

SMS: Short Message Service

GPS: Global Positioning System

MMS: Multi Media Services

WAP: Wireless Application Protocol

OSI: Open System Interphase

QoE: Individual Quality of Experience

SIM: Subscriber Identification Module

MS: Mobile Station

BSC: Base Station Controller

IMEI: International Mobile Equipment Identity

IMSI: International Mobile Subscriber Identity

MSC: Mobile service Switching Center

PSTN: Public Fixed Network

HLR: Home Location Register

VLR: Visitor Location Register

SS7: Signaling System Number 7

MSRN: Mobile Station Roaming Number

EIR: The Equipment Identity Register

TMSI: Temporary Mobile Station Identifier

SRES: Signed Response

SSD: Shared Secret Data

GPRS: General Packet Radio Service

RTT: Radio Transmission Technology

RAND: A random number

CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND OF THE STUDY

Communication is the backbone for the development of every society. Messages have to be exchanged from one person or one medium to another. The world is fast becoming a Global village and a necessary tool for this process is communication, of which wireless telecommunication is a key element. Wireless ad hoc networks are formed by a group of mobile users or devices spread over a certain geographical area. The users or devices forming network "nodes". Mobile networks have increased applicability in areas of military application such as sensor networks, tactical networks and positional systems Mobile networks have increasing applicability in Law enforcement. Various law enforcement agencies use Mobile networks to communicate with each other, to track movement of criminals and to spy on criminal activities Video conferencing in some situations where there is no network infrastructure can be done using networking which enables mobile on the spot conferencing.

Quality of Service has been defined by the United Nations Consultative Committee for International Telephony and Telegraphy (CCITT) recommendation E.800 as "The collective effect of service Performance which determines a degree of satisfaction of a user of the service". The Quality of Service is a rapidly growing area in both wired and Mobile Ad Hoc Network (MANET). Many problems exist especially for MANETs (Uma and Padmavathi 2009). They also stated that Quality of Service in mobile ad hoc networks depends not only on the available resources but also on the mobility rates of such resources. It means to provide a set of parameters to adapt the applications to the quality of the network while routing them through the network.

An ad hoc network as a dynamic type of Development in the telecommunications industry all over the world is very rapid as one innovation replaces another in a matter of weeks. A major breakthrough is the wireless telephone system, which comes in either fixed wireless lines or the Global system for mobile communication (GSM) (Wojuade, 2005). Global System for Mobil-telecommunication (GSM) and the Code Division Multiple Access (CDMA) are recent development that has come to stay so as to promote and ease the exchange of messages from one person or one medium to another. According to Adomi, (2006) GSM is used by Nigerians mostly to communicate with one another. He explained that students used it to communicate with their course mates, friends, lecturers and relations. Additionally, family matters, finance, and academic matters constitute the topics/subject of mobile communication for a majority of students. Mobile phones limit the need for students to travel as well as facilitating the exchange of information as the need may arise. It has helped to enhance computing on the move as services are rendered anywhere within the coverage area

> According to Patrick (2003) Quality of Service (QoS) is usually defined as a set of service requirements that need to be met by the network while transporting a packet stream from a source to its destination. The network needs are governed by the service requirements of end user applications. The network is expected to guarantee a set of measurable pre-specified service attributes to the users in terms of end-to-end performance, such as delay, bandwidth, probability of packet loss, delay variance (jitter) and many others.

Notwithstanding, for a mobile network telephony services specifically to be of quality, it has to meet up with some criteria such as Speech Quality, Call Completion Rate, Call Setup Success Ratio, Service Accessibility Telephony, Service Accessibility Short Message Service, and

Access Delay Short Message Service. The services have to be delivered to the customers as at when needed, audible enough and without noise and other related hitches.

QoS is sometimes used as a quality measure, with many alternative definitions, rather than referring to the ability to reserve resources. Quality of service sometimes refers to the level of quality of service that is the guaranteed service quality (Wikipedia free Encyclopedia).

One of the aims of QoS is to manage the service response provided to low-speed devices such as mobile wireless devices. The QoS can be ensured only when the achieved / actual performance is greater than or equal to the desired performance. With the growth of mobile services, it has become very important for an operator to measure the QoS and Quality of end-user Experience (QoE) of its network accurately and improve it further in the most effective and cost-efficient way to achieve customer loyalty and maintain competitive edge (David, 2006). The service provider must take steps to introduce new mechanisms to achieve the desired performance. Otherwise, QoS cannot be achieved.

1.1 MOTIVATION

Time without number, many subscribers suffer one or two undue penalties ranging from denial of service, over charge, double charges or charges without services rendered. This falls in line with the lamentation of the columnist Emmanuel Tiko Okoye in Daily Independence (Lagos, 2009) who said "I sent a ZAIN Short Message Service (SMS) to the 230 number as directed. I then checked my account balance and discovered that the sum of ₦100 (cost of SMS) had been deducted. 48 hours after the money was deducted the SMS was still Pending! It's a double whammy for me: I was deprived the usage of ₦100 worth of talk-time and was also denied the opportunity to participate in one of my favourite TV shows!" Sometimes it becomes difficult to

connect two different networks successfully in such situations different information like "Network busy" , "The number you have dialled is not on the Globacom Network", "Error in connection", "No answer", "Number busy and when the call goes through, the charge becomes higher or the Quality of Service is deplorable in its entirety. Either the charges are done without a successful call or the voice quality is poor or another person's voice (interference) is heard other than the intended callee. As a necessity each and every one has to enjoy it so as to ascertain the aim of which it is intended for and at a price relative to the services offered. It is alleged that GSM services and CDMA services also differ in terms of QoS.

1.2 STATEMENT OF PROBLEM

Due to the high demand of the services of mobile network operators many of them tend to render poor QoS. This is in line with the assumption that GSM services are better than those of the CDMA and vice versa. This work tried to provide answers to the following questions:

- Does QoS vary between GSM and CDMA networks for Intra and Inter network telephony services?
- Does GSM network have a better QoS than CDMA network for both intra and inter telephony services?

1.3 AIMS AND OBJECTIVES

This work is intended to:

- Evaluate and measure the QoS for both Intra and inter network telephony of GSM and CDMA networks under study from the users' perspective.

- Determine the difference in Quality of Service (QoS) between GSM and CDMA network services in Zaria.
- Determine the mobile network operator with the best quality of service in Zaria.
- Determine the most preferable network for each data collection site based on the KPIs.
- Proffer suggestions where necessary.

1.4 SCOPE OF THE STUDY

This research was carried out on the evaluation and comparative analysis of the quality of service of the four major GSM and CDMA networks operators in Nigeria the situation in Zaria from the users' perspective using manual/statistical means. This embodies two GSM networks (ZAIN and Globacom) as well as two CDMA networks (Starcomms and Visafone). The research will be conducted locally by collecting data from some selected locations using calls made in Zaria, Kaduna state, at different base stations and transceivers especially where traffics are always high like on campuses of Ahmadu Bello Univeristy, Samaru and Kongo campuses, Nuhu Bamalli polytechnic campus, Ameer Shehu, Idris College of Advanced Studies, Federal College of Education, Zaria, College of Agriculture Samaru and College of Chemical and Leather Technology, Samaru as the calling point to any other Base Transmission Stations (BTS) in the country as the callee points.

1.5 SIGNIFICANCE OF THE STUDY

This research will be of great significance to various mobile network stakeholders such as:

- Network Operators, it will help to determine the level and stand point of operation of the services they supply to the users.
- To the users it will help them determine which network is better for their use either financial wise or QoS wise.
- It will also give the government the insight of the standard and QoS of mobile networks and network types that prevail in the country and
- It will still enable academicians to go into more research on issues like the algorithms review and inventions that will lead to improvement and innovations in the general field of mobile networks in various parts of the country and the country as a whole.

1.6 CHALLENGES OF QUALITY OF SERVICE

In wireless mobile networks QoS refers to the measurement of a system with good transmission quality, service availability and minimum delay. In (Fourth Generation) 4G it is expected to have a reliability of at least 99.999 referred to as five nines reliability. The major challenges when considering QoS in cellular networks are varying rate channel characteristics, bandwidth allocation, fault tolerance levels and handoff support among heterogeneous wireless networks. It is fortunate that each layer which includes physical, Media Access Control (MAC), Internet Protocol (IP), Transmission Control Protocol (TCP) and application have got their own mechanisms to provide QoS. It is important to guarantee QoS in each layer so that the network is more flexible and tolerant to QoS issues. Some of the other challenges are efficient usage of the spectrum as its availability is limited. Bandwidth allocation plays a major role with respect to this aspect. It must be made sure that bandwidth is allocated in an efficient manner and also the remaining bandwidth should not be wasted (Monego, 2005).

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

Since the inception in Nigeria of the Global System for Mobile communications (GSM) and the Code Division Multiple Access (CDMA) networks in 2001, twelve years later there has been a tremendous change both in the quality of service offered by the operators as they fully went commercial. Some of these major network operators include MTN, Globacom, Zain (former Celtel, V.Mobile) Mtel, Visafone, Starcomms and Etisalat.

The mobile network helps the customers to get the benefits of the internet while on the move. Though the customers can enjoy benefits, it also challenges the service providers. The services provided in mobile environment has more complexity than in fixed wireless or wired environment. The ad hoc nature of the mobile networks poses more challenges in the protocols that they use. In other words, the protocols in each layer have to be enhanced in order to support mobility. Despite these difficulties, the service provider has to take measures to ensure Quality of Service (QoS) (Calduwel et al, 2009). This implies that QoS can be measured at different layers, from operators' perspective or at different levels from the users' perspectives. Notwithstanding, different methods such as Experimental (simulation) or analytical, statistical, manual methods are used to determine the QoS.

Quality of Service (QoS) in cellular networks is defined as the capability of the cellular service providers to provide a satisfactory service which includes voice quality, signal strength, low call blocking and dropping probability, high data rates for multimedia and data applications etc. For network based services QoS depends on the following factors as stipulated by Jain (2006):

i. Throughput: The rate at which the packets go through the network. Maximum rate is always preferred (measured by operator).
ii. Delay: This is the time which a packet takes to travel from one end to the other. Minimum delay is always preferred (measured by user).
iii. Packet Loss Rate: The rate at which a packet is lost. This should also be at a minimum as most as possible (measured by operator).
iv. Packet Error Rate: This is the errors which are present in a packet due to corrupted bits. This should be as minimal as possible (measured by operator).
v. Reliability: The availability of a connection (measured by user).

Applications often require a certain level of bandwidth, delay or security to work properly. Analyzing further, these applications reveal that their requirements also depend on the user's situation, (Kajackas, et al., 2005). The QoS depends on various parameters such as reliability, delay, jitter, bandwidth, coverage, Accessibility, call completion rate and so on. The requirement of above the parameters will differ from one application to another application.

Dushyanth, (2006) carried out another study on the QoS in cellular networks. In his study, he identified different schemes for providing Quality of Service (QoS) in cellular networks and each scheme has its own algorithm to provide QoS and every scheme has its advantages and disadvantages. He also brought about an important aspect of QoS which is the Individual QoS (iQoS), which measures the satisfaction rate per user and it is measured individually at each and every user terminal. Voice traffic is very delay sensitive and data traffic is less sensitive. The different schemes identified include:

Fault Tolerant Dynamic Allocation scheme which looks into methods of reusing the channels effectively between two cells, which are separated by a minimum distance so that they do not

interfere with each other. The channels are allocated dynamically as opposed to static allocation where the channels are allocated and reserved beforehand, (Yang, 2005).

The next scheme is the Call Admission Control (CAC) which employs pre blocking of calls based on the available bandwidth for handling calls. This algorithm is based on two schemes which were used earlier namely Pre request scheme and the guard channel scheme. CAC algorithm utilizes both the schemes and gives better performance in terms of successful call completion rates (SCCR) and provides guaranteed QoS for profiled users, (Kovvuri et al, 2003). In the Mobility prediction techniques hand off losses are reduced and due to which the blocking and the dropping probabilities are significantly reduced.

The renegotiation scheme is a scheme in which the bandwidth allocation is changed dynamically based on it availability. If a low priority service has been admitted with a bandwidth less than what it had asked and after sometime extra bandwidth is available due to completion of a high priority service then the remaining bandwidth is given to the low priority service and thus increases the QoS of the lower priority service. This scheme also ensures that the higher priority services get their requested bandwidth and they are not affected in any way, with a bandwidth less than what it had been asked for and after sometime extra bandwidth is available due to completion of a high priority service then the remaining bandwidth is given to the low priority service and thus increases the QoS of the lower priority service. This scheme also ensures that the higher priority services get their requested bandwidth and they are not affected in any way (Monego et al 2005).

(Dushyanth, 2006) emphasised on the different level of QoS such as An end - to - end service implies that the communication takes place from one Terminal Equipment (TE) to another. The user of the network service is provided with a QoS and it is the user who decides whether he is

satisfied with the QoS or not. A bearer service with clearly specified characteristics and functionalities is to be set up from source to destination to meet the network QoS requirement.

Access Bearer Service makes provision for the transport of signalling and user data between Mobile Terminated (MT) and CN Edge Node with QoS adequate to the negotiated UMTS bearer service or with default QoS for signalling.

Radio Bearer Services provides the unequal error protection if that feature has to be supported.

The Core Network Bearer Service of the Universal Mobile Telecommunication System (UMTS) core network connects the UMTS CN Edge Node with the CN Gateway to the external network. This service controls and utilizes the backbone network efficiently in order to provide the contracted UMTS bearer service.

(Thomson et al., 2000) used the Dynamic QoS Approach to carry out studies on the QoS in a dynamic environment; they also indicated various different protocols associated with the process. In the same way, (Ojesanmi, 2009) did a similar work but for the fact that the work was based precisely on the mobile agent technology enabled charging systems for efficient bandwidth utilization on mobile networks. In this work they emphasized that GSM is the most widely used mobile network in the world dating back to more than a decade ago (Bates, 1994). Amongst its objectives are the provision of good speech quality; low terminal and service cost; support for international roaming; support for handheld terminals; different range of services and facilities; spectral efficiency and ISDN compatibility. Currently, mobile phone networks are increasingly used for much more than voice calls. This is sequel to the improved capabilities of different handsets coupled with the increased data transfer rate (Chess et. al, 1995). As a result of these service improvements, mobile handsets can offer access to email, Short Message Service (SMS), Global Positioning System (GPS), IM, Multi Media Services (MMS) and WAP (Wireless

Application Protocol) based on increasing technological advancement in their operations. The sporadic growth in the acceptability of the GSM services has however led to the need to address the ever-growing complexity in the management of GSM telecommunication networks, which is sequel to expansion in size cum complexity in the delivery of services to the users.

Consequently, decentralized approaches to network/GSM services management is critically becoming evident due to the fact that centralized solutions has failed to successfully cope with scalability issues.

(Chess et. al, 1995), in a bid to avoid information overload and epileptic service rendition to the users, distributed intelligence approach to telecommunication management is currently being considered with mobile agent technology, (Bates, 1994), (Bieszczad, et al, 1998a), (Baldi and Picco, 1998); (Bieszczad and Pagurek, 1998); (Adhicandra and Pattinson, 2002); (Adhicandra, et al., 2003), providing extremely crucial role in many of these approaches (Busuoic and Griffiths, 1993).

They further stated that in order to accommodate the diversity of network components, management applications incorporate large numbers of interfaces and tools. Mobile phone network management systems are usually huge monoliths that are difficult to maintain. A review is made of a number of application areas aimed at illustrating the suitability of mobile agents in the management of mobile phone networks. The OSI management model identifies distinct functional areas based on the requirement of each category.

These include:

• Fault management

• Configuration management

• Performance management

• Network monitoring and accounting management

• Security management

There exist several potential applications in each of these areas but their focus is on network monitoring and accounting management.

On the issue of the quality of service, (Newton et. al, 2009) brought forth the idea that, the Quality of Service (QoS) which is a set of service requirements to be met by the network operators, often require a certain level of bandwidth, delay or security to work properly by applications. Analyzing further, these applications reveals that their requirements also depend on the user's situation. The QoS depends on various parameters such as reliability, delay, jitter, bandwidth, and so on. The requirement of above parameters will differ from one application to another application. The applications among others are video, audio, file transfer and web access. One of the aims of QoS is to manage the service response provided to low-speed devices such as mobile wireless devices. The QoS can be ensured only when the achieved / actual performance is greater than or equal to the desired performance. With the growth of mobile services, it has become very important for an operator to measure the QoS and Quality of end-user Experience (QoE) of its network accurately and improve it further in the most effective and cost-efficient way to achieve customer loyalty and maintain competitive edge. The service provider must take steps to introduce new mechanisms to achieve the desired performance. Otherwise, QoS cannot be achieved.

A general survey research was carried out on the quality of service on GSM in Portugal at (ANACOM , 2005). This survey's methodology is based on automatic end-to-end tests, thus identifying the quality of service on the field and providing the most realistic perspective on the networks' performance, from the user's standpoint. The results of the study only reflect the

behaviour of the networks on the places and moments of the measurements. It was discovered that there is continuous improvement in the QoS of the networks under study.

This work covered some QoS indicators on three major networks (OPTIMUS, TELECEL and TMN) at different areas of the country. The research was conducted for a period of five months where calls were made in some 23 cities and 10 major road arteries. Each call made lasted for a period of 75seconds giving a total of 250 calls were made in cities while 23,446 calls were made in major roads that covered a total mileage of 10,000Km. In his work an expensive and time-consuming automatic end-to-end testing method provided the exact information on the QoS provided by the telecommunication operators assessed in situ, thus giving an exact picture of the network performance from the user's point of view. Three different QoS indicators were used in the survey they include: Accessibility, coverage and audio quality. Three aspects were used in this method i.e. end-to-end measurement, impartiality and objectivity. The results of the analysis were displayed in the histogram form and it showed that the QoS provided by the network operators at that time in the stipulated locations was generally good.

In Bangladesh, the QoS of mobile operators was very poor as the studies carried out on the influence of Regulatory Environment on Service Quality on mobile phone sector (Yusuf, 2010) revealed. Three different focus groups were used to conduct the research so as to cut across the main segment of GSM users in the country. These groups include the households, business people and the professionals. Further the QoS was also differentiated into two broad groups of equipment and system oriented quality that include: activities directly related to the network and the people and process oriented quality comprising of activities provided over the network or face to face. He singled out the QoS indicators like network performance (made up of call success rate/ call set up success rate, call dropping rate, voice quality), customer services (call

answered by operator and complaints handling) and inaccurate billing to approximately measure the QoS. The result of the interview and meetings with the focused groups were presented in a table and analysed. This revealed that there exist high tariffs and poor QoS as reported by (Yusuf and Alam, 2009). Prepaid subscribers observed that they are overcharged for their talk time. It was confirmed by the views of one of the interviewee who stated: "after our talk over mobile phone, at times it happens that we are debited/charged more than our actual talk time".

(Popoola et al, 2009) carried out a study on the evaluation and improvement on the QOS of GSM in Nigeria. The investigation was conducted in the country's Federal Capital Territory (FCT) and some selected cities in all the six geo-political zones (North West, North-Central, North-East, South-West, South-South and South-East) of the country, where all the four GSM networks considered were operating. The GSM networks studied are Celtel, ZAIN, Globacom and M-Tel. The study was conducted using structured questionnaire. The primary data obtained from this investigation was later compared with secondary data from other previous related studies.

Further works by the GSM Association Permanent Reference Document: (IR.42, 2009), revealed a model for quality of service parameters. This model has three layers. The first layer is the Network Access, the basic requirement for all the other QoS aspects and QoS parameters. The outcome of this layer is the QoS parameter Network Accessibility.

The second layer contains the other three QoS aspects Service Access, Service Integrity and Service Retainability.

The different services are located in the third layer. Their outcomes are the QoS parameters as can be seen in Figure 2.1.

Some of these QoS parameter also known as key performance indicators (KPI) will be considered for study in this research.

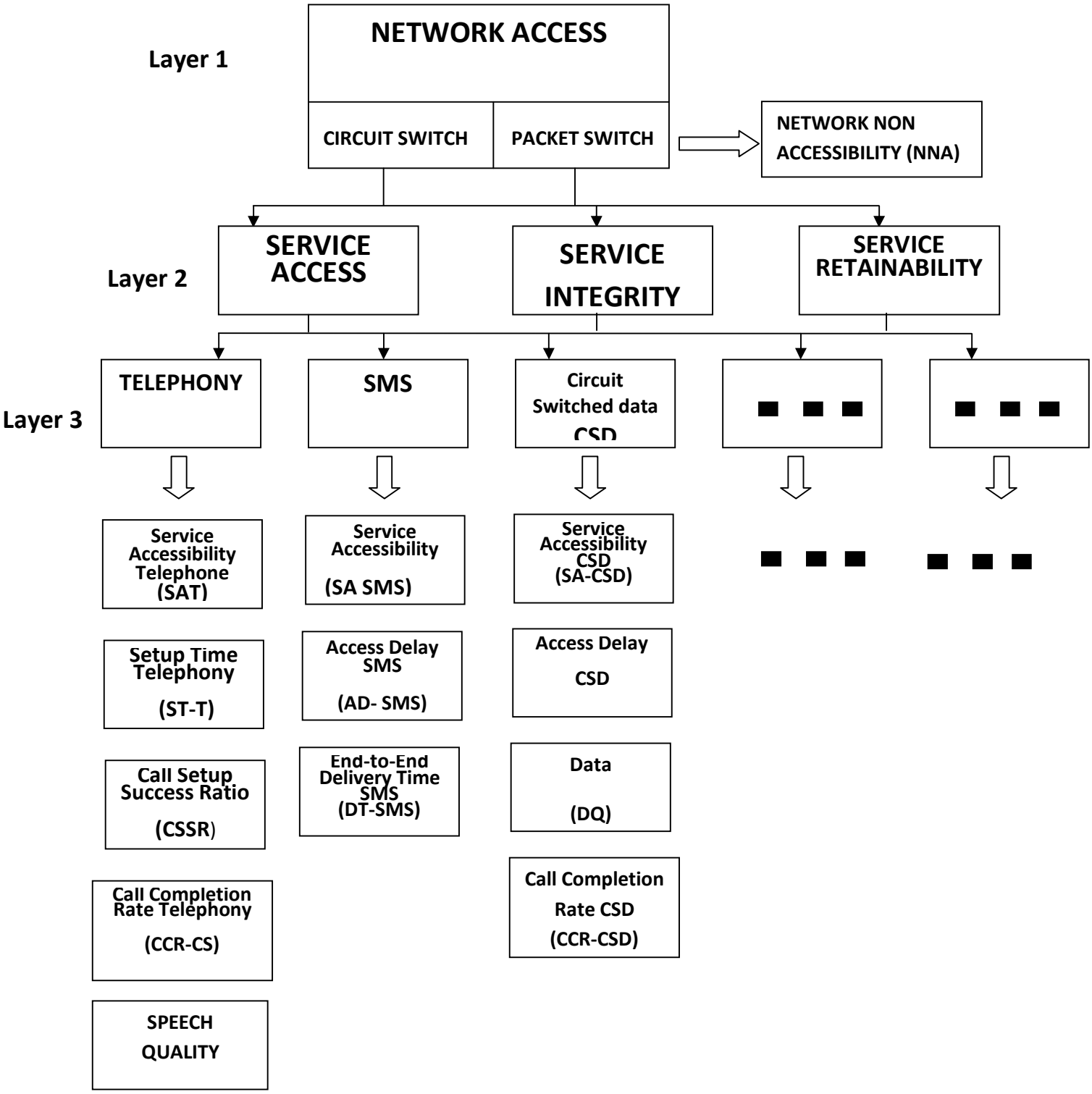


Figure 2.1: QoS aspects and the corresponding QoS parameters

Source: GSM Association Permanent Reference Document: IR.42

2.1 OVERVIEW OF MOBILE TECHNOLOGY

The Mobile network can be divided into three broad parts. The Mobile Station is carried by the subscriber; the Base Station Subsystem controls the radio link with the Mobile Station. The Network Subsystem, the main part of which is the Mobile services Switching Center, performs the switching of calls between the mobile and other fixed or mobile network users, as well as management of mobile services, such as authentication. The Mobile Station and the Base Station Subsystem communicate across the UM interface, also known as the air interface or radio link. The Base Station Subsystem communicates with the Mobile service Switching Center across the A interface.

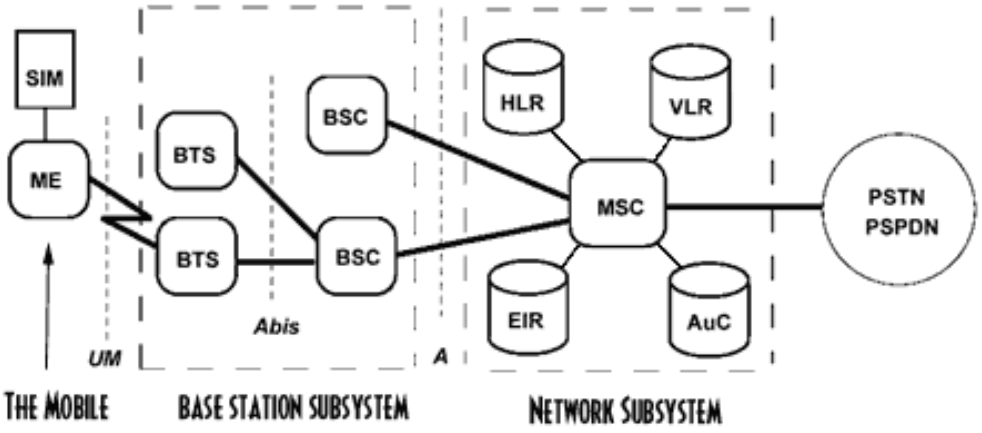


Figure 2.2: General architecture of a Mobile network

2.1.1 Mobile Station

The mobile station (MS) consists of the physical equipment, such as the radio transceiver, display and digital signal processors, and a smart card called the Subscriber Identification Module (SIM). The SIM provides personal mobility, so that the user can have access to all

subscribed services irrespective of both the location of the terminal and the use of a specific terminal. By inserting the SIM card into another GSM cellular phone, the user is able to receive calls at that phone, make calls from that phone, or receive other subscribed services. But for the CDMAs, the SIM card is configured in the phone itself.

The mobile equipment is uniquely identified by the International Mobile Equipment Identity (IMEI). The SIM card contains the International Mobile Subscriber Identity (IMSI), identifying the subscriber, a secret key for authentication, and other user information. The IMEI and the IMSI are independent, thereby providing personal mobility. The SIM card may be protected against unauthorized use by a password or personal identity number.

2.1.2 Base Station Subsystem

The Base Station Subsystem is composed of two parts, the Base Transceiver Station (BTS) and the Base Station Controller (BSC). These communicate across the specified Abis interface, allowing (as in the rest of the system) operation between components made by different suppliers.

The Base Transceiver Station houses the radio transceivers that define a cell and handles the radio link protocols with the Mobile Station. In a large urban area, there will potentially be a large number of BTSs deployed. The requirements for a BTS are ruggedness, reliability, portability, and minimum cost.

The Base Station Controller manages the radio resources for one or more BTSs. It handles radio channel setup, frequency hopping, and handovers, as described below. The BSC is the connection between the mobile and the Mobile service Switching Center (MSC). The BSC also

translates the 13 kbps voice channel used over the radio link to the standard 64 kbps channel used by the Public Switched Telephone Network.

2.1.3 Network Subsystem

The central component of the Network Subsystem is the Mobile services Switching Center (MSC). It acts like a normal switching node of the PSTN or ISDN, and in addition provides all the functionality needed to handle a mobile subscriber, such as registration, authentication, location updating, handovers, and call routing to a roaming subscriber. These services are provided in conjunction with several functional entities, which together form the Network Subsystem. The MSC provides the connection to the public fixed network (PSTN or ISDN), and signaling between functional entities uses the Signaling System Number 7 (SS7), used in ISDN and widely used in current public networks.

The Home Location Register (HLR) and Visitor Location Register (VLR), together with the MSC, provide the calling routing and (possibly international) roaming capabilities of GSM. The HLR contains all the administrative information of each subscriber registered in the corresponding GSM network, along with the current location of the mobile. The current location of the mobile is in the form of a Mobile Station Roaming Number (MSRN) which is a regular ISDN number used to route a call to the MSC where the mobile is currently located. There is logically one HLR per GSM network, although it may be implemented as a distributed database.

The Visitor Location Register contains selected administrative information from the HLR, necessary for call control and provision of the subscribed services, for each mobile currently

located in the geographical area controlled by the VLR. Although each functional entity can be implemented as an independent unit, most manufacturers of switching equipment implement one VLR together with one MSC, so that the geographical area controlled by the MSC corresponds to that controlled by the VLR, simplifying the signaling required. Note that the MSC contains no information about particular mobile stations - this information is stored in the location registers.

The other two registers are used for authentication and security purposes. The Equipment Identity Register (EIR) is a database that contains a list of all valid mobile equipment on the network, where each mobile station is identified by its International Mobile Equipment Identity (IMEI). An IMEI is marked as invalid if it has been reported stolen or is not type approved. The Authentication Center is a protected database that stores a copy of the secret key stored in each subscriber's SIM card, which is used for authentication and ciphering of the radio channel.

2.1.4 The security services provided by GSM

Anonymity: Anonymity is provided so that it is not easy to identify the user of the system. Using temporary identifiers provides it. When a user first switches on his/her radio set, the real identity (IMSI 1 number) is used, and a temporary identifier (TMSI 2 number) is then issued. From all future communication, the temporary identifier is used till end of this session. Only by tracking the user, it is possible to determine the temporary identity being used.

Authentication: Authentication is provided so that the operator knows who is using the mobile system for authorization and accounting purposes. Authentication is performed by a challenge and response mechanism. A random (RAND) challenge is issued to the Mobile Station (MS), the

mobile encrypts the challenge using the authentication algorithm (A3) and the key assigned to the mobile (SIM card key [Ki]), and sends a response (Signed Response [SRES]) back. The operator can check that, given the key of the mobile, the response to the challenge is correct.

User Data Protection: Encryption is provided so that user data passing over the radio path is protected. This is provided by A5 algorithm, input to which is a session key (Kc) and frame number (Fn) and output is the keystream, which is XORed with the plain text to get the cipher text. Session key is generated by the A8 algorithm, inputs to which are the SIM card key and a random number (RAND) is sent over by Base Station (BTS).

2.2.1 CDMA Architecture

CDMA is a modulation and multiple access scheme based on spread spectrum communication, a well-established technology that has been applied only recently to digital cellular radio communications and advanced wireless technologies.

With CDMA, each signal consists of a different pseudorandom binary sequence that modulates the carrier, spreading the spectrum of the waveform. A large number of CDMA signals share the same frequency spectrum. If CDMA is viewed in either the frequency or time domain, the multiple access signals appear to be on top of each other. The signals are separated in the receiver by using a correlator which accepts only signal energy from the selected binary sequence and despreads its spectrum. The other users' signals, whose codes do not match, do not despread in bandwidth and as a result, contribute only to the noise and represent a self interference generated by the system. The signal-to-interference ratio is determined by the ratio

of desired signal power to the sum of the power of all the other signals, and is enhanced by the system processing gain or the ratio of spread bandwidth to baseband data rate.

The major parameters that determine the CDMA digital cellular system capacity are processing gain, voice duty cycle, frequency reuse efficiency, and the number of sectors in 1 cell. The CDMA cellular telephone system achieves a spectral efficiency of up to 10 times the analogue FM system efficiency when serving the same area with the same antenna system. This is a capacity of up to one call per 10 kHz of spectrum.

In the cellular radio frequency reuse concept, interference is accepted but controlled with the goal of increasing system capacity. CDMA does this effectively because it is inherently an excellent anti-interference waveform.

Since all calls use the same frequencies, CDMA frequency reuse efficiency is determined by a small reduction in the signal-to-noise ratio caused by system users in neighbouring cells. CDMA frequency reuse efficiency is approximately 2/3 compared to 1/7 for narrowband (Frequency Division Multiple Access) FDMA systems. The CDMA system can also be a hybrid of FDMA and CDMA techniques where the total system bandwidth is divided into a set of wideband channels, each of which contains a large number of CDMA signals.

2.2.2 Authentication and security in CDMA

The authentication for CDMA access has been defined in IS-41 standard. In IS-41, intermediate keys called “Shared Secret Data (SSD)” are generated.

There is an SSD-A which is used in authentication signatures, and an SSD-B which is used for cryptographic key generation. These are each 64 bits.

There are also three session keys generated from SSD-B:

• The CMEA key (64 bits)

• The Voice Privacy Mask (520 bits)

• The DataKey (32 bits)

2.3 DIFFERENCES BETWEEN GSM AND CDMA NETWORKS

There exist some differences between the GSM and CDMA networks both in the mode of operation, technology, architecture, and so on. Some of these differences are hereby discussed.

2.3.1 Subscriber Identity Module (SIM) Card

Subscriber Identity Module (SIM) card, the onboard memory device that identifies a user and stores all of his information on the handheld device. This enables one to swap GSM SIM cards between handsets when a new one is necessary, which enables one to carry all of his contact and calendar information over to a new handset with no hassle. CDMA operators answer this flexibility with their own service that stores user data, including phone book and scheduler information, on the operator's database. This service makes it possible to not only swap over to a new handset with little trouble, but it also gives users the ability to recover contact date even if their phone is lost or stolen.

2.3.2 International Roaming with GSM and CDMA

Where international business travel is an issue, GSM leaps forward in the race for the title of "Most Accessible." Because GSM is used in more than 74% of the markets across the globe, users of tri-band or quad-band mobile stations can travel to Europe, India, and most of Asia and still use their cell phones. CDMA offers no multiband capability, however, and therefore one cannot readily use it in multiple countries. However, certain phones like the Blackberry Tour and the HTC Touch Pro 2 now have Quad-band GSM built in so they can be used overseas with special calling plans from carriers.

2.3.3 Data Transfer Methods in GSM and CDMA

Another difference between GSM and CDMA is in the data transfer methods. GSM's high-speed wireless data technology, GPRS (General Packet Radio Service), usually offers a slower data bandwidth for wireless data connection than CDMA's high-speed technology Single Carrier Radio Transmission Technology (1xRTT), which has the capability of providing Integrated Services Digital Network (ISDN)-like speeds of as much as 144Kbps (kilobits per second). However, 1xRTT requires a dedicated connection to the network for use, whereas GPRS sends in packets, which means that data calls made on a GSM handset don't block out voice calls like they do on CDMA phones

2.3.4 Interaction between GSM and CDMA

In cities and densely populated areas, there are often high concentrations of GSM and CDMA connection bases. In theory, GSM and CDMA are invisible to one another and should "play nice" with one another. In practice, however, this is not the case. High-powered CDMA signals

have raised the "noise floor" for GSM receivers, meaning there is less space within the available band to send a clear signal. This sometimes results in dropped calls in areas where there is a high concentration of CDMA technology. Conversely, high-powered GSM signals have been shown to cause overloading and jamming of CDMA receivers due to CDMA's reliance upon broadcasting across its entire available band.

The result of this little cross-broadcasting joust has led some cities to pass ordinances limiting the space between cell towers or the height they can reach, giving one technology a distinct advantage over the other. This is something to note when choosing a wireless provider. The distance between towers will severely affect connectivity for GSM-based phones because the phones need constant access to the tower's narrow band broadcasting.

2.3.5 Popularity and Market Share

GSM is a lot more widespread in Europe and Asia. In the United States, Sprint and Verizon networks are CDMA whereas AT&T and T-Mobile are on GSM. Most of Europe uses GSM and so does China. In India, Hutch, Bharti and BSNL are on GSM whereas Reliance and Tata Tele are on CDMA networks.

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

This research considers some Key Performance Indicators (KPIs) that are defined by the Nigerian Communication Commission and GSM Association Permanent Reference Document: (IR.42, 2009). These include: Telephony parameters which are made up of Service Accessibility, Call set up time, Call set up success Ratio and call completion rate.

Service Accessibility is defined as the Probability that the end-customer can access the Mobile Telephony Service when requested if it is offered by display of the network indicator on the Mobile Equipment.

$$\text{Service Accessibility (\%)} = \frac{\text{Number of successful call attempts X 100}}{\text{Number of call Attempts}} \qquad \textbf{equation 3.1}$$

Set- up Time telephony: Time between sending of complete address information and receipt of call set-up notification.

$$\text{Setup Time Telephony} = T_2 - T_1 \text{ in Seconds} \qquad \textbf{equation 3.2}$$

t_2: point of time where connect is established, t_1: point of time where the customer presses the send button on mobile equipment.

Call Setup Success Ratio (CSSR)

Call Setup Success Ratio (CSSR) expresses the relationship between the number of seizures and the sum of the number of seizures resulting in a successful established call.

$$\text{CSSR (\%)} = \frac{\text{Number of successful call establishments X 100}}{\text{Number of call attempts}} \qquad \textbf{equation 3.3}$$

Beginning of the call attempt: successful pressing send button (it is important to check, if coverage has been given when send button is pressed.

Successful call establishment: open connection between A-party and B-party, where both parties can hear each other.

Call Completion Rate Circuit Switched Telephony (CCR-CS-T):

Probability that a successful call attempt is maintained for a predetermined time until it is released intentionally by A- or B-party.

$$\text{CCR-CS-T}(\%) = \frac{\text{Number of intentionally terminated calls} \times 100}{\text{Number of successful call attempts telephony}} \qquad \textbf{equation 3. 4}$$

Successful call attempt: connect measurement (e.g. 'alerting' or 'busy' detected by A- party)
Terminated call: release of connection directly by A- or B-party.

3.1 MATERIALS

For the purpose of this research the following materials will be needed:

- Mobile cellular phones that are in full good working conditions,
- Subscribers Identification Modules (SIMs) for all the networks under consideration (ZAIN and Globacom) as well as Visafone and Starcomms network SIMs
- An electronic stop watch

A designed form to collect the data for the parameters under study such as: Name of network, call setup time telephony, Call Setup Success Ratio calls completion status among others for both intra and inter network calls.

3.2 PROCEDURE

The mobile cellular sets are each equipped with a different SIM card from each network under study. Assurance is made of full power, enough credit, and full functioning of the cellular phone. Calls were made randomly from ten selected locations around Zaria to any other part of the Country. On daily basis, the data was collected four times Starting at 6.00am stretching over to 6 p.m. at an interval of every two hours. This therefore, lasted for a period of twelve hours where each call made took duration between fifteen seconds and sixty seconds. This daily period of twelve hours, is to ensure that about half of the total twenty-four hours is covered and hence to ascertain that peak call periods are covered. The exercise lasted for a period of fourteen days (two weeks). At the end of every time slot therefore, 160 (16 call x 10areas) calls were made while for the whole day, 640 (4 times x 160) calls were carried out. This gives a total of 8960 (14 days x 10 different areas x 4 times x 16) calls for the fourteen days of data collection period.

The calls were made for both intra and inter networks and then GSM and CDMA (Code Division Multiple Access) networks to ensure that all of the network interactions are attended to. At each instance, the data collected either from the mobile cellular set or the electronic stop watch or both was recorded in the appropriate form designed (see appendix 1).

Data for analysis was extracted from the data in appendix 1 for each network type. Line graphs were used to show the trend of intra and inter connection while bar charts were also used for the

comparison of the network type based on each KPI for given instance or period as the case may be.

Calculations of inter connection for each of the KPIs for each network and network type would be made. A graph of the values was plotted using Micro soft Excel for windows 2007, first for each intra network type and secondly for inter network type, one for each network and network type to show the individual trend on the QoS for the particular KPIs under consideration. The mean values of each KPI per network together with the line graph would be able to reveal the network with a better QoS for intra and inter network telephony. In the same way the comparison was made between the GSM and CDMA network types, by use of bar charts.

The data was collected from ten different locations in Zaria vicinity; these areas were selected in such a way that different base stations and transceivers were considered. The locations included: Samaru, Shika, Kongo, Deke chi, Wusasa, Basawa, Muchia, Kofa Doka, Gaskiya and Angwa Godo. It was also made sure that the data was collected especially from those areas where network traffic is always very high such as in different campuses like; Ahmadu Bello University, Samaru and Kongo campuses, Federal College of Education Zaria, Ameer Shehu Idris College of Advanced Studies campus, Nuhu Bamalli Polytechnic, Gaskiya campus, College of Agriculture campus, College of Chemical and Leather Research all in Samaru.

3.2.1 QUALITY OF SERVICE

Aggregate values from the various tables of each network and network type, were taken to obtain the general Quality of Service (QoS) considering all the stated KPIs. These values will be tabulated and hence bar charts will be constructed from them.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.0 INTRODUCTION

The data collected during the research period is hereby presented and the analysis done for all the KPIs under consideration for all the network types.

A total of 8960 calls were made from the networks under study. In order to carry out the analysis, the averages and totals for the call set up time and other KPIs respectively were calculated for the ten different locations for the study period of fourteen days. This reduces the data to a total of 64 calls. Furthermore, the averages for each intra and inter connections for each network and time instance are found again. This is done same by finding the totals of the other KPIs. These are now used to determine the behaviour of the networks according to the equations given in equations 3.1, 3.2, 3.3 and 3.4 relative to the KPIs under consideration.

4.1 SERVICE ACCESSIBILITY

The values for these tables (4.1 and 4.2) are gotten by finding the sum of all successful call attempts for the different time instances for each of the different Network types for the two weeks from each of the ten different locations of data collection. This gives a total of 42 (14 x 3) successful calls attempts for a given time instance and then a total of 56 (14 x 4) calls from each network type. The best service accessibility time for the location is obtained by taking the time with the highest values of successful call attempts while the service accessibility of each network type is obtained by taking the highest percentage values when expressed in percentage form as seen in equation 3.1. It is worth noting that a successful call attempt is when the caller hears the

phone rings or gives a comment such as number busy, number not available or number switched off, number does not exist from the machine.

Table 4.1: Service Accessibility Intra Network connection for Wusasa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	13	14	55	98.2
ZAIN	14	14	14	14	56	100
STAR	12	13	14	13	52	97.3
VISA	14	13	14	14	55	92.8
Total	54	54	55	55		

The different values for each time instance indicates the number of all the successful call attempts made for those time instances for all networks type for Wusasa, this shows that none of the time instances had all the calls successful. This is an indication that there is no network that has 100percent complete accessibility at Wusasa. It can thus be seen from table 4.1, that service Accessibility is best at about 12-14 pm and between 16-18pm this is because 55 out of the 56 intra network calls made at these time instances were successful.

It also reveals that, Zain possesses the best intra connection service accessibility qualities carrying a 100%. This is closely followed by that of Globacom with 98.2%. Starcomms follows suite (97.3%), then Visafone recorded the lowest accessibility value of 92.8%. This again shows that only GSM networks have good intra connection accessibility than the CDMA networks.

Table 4.2: Service Accessibility, GSM Inter Network connection for Wusasa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	12	14	13	14	53	94.6
GLO/ STAR	13	13	13	13	52	92.9
GLO/ VISA	14	13	14	13	54	96.6
Total	**39**	**40**	**40**	**40**		$\bar{x}$**=94.7**
ZAIN/GLO	14	14	13	14	55	98.2
ZAIN/STAR	14	14	12	14	54	96.6
ZAIN/VISA	13	13	14	14	54	96.6
Total	**41**	**41**	**39**	**42**		$\bar{x}$**=97.1**

The table (4.2) shows that interconnections by Globacom were good at time instances of 8-10am, 12-14 and 16-18pm each with a total value of 40 successful calls. That of Zain outweighed it as all its values are higher with the best accessibility time at 16-18pm, which is followed closely by that 6-8am then by that between 8-10am. It was low at about noon. In same vein, Zain performed better than Globacom in this KPI.

The results show that Zain has good Service Accessibility with the Globacom where it records a percentage of 98.2%, then followed by that with star and Visafone (96.6%) which also goes to Globacom and Visafone interconnections. The lowest percentage value exists only with Globacom/Starcomms; showing a percentage of 92.9%. Therefore, it is seen that Zain interconnects well with CDMAs than Globacom does.

Table 4.3: Service Accessibility, CDMA Inter Network connection for Wusasa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
VISA/GLO	12	12	13	14	51	91.1
VISA/ STAR	14	13	14	13	54	96.6
VISA/ZAIN	14	12	14	14	54	96.6
Total	**39**	**40**	**40**	**40**		$\bar{x}$**=94.8**
STAR/GLO	13	12	14	12	51	91.1
STAR/ZAIN	14	13	14	14	54	96.6
STAR/VISA	14	13	14	14	55	98.2
Total	**41**	**41**	**39**	**42**		$\bar{x}$**=95.3**

Table 4.3 shows that Visafone network has no complete interconnections for any time instance. Its best interconnection is seen as from 8-10am, 12-14pm and 16-18pm with 40 successful calls each, this is immediately followed by that at 6-8am with a just a unit lower (39). At the same time, Starcomms performance is best at 16-18pm where all the calls made (42) went successful. The trend jumps to 6-8 am and 8-10am where only one call fails (41). At 12-14pm only 39 calls attempts went successful. Starcomms performed better than the Visafone.

It is also seen that CDMA networks have Service Accessibility of 98.2% as indicated by the Starcomms/Visafone interconnection. This is followed by that of Starcomms/Zain, Visafone/Starcomms, Visafone/Zain all with percentage value of 96.6%. It is clear then that CDMAs have a higher service accessibility when inter connecting with GSM networks as well as with CDMA networks.

Table 4.4: Service Accessibility Intra Network connection for Deke Chi Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	14	14	14	14	56	100
STAR	14	13	14	13	54	96.4
VISA	14	14	12	14	54	96.4
Total	**56**	**55**	**54**	**55**		

All the 56 calls made at 6-8am were accessible, this value declined slowly throughout the day.

All the calls attempts from the GSM lines were all accessible with 100% service accessibility, table 4.4

Table 4.5: Service Accessibility, GSM Inter Network connection for Deke Chi Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	14	14	13	13	54	96.4
GLO/ STAR	14	13	14	14	55	98.2
GLO/ VISA	13	14	13	14	54	96.4
Total	**41**	**41**	**40**	**41**		$\bar{x}$**=97.0**
ZAIN/GLO	12	14	14	14	54	96.4
ZAIN/STAR	14	14	14	14	56	100
ZAIN/VISA	14	14	14	14	56	100
Total	**40**	**42**	**42**	**42**		$\bar{x}$**=98.8**

Table 4.5 indicated that all the daylong only 12-14pm experienced up to two inaccessible calls, thus the other time instances scored 41 accessible calls. For zain line all the calls (42) were accessible from 8am to 18pm.

Glo/star had a service accessibility value of 98.2% while for zain/glo 96.4% were accessible but the rest of the calls from the same zain network were all (100%) accessible.

Table 4.6: Service Accessibility, CDMA Inter Network connection for Deke Chi Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
VISA/GLO	14	14	14	13	55	98.2
VISA/ STAR	13	14	14	11	52	92.8
VISA/ZAIN	14	14	14	13	55	98. 2
Total	**41**	**42**	**42**	**37**		$\bar{x}$**=96.4**
STAR/GLO	14	14	13	14	55	98.2
STAR/ZAIN	14	14	14	14	56	100
STAR/VISA	14	13	13	13	53	94.6
Total	**42**	**41**	**40**	**41**		$\bar{x}$**=97.6**

Service accessibility for Visafone was good at 8am to 14pm where all the 42 calls were accessible but for Starcomms this value of 42 is only observed at 6-8am

98.2% service accessibility was observed from visa/glo and visa/zain interconnection. At the same time star/zain observed 100% service accessibility, as seen from table 4.6.

Table 4.7: Service Accessibility Intra Network connection for Shika Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	13	13	13	14	53	94.6
ZAIN	14	14	13	13	54	96.4
STAR	14	13	13	14	54	96.4
VISA	14	12	14	13	53	94.6
Total	**52**	**53**	**52**	**55**		

Service accessibility was high at 16-18pm where 55 accessible calls were registered. Visafone and Globacom networks scored 94.6% each for the accessible calls as shown in table 4.7.

Table 4.8: Service Accessibility, GSM Inter Network connection for Shika Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	14	14	14	14	56	100
GLO/ STAR	14	14	14	13	55	98.2
GLO/ VISA	13	13	14	14	54	96. 4
Total	**41**	**41**	**42**	**41**		$\bar{x}$**=98.2**
ZAIN/GLO	12	14	12	14	52	92.9
ZAIN/STAR	13	14	14	13	54	96.4
ZAIN/VISA	14	14	14	14	56	100
Total	**39**	**42**	**40**	**41**		$\bar{x}$**=96.4**

Mid day (12-14pm) registered 42 accessible calls from Globacom network this number was also registered from Zain network at 8-10am.

For Glo/zain and Zain/Visa interconnections all the calls were accessible as revealed from table 4.8.

Table 4.9: Service Accessibility, CDMA Inter Network connection for Shika Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
VISA/GLO	14	13	14	13	54	96.4
VISA/ STAR	13	13	13	14	53	94.6
VISA/ZAIN	13	14	13	13	53	94. 6
Total	**40**	**40**	**40**	**40**		$\bar{x}$**=95.2**
STAR/GLO	14	14	13	13	54	96.4
STAR/ZAIN	13	12	13	14	52	92.6
STAR/VISA	13	13	14	14	54	96.4.
Total	**40**	**39**	**40**	**41**		$\bar{x}$**=95.1**

Table 4.9 showed that the whole day from 6am to 6pm had a flat accessibility of 40 calls out of 42 for Visafone network and 41 accessible calls were recorded at 16-18pm from Starcomms network.

While visa/star and visa/zain obtained 94.6% of accessible calls, star/visa and star/glo recorded 96.4%.

Table 4.10: Service Accessibility Intra Network connection for Zaria City Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	13	14	13	13	53	94.6
STAR	13	13	13	14	53	94.6
VISA	13	13	12	14	52	92.9
Total	**53**	**54**	**52**	**55**		

Generally access to service is obtained almost all day long in Zaria city when carrying out intra calls as seen from table 4.10. The best results of 55 calls were obtained at 16-18pm, 54 at 8-10am then 53 at 6-8am but at mid day it fell down to 52 calls.

All the calls made from Globacom experienced full service of 100%, zain and Starcomms got 94.6% each while visa rounded it with only 92.9% as indicated in table 4.10.

Table 4.11: Service Accessibility, GSM Inter Network connection for Zaria City Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	13	13	12	14	52	92.9
GLO/ STAR	13	14	14	14	55	98.2
GLO/ VISA	14	14	14	13	55	98.2
Total	**40**	**41**	**40**	**41**		$\bar{x}$**=96.4**
ZAIN/GLO	14	14	12	14	54	96.4
ZAIN/STAR	14	12	13	13	52	92.9
ZAIN/VISA	13	13	14	13	53	94.6
Total	**41**	**39**	**39**	**40**		$\bar{x}$**=94.6**

The table 4.11 shows that Globacom inter plays well with any other network. This is seen from the results as 6-8am and 12-14pm registered 40 accessible calls each and 8-10am and 16-18pm

41 accessible calls each. Zain better inter connection is at 6-8am with 41 calls then 16-18pm with 40 calls. 8-10am and 12-14pm both registered 39 calls each.

The table again shows that Glo/star and Glo/visa inter connection are good as 98.2% of the calls made were all accessible but Glo/zain performance is low with 92.9% calls. Zain/glo stood at 96.4% as highest, then 94.6% for zain/visa and Zain/star at 92.4% as lowest. This indicates that Globacom inter connects well with CDMAs as shown in table 4.11.

Table 4.12: Service Accessibility, CDMA Inter Network connection for Zaria City Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
VISA/GLO	14	12	14	14	54	96.6
VISA/ STAR	13	13	14	13	53	94.6
VISA/ZAIN	13	12	13	13	51	91.1
Total	**40**	**37**	**41**	**40**		$\bar{x}$**=94.1**
STAR/GLO	14	14	14	14	56	100
STAR/ZAIN	13	14	14	12	53	94.6
STAR/VISA	14	13	14	14	55	98.2
Total	**41**	**41**	**42**	**40**		$\bar{x}$**=97.6**

Table 4.12 revealed that Starcomms had a good accessibility for the whole period especially at mid day where 42 calls were accessed, 6-8 am and 8-10am 41 calls and lastly 40 calls at 16-18pm. Visa's 41 calls also experienced at mid day, then 40 calls at 16 -18pm and 6-8am while a lower value was recorded at 8-10am with only 37 calls.

Starcomms played well with Globacom scoring 100%, the 98.2% with Visa and 94.6% as its lower percentage with zain, while 96.6% was registered by Visa/Glo the 94.6% and 91.1% by visa/star and visa/zain respectively. This shows that Starcomms inter connects well with both network types especially GSM.

Table 4.13: Service Accessibility Intra Network connection for Angwua Godo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	13	14	14	14	55	98.2
ZAIN	14	14	13	13	54	96.4
STAR	14	14	13	14	55	98.2
VISA	14	14	14	14	56	100
Total	**55**	**56**	**54**	**55**		

Table 4.13 showed that all the calls (56) made at 8-10am were all easily accessible as those at 6-8am and 16-18pm reduced by a unit yielding 55 of the accessible calls then 54 at 12-14pm. This shows that intra accessibility was high at 8-10am. Visafone registered the highest performance as all calls from it went through, then followed by Globacom and Starcomms with 55 calls and lastly by Zain with 54 calls.

Table 4.14: Service Accessibility, GSM Inter Network connection for Angwua Godo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	13	14	13	14	54	96.4
GLO/ STAR	13	14	13	14	54	96.4
GLO/ VISA	14	14	14	14	56	100
Total	**40**	**42**	**40**	**42**		$\bar{x}$**=97.6**
ZAIN/GLO	14	14	14	14	56	100
ZAIN/STAR	14	13	13	14	54	96.4
ZAIN/VISA	12	14	13	12	51	91.1
Total	**40**	**41**	**40**	**40**		$\bar{x}$**=95.8**

GSM Inter connection was accessible at 8-10am and 16-18pm with all the 42 calls accessible for Globacom while 8-10am, 42 calls were recorded. This was closely followed by rest of the time instances each with 40 calls. In same manner, Zain highest accessibility was registered at 8-

10am with 41 calls and the 40 calls for the rest of the day. Glo/Visa and Zain/Glo were all fully accessible as they scored 100% each (table 4.14).

Table 4.15: Service Accessibility, CDMA Inter Network connection for Angwua Godo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
VISA/GLO	14	13	14	14	55	98.2
VISA/ STAR	14	13	14	13	54	96.4
VISA/ZAIN	13	14	13	12	52	92.8
Total	**41**	**40**	**41**	**39**		$\bar{x}$**=95.8**
STAR/GLO	13	14	14	14	55	98.2
STAR/ZAIN	14	13	14	14	55	98.2
STAR/VISA	13	14	14	13	54	96.4
Total	**40**	**41**	**42**	**41**		$\bar{x}$**=97.6**

The accessibility for Visafone a good time of 6-8am and 12-14pm with 41 calls were recorded then Starcomms had it at mid day with 42 calls and 41 at 8-10am and 16- 18pm. Notwithstanding, Visa/glo, star/glo and star/zain each scored 98.2% accessibility (table 4.15).

Table 4.16: Service Accessibility Intra Network connection for Kongo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	13	55	98.2
ZAIN	13	14	14	11	52	92.8
STAR	13	14	14	13	54	96.4
VISA	14	14	14	14	56	100
Total	**54**	**56**	**56**	**51**		

Table 4.16 indicates that 8-10am and 12-14pm has a good accessibility as all the calls made were all accessible. At the same time; Visafone has the best accessibility of 100% followed by Globacom with 98.2%.

Table 4.17: Service Accessibility, GSM Inter Network connection for Kongo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	14	14	14	13	55	98.2
GLO/ STAR	14	14	14	13	55	98.2
GLO/ VISA	14	14	14	13	55	98.2
Total	**42**	**42**	**42**	**39**		$\bar{x}$**=98.2**
ZAIN/GLO	14	14	14	13	55	98.2
ZAIN/STAR	14	13	14	14	55	98.2
ZAIN/VISA	13	13	12	14	52	92.9
Total	**40**	**41**	**40**	**40**		$\bar{x}$**=96.4**

It can be seen from table 4.17 that Service Accessibility for GSM interconnection was very good from morning 6am till afternoon for Globacom connections and for Zain 8-10am has 41 easily accessible calls. The rest of the time instances all obtained 40 calls.

Globacom connections to any other network were good as 98.2% was registered for all the calls made from it. Zain only fell a bit below the 98.2% when connecting with Visafone (92.9%)

Table 4.18: Service Accessibility, CDMA Inter Network connection for Kongo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	Tota l	%
VISA/GLO	13	12	14	14	53	94.6
VISA/ STAR	13	14	14	13	54	96.4
VISA/ZAIN	13	14	14	14	55	98.2
Total/%	**39**	**40**	**42**	**41**		$\bar{x}$**=96.4**
STAR/GLO	14	13	14	14	55	98.2
STAR/ZAIN	14	13	13	14	55	98.2
STAR/VISA	12	14	14	13	54	96.4
Total	**40**	**40**	**41**	**41**		$\bar{x}$**=97.6**

Mid day connection with 42 calls made successfully was the best when using Visafone. This dropped a by unit at 16-18pm. Starcomms accessibility for interconnections was good from 12 noon down to 18pm, 41 calls were easily accessed. The rest of the day got 40 calls.

Visa/Zain connection was easily accessible with a 98.2%, while Star/glo and star/zain all stood at 98.2%. Starcomms inter connects fairly well with GSM networks than Visafone (table 4.18)**.**

Table 4.19: Service Accessibility Intra Network connection for Samaru Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	13	13	14	14	54	96.4
ZAIN	14	13	14	14	55	98.2
STAR	11	14	13	14	53	94.6
VISA	14	14	14	14	56	100
Total	**50**	**54**	**55**	**56**		

Table 4.19 revealed that service became stronger from noon down to 18pm as 6-8am with 50 successful calls emerges the lowest then 54 at 8-10am, 56 at 16-18pm. Of these networks Visafone acted well in the KPI for all calls from it were easily accessible.

Table 4.20: Service Accessibility, GSM Inter Network connection for Samaru Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	Total	%
GLO/ ZAIN	13	13	14	14	54	96.4
GLO/ STAR	14	13	14	14	55	98.2
GLO/ VISA	14	14	11	12	55	98.2
Total	**41**	**40**	**39**	**40**		$\bar{x}$**=97.6**
ZAIN/GLO	13	13	14	13	53	94.6
ZAIN/STAR	13	13	12	14	52	92.9
ZAIN/VISA	12	13	14	14	53	96.4
Total	**38**	**39**	**40**	**41**		$\bar{x}$**=94.6**

Globacom connection is good between 6-8am with 41 calls service access while Zain with also 41 calls service accessed at 16-18pm. Globacom also connect Starcomms and Visafone with 98.2% accessibility rate while zain did it better with Visafone at 96.4% (table 4.20).

Table 4.21: Service Accessibility, CDMA Inter Network connection for Samaru Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	Tota l	%
VISA/GLO	13	14	14	14	55	98.2
VISA/ STAR	14	14	14	13	55	98.2
VISA/ZAIN	14	13	14	14	55	98.2
Total	**40**	**37**	**41**	**40**		$\bar{x}$**=98.2**
STAR/GLO	14	14	13	13	54	96.4
STAR/ZAIN	14	13	12	13	52	92.9
STAR/VISA	13	12	13	14	52	92.9
Total	**41**	**41**	**42**	**40**		$\bar{x}$**=94.1**

Good service accessibility rate of 41 calls for Visafone lines and 42 calls for Starcomms lines were obtained between 12-14pm

Visafone inter connected all other networks with a service accessibility of 98.2% whereas Starcomms interconnected Globacom at 96.4% (table 4.21)

Table 4.22: Service Accessibility Intra Network connection for Basawa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	13	14	14	14	55	98.2
STAR	14	14	14	12	54	96.4
VISA	12	14	13	14	53	94.6
Total	**53**	**56**	**56**	**54**		

From the table 4.21, it is seen that all the calls from 8am to 14pm were all accessible.

Of these the network with good intra connection was Globacom whose calls were completely (100%) accessible .while for the CDMAs, star came up with 96.4% of them

Table 4.23: Service Accessibility, GSM Inter Network connection for Basawa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	Total	%
GLO/ ZAIN	13	14	13	14	54	96. 4
GLO/ STAR	14	13	13	14	54	96.4
GLO/ VISA	14	12	12	14	52	92.9
Total	**41**	**39**	**38**	**42**		$\bar{x}$**=95.2**
ZAIN/GLO	14	14	13	14	55	98.2
ZAIN/STAR	14	14	14	12	54	96.4
ZAIN/VISA	14	13	14	14	55	98.2
Total	**42**	**41**	**41**	**40**		$\bar{x}$**=97.6**

From table 4.23 it is seen that all the calls made from globacom line at 16 -18pm were through with a value of 42 while for Zain, 42 came up from 6-8am.

Glo/zain and Glo/star accessibility was highest at 96.4% each then Zain/glo and Zain/Visa came with 98.2% each. Zain played well in this KPI at this location.

Table 4.24: Service Accessibility, CDMA Inter Network connection for Basawa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	Total	%
VISA/GLO	12	13	12	13	50	89.3
VISA/ STAR	14	14	11	14	53	94.6
VISA/ZAIN	13	14	14	14	55	98.2
Total	**37**	**41**	**37**	**41**		$\bar{x}$**=94.0**
STAR/GLO	14	14	14	14	55	98.2
STAR/ZAIN	12	14	14	13	53	94.6
STAR/VISA	14	13	13	13	53	94.6
Total	**40**	**41**	**41**	**40**		$\bar{x}$**=95.8**

Table 4.24 shows a good results of 41 accessible calls are gotten at 8-10am and 16-18pm for Visafone line and 8am to 14pm for Starcomms lines.

Visa/zain interconnection was some ease as the accessibility value of 98.2% which went same for Star/Glo interconnection.

Table 4.25: Service Accessibility Intra Network connection for Gaskiya Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	13	14	14	14	55	98.2
STAR	13	13	12	13	51	91.1
VISA	12	12	12	14	50	89.3
Total	**52**	**53**	**52**	**55**		

A total of 55 calls were accessible at 16-18pm the rest of the day fell below this figure. Calls from Globacom line were all (100%) completely accessible (table 4.25).

Table 4.26: Service Accessibility, GSM Inter Network connection for Gaskiya Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	Total	%
GLO/ ZAIN	14	14	13	14	55	98. 2
GLO/ STAR	13	14	13	13	53	94. 6
GLO/ VISA	13	14	12	14	53	94.6
Total	**40**	**42**	**38**	**41**		$\bar{x}$**=95.8**
ZAIN/GLO	14	13	14	14	55	98.2
ZAIN/STAR	13	14	13	14	54	96.4
ZAIN/VISA	14	13	14	14	55	98.2
Total	**41**	**40**	**41**	**42**		$\bar{x}$**=97.6**

Table 4.26 shows that all the calls made from Globacom line at 8-10am were accessible, but this figure was recorded from zain line came up at 16-18pm.

From globacom line, 98.2% of the calls were accessible while the same percentage was obtained from zain/visa and zain/glo interconnection.

Table 4.27: Service Accessibility, CDMA Inter Network connection for Gaskiya Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
VISA/GLO	09	12	13	13	47	83. 9
VISA/ STAR	14	12	13	13	52	92.9
VISA/ZAIN	13	13	14	14	54	96.4
Total	**36**	**39**	**40**	**40**		$\bar{x}$**=91.1**
STAR/GLO	13	12	14	14	53	94.6
STAR/ZAIN	14	14	14	14	56	100
STAR/VISA	14	14	13	14	55	98.2
Total	**41**	**40**	**41**	**42**		$\bar{x}$**=97.6**

Visafone calls (40) were easily accessible from mid day till 18pm, then 42 calls were realised from Starcomms line at 16-18pm. Star/zain calls were all accessible while visa/zain recorded 96.4% (table 4.27).

Table 4.28: Service Accessibility Intra Network connection for Muchia Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	14	13	14	14	55	98.2
STAR	14	14	13	13	54	96.4
VISA	14	14	14	13	55	98.2
Total	**56**	**55**	**55**	**54**		

The table 4.28 shows that it would be better to call at 6-8am from any network since all the 56 calls attempted were all accessible. At the same time, calling from Globacom network proved to be the best since all the calls from it were accessible.

Table 4.29: Service Accessibility, GSM Inter Network connection for Muchia Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	14	14	13	14	55	98.2
GLO/ STAR	14	14	14	13	55	98.2
GLO/ VISA	14	13	14	14	55	98. 2
Total	**42**	**41**	**41**	**41**		$\bar{x}$**=98.2**
ZAIN/GLO	13	14	12	14	53	94.6
ZAIN/STAR	14	13	13	14	54	96.4
ZAIN/VISA	14	14	13	14	55	98.2
Total	**41**	**41**	**38**	**42**		$\bar{x}$**=96.4**

Making and inter call at 6-8am from Globacom is better. All the calls made at this time of the day from GSM network were accessible. Similarly, all the Globacom calls to other networks performed in the same manner with the same service accessibility percentage of 98.2%. On the other hand, at this area, evening time (16-18pm) is good to make calls as all calls made from zain to any other network were accessible with the best of them observed with zain/visa interconnection (table 4.29).

Table 4.30: Service Accessibility, CDMA Inter Network connection for Muchia Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
VISA/GLO	14	14	14	14	56	100
VISA/ STAR	12	14	14	14	54	96.4
VISA/ZAIN	13	14	14	13	54	96. 4
Total	**39**	**42**	**42**	**41**		$\bar{x}$**=97.6**
STAR/GLO	14	14	14	14	56	100
STAR/ZAIN	14	14	14	13	55	98.2
STAR/VISA	14	14	13	13	54	96.4
Total	**42**	**32**	**41**	**41**		$\bar{x}$**=98.2**

Table 4.30 shows that the time 8am to 14pm had a good service accessibility since all the 42 calls made from Visafone network were accessible. Of these calls 100% value was recorded by Visa/Glo interconnection. The same 100% was also recorded by Star/glo interconnection though the best accessible time came up in the morning hours of 6-8am.

4.2 SET UP TIME TELEPHONY

This is the time between sending of a complete address information and receipt of call set-up notification.

The data is collected by the use of an electronic stop watch as stated in equation 3.2.

The tables (4.31, to 4.60) comprise of values derived by finding the average time in seconds for each of the time instances for the fourteen days. Their sum is obtained and then the average for the four network type is found and recorded in the last columns. The sum for each column is found and used to determine which of the time instances has the best set up time, the smaller the time the better the set up time.

Table 4.31: Set Up Time Telephony Intra Network connection for Wusasa Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	6.9	7.5	6.9	6.6	7.0
ZAIN	5.0	6.7	7.6	7.9	6.8
STAR	6.4	5.5	6.7	8.4	7.0
VISA	6.0	6.1	6.6	7.0	6.4
Total($\bar{x}$)	**24.3 (6.1)**	**25.8 (6.4)**	**27.8 (6.9)**	**29.9 (7.4)**	

It is indicated in table 4.31 that a better set up time was experienced in the morning hours at about 6-8am though afternoon as the average values progressed from 6.1,6.4 and 6.9 respectively then higher at 16-18pm with an average value of 7.4 seconds. This is as revealed from the total/average of each column.

The Intra Network connection set up telephony time is highest with Globacom and Starcomms networks with both taking 7.0 seconds to connect, closely followed by Zain with a value of 6.8 seconds while the Visafone interconnects at a lowest time value of 6.4 seconds. This signifies that CDMAs connect faster than the GSM networks, with Visafone having the best setup time (6.4 seconds) among all the CDMA networks. All the network types showed a better Set- Up

Table 4.32: Set Up Time, GSM inter connection for Wusasa Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	6.0	7.0	7.0	7.2	6.8
GLO/ STAR	4.9	6.7	6.8	7.2	6.4
GLO/VISA	7.2	8.5	7.4	8.4	7.9
Total ($\bar{x}$)	**24.3(8.1)**	**25.8 (8.6)**	**27.8 (9.3)**	**29.9 (9.7)**	
					$\bar{x}$=7.0
ZAIN/GLO	6.0	6.9	12	6.9	8.0
ZAIN/STAR	6.1	7.4	6.6	6.5	6.7
ZAIN/VISA	9.7	7.0	9.0	6.7	5.9
Total ($\bar{x}$)	**21.8(7.3)**	**21.3 (7.1)**	**25.6(8.5)**	**20.1(6.7)**	
					$\bar{x}$=6.9

Generally, Globacom/starcomms has a good set up interconnection time at 6-8am where an average value of 4.9 seconds is recorded as against the highest value of 9.7 seconds for Zain/Visafone inter connection. Globacom also connects fast at 6-8am while zain connects the fester at 16-18pm. Zain performed well at the other time instances than did Globacom. Hence Zain connects general with ease to other networks considered.

Zain has a better set up telephony interconnection time (5.9 seconds) with Visafone and takes much time (6.7 and 8.0 seconds) to connect with Starcomms and Globacomm respectively. Meanwhile, the set up telephony time of Globacom/Visafone is 7.9 seconds then 6.8 seconds with Zain and with Starcoms as low as 6.4 seconds. Zain can therefore be said to have a better inter connection set up time than Globacom (table 4.32).

Table 4.33: Set Up Time, CDMA inter Network connection for Wusasa Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	5.9	7.6	7.1	7.8	7.1
VISA/ STAR	7.6	7.2	6.1	6.0	6.7
VISA/ZAIN	7.1	7.2	7.6	7.6	7.4
Total ($\bar{x}$)	**20.6(6.8)**	**22.0(7.3)**	**20.8(6.9)**	**21.4(7.1)**	
					$\bar{x}$=7.1
STAR/GLO	7.7	7.3	8.3	6.9	7.6
STAR/ZAIN	6.1	5.8	6.9	7.2	6.5
STAR/VISA	9.2	6.9	7.9	6.5	7.6
Total ($\bar{x}$)	**23.0(7.6)**	**20.0(6.6)**	**23.1(7.7)**	**20.6(6.8)**	
					$\bar{x}$=7.2

From table 4.33, it is observed that, Visafone connected faster at 6-8am and 12-14pm with average set up times of 6.8 and 6.9 seconds respectively; then followed closely by 16-18pm (21.4 seconds) and lastly at 8-10am which takes longer to set up. Meanwhile Starcomms

registered shorter set up times at 8-10am (6.6 seconds) and 16-18pm (6.8seconds) followed by that at 6-8am (7.6seconds) and lastly at 12-14pm with 7.7 seconds.

It can also be seen from the table that it takes a shorter time to interconnect Starcomms/zain and Visafone/Starcomms lines. This is because of the lower value of 6.5 and 6.7 seconds respectively as it indicates. Also, Starcomms/Visafone and Starcomms/Globacom both connect at a pace of 7.6 seconds while Visafone/zain connects at 7.4 seconds followed by the connection of Visa/Glo at 7.1. Again, Visa/Starcomms connections stood at 6.7 seconds. Notwithstanding, Visafone connects easily with any other network than does Starcomms.

Table 4.34: Set Up Time Telephony Intra Network connection for Zaria City Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	6.4	6.8	7.3	7.5	7.0
ZAIN	6.2	7.1	7.5	6.3	6.8
STAR	6.0	6.8	7.7	7.1	6.9
VISA	7.6	6.0	5.1	7.0	6.4
Total	**31.2**	**32.7**	**27.6**	**27.9**	

The fastest connection was made between the hours 12-14pm where the set up time was 27.6 seconds. Of all the four different networks, Visafone registered the least set up time of 6.4 seconds, but GSM, zain registered 6.8 seconds (table 4.34).

Table 4.35: Set Up Time, GSM inter connection for Zaria City Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	7.1	9.2	6.0	7.0	7.3
GLO/ STAR	7.1	6.1	6.5	6.5	8.2
GLO/VISA	7.1	7.4	8.1	6.3	7.2
Total ($\bar{x}$)	**24.3 (8.1)**	**25.8(8.6)**	**27.8 (9.2)**	**29.9 (9.9)**	
					$\bar{x}$=7.6
ZAIN/GLO	6.1	7.6	6.5	6.5	6.4
ZAIN/STAR	9.9	5.9	6.4	6.4	8.8
ZAIN/VISA	6.6	5.7	7.7	6.0	6.5
Total ($\bar{x}$)	**21.8 (7.2)**	**21.3(7.1)**	**25.6(8.5)**	**20.1 (6.7)**	
					$\bar{x}$=7.2

The table 4.35 shows that for this KPI at data collection area, the best set up time is 16-`8pm with a value of 6.7 seconds when using zain and at 6-8am (8.1 seconds) when using Globacom. In the same vein, the worst set up time is at 16 -18pm (9.9seconds) for Globacom and12-14pm (8.5seconds) for Zain.

In consideration of this KPI only, the Zain/glo played good at 6.4seconds next to Zain/visa, 6.5seconds but a greater average value of 8.8 seconds with zain/star. Glo/visa stands at 7.2 seconds, the glo/zain at 7.3seconds and lastly with glo/star at 8.2 seconds. So Zain inter connects better than Globacom.

Table 4.36: Set Up Time, CDMA inter Network connection for Zaria City Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	7.2	6.4	8.4	6.2	7.1
VISA/ STAR	7.8	5.9	6.5	6.1	6.6
VISA/ZAIN	6.8	6.2	7.0	6.0	6.5
Total ($\bar{x}$)	**21.0 (7.0)**	**18.5 (6.2)**	**21.9 (7.3)**	**18.3(6.1)**	
					$\bar{x}$=6.7
STAR/GLO	7.0	8.1	9.0	6.3	7.6
STAR/ZAIN	6.5	8.2	7.4	6.4	6.5
STAR/VISA	7.9	6.0	7.4	6.7	8.9
Total ($\bar{x}$)	**21.4 (7.1)**	**22.3 (7.4)**	**23.8(7.9)**	**19.4(6.5)**	
					$\bar{x}$=7.7

The table4.36 reveals that visa inter connections is faster at 16 -8pm where it takes only 6.2 seconds for a call to be established. This is followed by 6.1seconds at 8-10am then 6.5 seconds at 16-18pm with Starcomms connection while rest of the time instances is above 7seconds set up time. So Visa is good here and the best set up time for this area is 16-18pm when using CDMAs to call other networks.

The lowest interconnection set up time is seen with visa/zain and star/zain connection which all scored 6.5 seconds. Any other set up time is above 7 seconds. Zain is a good tolerance than other networks.

Table 4.37: Set Up Time Telephony Intra Network connection for Angwua Godo Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	6.4	7.5	7.1	12.6	8.4
ZAIN	7.1	6.5	6.2	6.5	6.6
STAR	7.1	7.5	7.7	7.7	7.5
VISA	6.2	7.4	7.1	6.9	6.9`
Total ($\bar{x}$)	**26.8(6.7)**	**28.9(7.2)**	**28.1(7.0)**	**33.7(8.4)**	

Here shortest set up time was recorded between 6-8am with 6.7 seconds the 7.0 seconds at mid day and 7.2 seconds between 8-10am. Zain connects with the shortest up time of 6.6 seconds then Visafone with 6.9 seconds (table 4.37).

Table 4.38: Set Up Time, GSM inter connection for Angwua Godo Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	6.0	6.7	7.1	6.1	6.5
GLO/ STAR	7.1	7.5	7.8	8.7	7.8
GLO/VISA	7.6	7.1	8.1	6.2	7.3
Total	**20.7 (6.9)**	**21.3(7.1)**	**23.0(7.6)**	**21.0 (7.0)**	
					$\bar{x}$=7.2
ZAIN/GLO	8.4	7.3	6.5	9.2	7.9
ZAIN/STAR	7.1	7.5	8.1	8.6	7.8
ZAIN/VISA	5.4	6.5	6.4	5.9	6.1
Total	**20.9(6.9)**	**21.3(7.1)**	**21.0(7.0)**	**23.7(7.9)**	
					$\bar{x}$=7.3

The best set up time for both GSM in this area was 6-8am with a set up time of 6.9 seconds closely followed by 8-10am with 7.1 seconds. Zain/visa connection was the fastest with 6.1 seconds set up time while Glo/zain stood at 6.5 seconds (table 4.38).

Table 4.39: Set Up Time, CDMA inter Network connection for Angwua Godo Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	7.1	6.1	7.6	11.8	8.2
VISA/ STAR	7.4	6.6	7.4	5.4	8.9
VISA/ZAIN	6.4	6.3	13.3	6.1	8.1
Total ($\bar{x}$)	**20.9 (6.9)**	**19.0(6.3)**	**28.3(9.4)**	**23.3(7.7)**	
					$\bar{x}$=8.4
STAR/GLO	8.0	6.6	7.6	6.9	7.3
STAR/ZAIN	7.3	7.4	7.0	6.5	7.1
STAR/VISA	6.7	7.9	8.0	6.5	7.3
Total ($\bar{x}$)	**22.0 (7.3)**	**21.9(7.3)**	**22.6 (7.5)**	**19.9(6.6)**	
					$\bar{x}$=7.2

Table 4.39 shows that 8-10am has the shortest set up time of 6.3 seconds when calling from Visafone and 16 -18pm has 6.6 seconds when calling from Starcomms. So, Visa/zain registered an average set up time of 8.1 seconds while 7.1 seconds was registered by Star/Zain. So zain tolerates the CDMA numbers

Table 4.40: Set Up Time Telephony Intra Network connection for Kongo Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	7.8	8.3	6.6	6.4	7.3
ZAIN	6.9	7.9	8.4	5.1	7.1
STAR	6.9	5.6	6.2	7.9	6.7
VISA	6.8	7.3	6.1	5.7	6.5
Total ($\bar{x}$)	**28.4 (7.1)**	**29.1 (7.3)**	**27.3 (6.8)**	**25.1(6.3)**	

The shortest call establishment time is realised at 16 -18pm where set up time stood at 6.3 seconds then 6.8seconds at 12-14pm. Visafone also had the shortest setup time of 6.5 seconds (table 4.40).

Table 4.41: Set Up Time, GSM inter connection for Kongo Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	7.5	7.1	6.4	5.6	6.7
GLO/ STAR	7.9	7.7	6.7	6.6	7.2
GLO/VISA	7.4	6.9	7.6	6.1	7.0
Total ($\bar{x}$)	**22.8 (7.6)**	**21.7 (7.2)**	**20.7 (6.9)**	**18.3 (6.1)**	
					$\bar{x}$=7.0
ZAIN/GLO	7.0	6.6	5.6	6.7	6.5
ZAIN/STAR	7.4	6.6	8.1	8.2	7.6
ZAIN/VISA	6.6	6.9	6.4	8.3	7.1
Total ($\bar{x}$)	**21.0 (7.0)**	**19.1 (6.3)**	**22.1(7.3)**	**23.2 (7.7)**	
					$\bar{x}$=7.1

For Globacom inter calls the best time was afternoon down to 16-18pm with set up times of 6.9seconds and 6.1 seconds respectively. Whereas Zain inter calls at 8-10am experienced set up time of 6.3 seconds.

Calling Zain lines from Globacom possessed a short set up time of 6.7 seconds while zain/Glo got 6.5 seconds, so zain inter connects easily with Globacom (table 4.41).

Table 4.42: Set Up Time, CDMA inter Network connection for Kongo Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	7.9	6.0	6.6	5.9	6.6
VISA/ STAR	5.9	7.0	7.6	6.0	6.6
VISA/ZAIN	7.9	7.1	7.5	7.8	7.6
Total ($\bar{x}$)	**20.9 (6.9)**	**19.0 (6.3)**	**28.3 (9.4)**	**23.3 (7.7)**	
					$\bar{x}$=6.9
STAR/GLO	8.3	9.0	6.9	6.6	7.7
STAR/ZAIN	6.9	6.6	7.7	7.9	7.3
STAR/VISA	5.8	5.9	7.7	5.6	6.3
Total ($\bar{x}$)	**21.0 (7.0)**	**21.5 (7.1)**	**22.3 (7.6)**	**20.1 (6.7)**	
					$\bar{x}$=7.1

Inter network calls from Visafone had a short set up time of 6.3 seconds at 8-10am while Starcomms got it (6.7seconds) at 16-18p. Using each of them will be good at these stated times.

Visafone inter connects with Glo and Star at a set up time of 6.6 seconds each, while star/visa did it a 6.3 seconds (table 4.42).

Table 4.43: Set Up Time Telephony Intra Network connection for Samaru Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	6.3	6.1	6.6	7.4	8.8
ZAIN	6.8	6.8	5.5	7.3	8.8
STAR	6.0	7.0	7.5	6.3	8.9
VISA	6.1	6.9	7.0	6.6	8.9
Total ($\bar{x}$)	**25.2 (6.3)**	**26.8 (6.7)**	**26.6 (6.6)**	**27.6 (6.9)**	

6.3 seconds as the table shows is the shortest set up time which came up at 6-8am. At the same time the network with the shortest set up time was Zain and Globacom with 8.8 seconds each. GSMs performed better than the CDMAs in this PKI as revealed in table 4.43.

Table 4.44: Set Up Time, GSM inter connection for Samaru Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	6.6	5.9	7.7	7.3	6.9
GLO/ STAR	6.1	6.5	7.7	6.9	6.8
GLO/VISA	8.2	8.1	6.7	5.0	7.0
Total ($\bar{x}$)	**20.9 (6.9)**	**20.5 (6.8)**	**22.1 (7.3)**	**19.2 (6.4)**	
					$\bar{x}$=6.9
ZAIN/GLO	6.6	6.9	6.9	7.5	7.0
ZAIN/STAR	10.1	6.6	5.7	7.0	7.4
ZAIN/VISA	6.0	6.5	6.4	7.5	6.6
Total ($\bar{x}$)	**21.8 (7.2)**	**21.3 (7.1)**	**25.6 (8.5)**	**20.1(6.7)**	
					$\bar{x}$=7.0

Calls made from Globacom lines had a short set up time of 6.4 seconds towards evening at 16 - 18pm and those from Zain lines stood at 6.7 seconds still at the same time instance.

The Globacom inter connection shortest set up time was 6.8 seconds experienced with Glo/Star connection and 6.6 seconds was experienced with Zain/Visa connection as revealed in table 4.44.

Table 4.45: Set Up Time, CDMA inter Network connection for Samaru Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	7.4	6.4	7.7	6.7	7.1
VISA/ STAR	7.1	6.6	6.5	6.2	6.7
VISA/ZAIN	6.8	7.3	7.3	6.5	7.0
Total ($\bar{x}$)	**21.3(7.1)**	**20.3(6.7)**	**21.5(7.1)**	**19.4(6.4)**	
					$\bar{x}$=6.9
STAR/GLO	8.3	7.9	6.9	6.5	7.4
STAR/ZAIN	8.1	6.9	6.0	6.4	6.9
STAR/VISA	6.8	5.3	6.0	7.1	6.3
Total ($\bar{x}$)	**23.2 (7.7)**	**20.1(6.7)**	**18.9(6.3)**	**20.0(6.6)**	
					$\bar{x}$=6.9

Evening time of 16-18pm was good for Visafone connection in Samaru as a short average set up time of 6.4 seconds was obtained and for Starcomms this came up between 12-14pm recording set up time of 6.3 seconds.

Visafone connected faster with Starcomms at 6.7 seconds while a Star/Visa connection was established in 6.3 seconds as shown in table 4.45.

Table 4.46: Set Up Time Telephony Intra Network connection for Basawa Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	7.3	7.5	6.9	7.3	7.3
ZAIN	8.3	6.7	7.6	8.3	7.7
STAR	6.4	5.5	6.7	6.4	6.3
VISA	6.0	6.1	6.6	6.4	6.3
Total ($\bar{x}$)	**28 (7.0)**	**25.8(6.4)**	**27.8(6.9)**	**28.4 (7.1)**	

Table 4.46 shows a good set up time of 6.4 seconds was established at 8-10am time instance closely followed by that of 12-14pm with 6.9 seconds.

Starcomms and Visafone all showed the faster connection time of 6.3 seconds each better than the Globacom and zain whose score was above 7.0 seconds.

Table 4.47: Set Up Time, GSM inter connection for Basawa Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	7.3	8.4	6.9	6.4	7.3
GLO/ STAR	7.4	6.5	6.7	7.6	7.1
GLO/VISA	6.9	7.1	6.0	7.9	7.0
Total ($\bar{x}$)	**21.6(7.2)**	**22.0(7.3)**	**27.6(9.2)**	**21.9(7.3)**	
					$\bar{x}$=7.1
ZAIN/GLO	7.1	6.5	7.3	6.1	6.8
ZAIN/STAR	7.5	6.9	6.2	7.1	6.9
ZAIN/VISA	7.9	7.2	7.6	7.5	7.6
Total ($\bar{x}$)	**21.8(7.2)**	**21.3(7.1)**	**25.6(8.5)**	**20.1(6.7)**	
					$\bar{x}$=7.1

Globacom inter connected better with a 7.2 seconds set up time at 6-8am while Zain obtained its better connection at 16-18pm.

While Glo/visa showed a good set up time of 7.0 seconds, Zain/Glo emerged with the fastest of 6.8 seconds. Zain played well here than Globacom (table 4.47).

Table 4.48: Set Up Time, CDMA inter Network connection for Basawa Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	6.4	7.2	5.6	7.8	6.7
VISA/ STAR	6.6	7.0	7.4	5.2	6.6
VISA/ZAIN	6.5	7.9	5.6	5.6	6.4
Total ($\bar{x}$)	**19.5 (6.5)**	**22.1(7.3)**	**18.6(6.2)**	**18.6(6.2)**	
					$\bar{x}$**=6.6**
STAR/GLO	8.2	9.9	6.4	7.9	8.1
STAR/ZAIN	6.3	8.1	10.0	6.3	7.7
STAR/VISA	7.5	6.7	6.2	6.1	6.6
Total ($\bar{x}$)	**23.0(7.6)**	**20.0(6.6)**	**23.1(7.7)**	**20.6(6.8)**	
					$\bar{x}$**=7.4**

Mid day till evening time proved to be the best time to use Visafone line as a faster connection time of 6.2 seconds was obtained. But for Starcomms lines, 6.8seconds at 16-18pm was the fastest connections time.

Visa/Zain has been shown to be the fastest (6.4 seconds) among all other Visafone connections while Star/Visa 6.6 seconds stands for Starcomms connection shortest time (table 4.48).

Table 4.49: Set Up Time Telephony Intra Network connection for Gaskiya Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	8.1	7.2	6.7	7.0	7.3
ZAIN	6.1	6.7	6.7	7.9	6.9
STAR	6.2	7.0	6.0	7.2	6.6
VISA	4.1	5.7	5.2	5.8	5.2
Total ($\bar{x}$)	**24.5 (6.1)**	**26.6(6.6)**	**24.6(6.2)**	**27.9(6.9)**	

The best set up time of 6.1 seconds was observed in the morning hours of 6-8am, but Visafone network had the best set up time of 5.2 seconds (table 4.49).

Table 4.50: Set Up Time, GSM inter connection for Gaskiya Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	7.3	6.5	7.5	6.4	6.9
GLO/ STAR	6.3	7.7	8.0	6.3	7.1
GLO/VISA	7.2	7.2	6.3	7.7	7.1
Total ($\bar{x}$)	**20.8(6.9)**	**21.4(7.1)**	**21.8(7.2)**	**20.4(6.8)**	
					$\bar{x}$=7.0
ZAIN/GLO	6.8	6.5	6.2	5.7	6.3
ZAIN/STAR	8.9	7.0	7.5	7.0	7.6
ZAIN/VISA	6.6	7.8	7.1	6.5	7.0
Total($\bar{x}$)	**22.3(7.4)**	**21.3(7.1)**	**20.8(6.9)**	**19.2(6.4)**	
					$\bar{x}$=7.0

Table 4.50 revealed a set up time of 6.8 seconds from Globacom line was experienced at 16-18pm this time instance was also true from zain line but the set up time stood at 6.4 seconds.

The fastest inter connection of 6.9 seconds was between Glo/zain and then zain/glo connection was 6.3 seconds. So the GSM network performed better in the KPI.

Table 4.51: Set Up Time, CDMA inter Network connection for Gaskiya Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	6.2	5.0	7.3	6.8	6.3
VISA/ STAR	6.3	5.6	6.6	8.7	6.8
VISA/ZAIN	6.5	7.6	7.9	6.2	7.1
Total($\bar{x}$)	**19.0(6.3)**	**18.2(6.1)**	**21.8(7.2)**	**21.7(7.2)**	
					$\bar{x}$=6.7
STAR/GLO	6.5	6.7	7.3	7.5	7.0
STAR/ZAIN	7.8	6.1	7.0	8.5	7.4
STAR/VISA	6.9	8.2	7.7	6.0	7.2
Total ($\bar{x}$)	**21.2(7.1)**	**21.0(7.0)**	**22.0(7.3)**	**22.0(7.3)**	
					$\bar{x}$=7.2

The early morning period of 6-8am demonstrated a set up time of 6.3seconds from Visafone line but from Starcomms lines it came up at 12-14pm with 7.0 seconds.

Visa/glo interconnection experienced a faster set up time of 6.3 seconds while 7.0 seconds was for Star/glo interconnection as seen from table 4.51.

Table 4.52: Set Up Time Telephony Intra Network connection for Shika Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	6.6	7.3	6.1	7.7	6.9
ZAIN	6.7	8.4	7.1	6.3	7.1
STAR	7.9	6.9	6.6	8.2	7.4
VISA	7.6	5.0	7.1	5.5	6.3
Total($\bar{x}$)	**28.8(7.2)**	**27.6(6.9)**	**26.9(6.7)**	**27.7(6.9)**	

The set up time for this data collection area stood at 6.7 seconds between 12-14pm, this time instance was flung by 6.9 seconds.

Visafone network emerged first with the shortest set up time of 6.3seconds (table 4.52)

Table 4.53: Set Up Time, GSM inter connection for Shika Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	7.2	7.2	6.8	6.8	7.0
GLO/ STAR	7.0	6.7	7.8	6.7	7.1
GLO/VISA	6.8	7.5	8.5	6.3	7.3
Total($\bar{x}$)	**21.0(7.0)**	**21.4(7.1)**	**23.1(7.7)**	**19.8(6.6)**	
					$\bar{x}$=7.1
ZAIN/GLO	5.8	7.8	6.4	7.4	6.9
ZAIN/STAR	8.4	5.2	6.6	6.7	6.7
ZAIN/VISA	10.4	7.3	8.3	7.2	8.3
Total($\bar{x}$)	**24.6(8.2)**	**20.3(6.7)**	**21.3(7.1)**	**21.3(7.1)**	
					$\bar{x}$=7.3

Table 4.53 indicates that the best set up time for this area was observed between 16-18pm with a value of 6.6 seconds for all the calls made from Globacom network meanwhile 8-10am registered 6.7seconds for all the calls from zain network.

Globacom connection to zain had a set up time of 7.0 seconds and Zain/glo registered 6.9 seconds.

Table 4.54: Set Up Time, CDMA inter Network connection for Shika Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	7.3	6.7	6.3	5.4	6.4
VISA/ STAR	6.9	6.2	6.6	7.9	6.8
VISA/ZAIN	6.9	7.5	7.9	6.5	7.2
Total($\bar{x}$)	**21.1(7.0)**	**20.4(6.8)**	**20.8(6.9)**	**19.8(6.6)**	
					$\bar{x}$=6.8
STAR/GLO	7.1	7.9	7.9	6.7	7.4
STAR/ZAIN	7.6	6.7	8.4	7.4	7.5
STAR/VISA	7.5	5.1	6.9	6.7	6.6
Total($\bar{x}$)	**21.2(7.1)**	**21.0(7.0)**	**22.0(7.3)**	**22.0(7.3)**	
					$\bar{x}$=7.2

The set up time started declining from 8-10am but a fastest connection was observed at 16-18pm with set up time of 6.6 seconds for Visafone connections. The value almost had a flat time of slightly above 7seconds but fastest connection was between 8-10am with 7 seconds set up time.

Visa/glo calls were connected with a set up time of averagely 6.4 seconds while 6.6 seconds was recorded for star/visa interconnection (table 4.54).

Table 4.55: Set Up Time Telephony Intra Network connection for Muchia Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	7.1	7.4	7.1	6.8	5.6
ZAIN	7.4	7.3	7.4	6.4	5.6
STAR	8.1	7.0	6.2	6.9	5.5
VISA	8.4	7.0	5.9	6.0	6.8
Total ($\bar{x}$)	**31.0(7.7)**	**28.7(7.1)**	**26.6(6.6)**	**26.1(6.5)**	

The shortest connection time was at 16-18pm with a set up time of 6.5 seconds, but Starcomms network manifested with the faster connection time of 5.5 seconds, revealed by table 4.55.

Table 4.56: Set Up Time, GSM inter connection for Muchia Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	7.6	7.4	7.2	6.5	5.7
GLO/ STAR	7.6	7.0	7.0	7.3	5.5
GLO/VISA	7.8	7.2	8.1	7.1	7.6
Total($\bar{x}$)	**22.0(7.3)**	**21.6(7.2)**	**22.3(7.4)**	**21.1(7.0)**	
					$\bar{x}$=6.3
ZAIN/GLO	6.9	6.5	5.4	5.7	8.6
ZAIN/STAR	7.1	6.9	8.9	6.7	7.4
ZAIN/VISA	9.4	6.8	6.1	7.2	7.4
Total ($\bar{x}$)	**23.4(7.8)**	**20.2(6.7)**	**20.4(6.8)**	**19.6(6.5)**	
					$\bar{x}$=7.8

From Globacom network interconnection, the fastest was only experienced at 16-18pm with 7.0 seconds and from zain line still at the same time of 16-18pm with 6.5 seconds.

5.5 seconds was the set up time recorded by Glo/star and 7.4 seconds recorded by both zain/star and zain/visa as demonstrated by table 4.56

Table 4.57: Set Up Time, CDMA inter Network connection for Muchia Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	6.3	6.4	6.8	5.8	6.3
VISA/ STAR	6.1	6.9	6.9	6.3	5.1
VISA/ZAIN	7.6	7.7	6.6	5.9	7.0
Total($\bar{x}$)	**19.9(6.6)**	**21.0(7.0)**	**20.3(6.7)**	**18.0(6.0)**	
					$\bar{x}$=6.1
STAR/GLO	6.8	7.4	8.9	6.0	7.3
STAR/ZAIN	8.1	7.2	6.7	7.6	8.0
STAR/VISA	7.5	6.6	6.5	6.3	6.7
Total ($\bar{x}$)	**22.4(7.4)**	**21.2(7.2)**	**22.1(7.1)**	**19.9(6.6)**	
					$\bar{x}$=7.3

For both Starcomms and Visafone inter network connection the faster time came up 16-18pm with 6.0 seconds and 6.6 seconds respectively.

The best inter connection was visa/glo with 6.3 seconds and star/visa with 6.7seconds (Table 4.57).

Table 4.58: Set Up Time Telephony Intra Network connection for Deke Chi Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO	7.0	6.6	6.6	7.4	6.9
ZAIN	7.5	7.2	6.2	6.4	6.9
STAR	6.5	7.5	7.1	7.0	7.0
VISA	7.4	6.6	5.1	5.6	6.2
Total ($\bar{x}$)	**28.4(7.1)**	**27.9(6.9)**	**25.0(6.2)**	**26.4(6.6)**	

The fastest connection as revealed from the table was 6.2 second that came between the hours of 12-14pm.

The same 6.2 seconds was also experienced by all the Visafone intra calls (table 4.58).

Table 4.59: Set Up Time, GSM inter connection for Deke Chi Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
GLO/ZAIN	6.9	6.1	7.6	7.1	7.2
GLO/ STAR	7.5	7.6	9.1	7.1	7.8
GLO/VISA	7.0	6.6	7.6	6.5	6.9
Total ($\bar{x}$)	**21.4(7.1)**	**20.3(6.7)**	**22.3(7.4)**	**20.7(6.9)**	
					$\bar{x}$=7.3
ZAIN/GLO	6.1	7.9	6.1	6.2	6.6
ZAIN/STAR	8.1	5.9	11.0	7.5	7.9
ZAIN/VISA	7.4	7.6	6.9	7.0	7.2
Total($\bar{x}$)	**21.6(7.2)**	**21.4(7.1)**	**24(8.0)**	**20.7(6.9)**	
					$\bar{x}$=7.2

The table (4.59) shows a good set up time of 6.7seconds was recorded at 8-10am for Globacom line calls and at the same time, zain network calls experienced it at 16-18pm with a value of 6.9seconds.

An average set up time of 6.9 seconds was registered by Glo/visa calls and zain/Glo scored 6.6 seconds set up time.

Table 4.60: Set Up Time, CDMA inter Network connection for Deke Chi Area

Network	6-8am $\bar{x}$	8-10am $\bar{x}$	12-14pm $\bar{x}$	16-18pm $\bar{x}$	Total $\bar{x}$
VISA/GLO	7.4	7.4	6.1	6.7	6.9
VISA/ STAR	8.3	6.5	7.1	5.1	6.8
VISA/ZAIN	7.9	6.9	6.1	6.3	6.9
Total ($\bar{x}$)	**23.6(7.8)**	**20.8(6.9)**	**19.3(6.4)**	**18.1(6.0)**	
					$\bar{x}$=6.9
STAR/GLO	8.0	7.3	8.0	8.3	7.9
STAR/ZAIN	7.6	6.0	7.4	6.8	5.6
STAR/VISA	7.2	6.4	7.1	5.6	6.6
Total($\bar{x}$)	**22.8(7.6)**	**19.7(6.5)**	**22.5(7.5)**	**20.7(6.9)**	
					$\bar{x}$=6.7

At the time instance of 16-18pm the shortest set up time of 6.0 seconds was recorded from Visafone network inter calls while the value of 6.5 seconds was recorded for Starcomms line between the hours of 8-10am

Visa/star inter calls had an average set up time of 6.8 seconds and 6.6seconds was made from star/visa inter calls (table 4.60).

4.3 CALL SETUP SUCCESS RATIO (CSSR) (percentage)

The sum of all the call setup success ratio time in seconds is taken for each of the different time instances for the period of study. The values in each column of the table are out of the total of 56 calls made under the period of study and they are gotten by finding the sum of all completed calls where both parties A and B hears each other. The percentages for each of the Network types are found according to equation 3.3. These values are shown in tables 4.61 to 4.90 for both intra and inter call set up success ratio telephony respectively. The total for each time instance is obtained out of a Global sum of 56 per time instance and is used to determine the time with a good call setup success ratio telephony connection.

Table 4.61: Call Set Up Success Ratio Intra Network connection for Wusasa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	13	13	13	14	53	94.6
ZAIN	14	13	13	14	54	96.4
STAR	12	12	13	13	50	89.3
VISA	14	11	13	14	52	92.9
Total	**53**	**49**	**52**	**41**		

The table (4.61) indicates that the better set up success ratio is realised at 6-8am where 53 success ratio calls are obtained. This is followed closely by 52 success ratio calls at 12-14pm then 8-10am with a value of 49 and lastly 16-18pm registering 41 success ratios.

The table still shows that Zain emerges at the top with higher percentage of success ratio value of 96.4% followed by Globacom 94.6%. CDMAs performance is lower as 92.9% is registered by Visafone as the highest value, 89.3% the lowest value. GSMs has a good performance here than CDMAs.

Table 4.62: Call Set Up Success Ratio GSM Inter Network connection for Wusasa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	12	13	13	13	53	94.6
GLO/ STAR	13	12	13	13	54	96.4
GLO/ VISA	13	13	13	13	50	89.3
Total	**38**	**48**	**41**	**41**		$\bar{x}$ **=93.4**
ZAIN/GLO	14	14	12	14	54	96.4
ZAIN/STAR	14	12	11	14	51	91.1
ZAIN/VISA	13	13	12	14	52	92.8
Total	**41**	**39**	**35**	**42**		$\bar{x}$ **=93.4**

A better call setup success Ratio according to table 4.62 for Globacom network interconnection is registered at 8-10am then followed by 12-14am and that of 16-18pm with values of 48 and 41set up success ratio and a low score at 6-8am. While for Zain it is best at 16-18pm with all success ratio calls obtained (i.e 42). This is followed by 6-8am (41) and then 8-10am and lowest at 12-14pm with only 35 out of the 42 call attempts.

Table 4.63: Call Set Up Success Ratio, CDMA Inter Network connection for Wusasa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	14	14	14	14	56	100
STAR/ZAIN	13	14	14	12	53	94.6
STAR/ VISA	14	13	14	14	55	98.4
Total	**40**	**41**	**40**	**41**		$\bar{x}$**=97.7**
VISA/GLO	14	12	14	14	54	96.4
VISA/ZAIN	13	14	13	13	53	94.6
VISA/STAR	13	13	14	13	53	94.6
Total	**40**	**39**	**39**	**40**		$\bar{x}$**=95.2**

From the table 4.63 again, a high percentage of 96.4 is shared between glo/star and zain/glo interconnections. Glo/zain follows with a 94.6% then 92.8% by zain/visa. The lowest percentage values come up with glo/visa interconnections, thus Zain in proving to be good in this KPI.

Table 4.64: Call Set Up Success Ratio, GSM Intra Network connection for Zaria City Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	13	13	13	14	53	94.6
ZAIN	14	13	13	14	54	96.4
STAR	12	12	13	13	50	89.3
VISA	14	11	13	14	52	92.9
Total	**53**	**49**	**52**	**41**		

As seen from table 4.64, more successful calls were established at 6-8am (53) then 12-14pm (52) followed by 49 and 41 at 8-10am and 16-18pm respectively.

Zain has emerged with a better success ratio percentage of 96.4% followed by 94.6% for Globacom the 92.9% and 89.3% respectively for Starcomms and Visafone. So the GSMs are better than the CDMA in so far as this KPI is concerned.

Table 4.65: Call Set Up Success Ratio GSM Inter Network connection for Zaria City Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	13	13	12	14	52	92.8
GLO/ STAR	13	14	14	14	55	98.4
GLO/ VISA	14	14	14	13	55	98.4
Total	**40**	**41**	**40**	**41**		$\bar{x}$**=96.5**
ZAIN/GLO	14	14	12	14	54	96.4
ZAIN/STAR	14	12	13	13	52	92.8
ZAIN/VISA	13	13	14	13	53	94.6
Total	**40**	**39**	**39**	**40**		$\bar{x}$**=94.6**

The success ratio level for Globacom as a whole is good since the call values stood at 41 for 8-10am and 16-18pm and 40 for both 6-8am and 12-14pm. Zain records 40 each at 6-8am and 16-18pm and 39 at 8-10am and 12-14pm respectively.

Globacom proves to be good interconnection with CDMAs as it records 98.4% for interconnections with Starcomms and Visafone; a lower value of 92.8% with Zain. On the other hand, zain has its higher value at 96.4% with Starcomms and 94.6% with Visa, same lower value of 92.8% with Visa (table 4.65).

Table 4.66: Call Set up Success Ratio, CDMA inter Network connection for Zaria City Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	14	14	14	14	56	100
STAR/ZAIN	13	14	14	12	53	94.6
STAR/ VISA	14	13	14	14	55	98.4
Total	**40**	**41**	**40**	**41**		$\bar{x}$**=97.7**
VISA/GLO	14	12	14	14	54	96.4
VISA/ZAIN	13	14	13	13	53	94.6
VISA/STAR	13	13	14	13	53	94.6
Total	**40**	**39**	**39**	**40**		$\bar{x}$**=95.2**

The success ratio level for Starcomms as generally in this area is good since the call values stood at 41 for 8-10am and 16-18pm and 40 for both 6-8am and 12-14pm. Zain records 40 each at 6-8am and 16-18pm; 39 at 8-10am and 12-14pm respectively. The table also reveals that 16-18pm is the best time in so far as this KPI is concerned.

While star/glo has 100%, Visa/glo is recording 96.4% as its highest percentage, but both Starcomms and Visafone record 94.6% with star/zain and visa/star as their lowest percentages. This signifies that Starcomms performance in this KPI is higher than that of Visafone. But the CDMAs inter connect well with the GSMs (table 4.66).

Table 4.67: Call Set Up Success Ratio, Intra Network connection for Angwua Godo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	13	14	14	14	55	98.2
ZAIN	14	14	13	13	54	96.4
STAR	14	14	13	14	55	98.2
VISA	14	13	14	14	55	98.2
Total	**55**	**55**	**54**	**55**		

The table 4.67 shows that most of the calls made at this data collection area are successful throughout the day as only one out the 56 calls failed except at mid day where up to two calls failed.

At the same time, all the network types performed well here as all scored 98.2% except zain with 96.4%

Table 4.68: Call Set Up Success Ratio GSM Inter Network connection for Angwua Godo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	13	14	12	14	53	94.6
GLO/ STAR	13	14	13	12	52	92.9
GLO/ VISA	14	14	14	13	55	98.2
Total	**40**	**42**	**39**	**39**		$\bar{x}$**=95.2**
ZAIN/GLO	14	12	13	12	51	90.1
ZAIN/STAR	14	12	13	12	51	90.1
ZAIN/VISA	12	13	13	12	50	89.3
Total	**40**	**37**	**39**	**36**		$\bar{x}$**=89.8**

8-10am is the best time to call from globacom to any network because all the calls at that time instance went on successfully. Zain calls are good at 6-8am where majority of the calls (40) went through. The worst time is at 16 -18pm with only 36 calls that went on successfully.

Glo/Visa call are preferable here as 98.2% of them went through then followed by glo/zain with 94.6%. Zain/glo and Zain/star are also preferable for they scored 90.1%. In actual sense, Globacom performed better here than Zain as shown in table 4.68.

Table 4.69: Call Set Up Success Ratio, CDMA inter Network connection for Angwua Godo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	12	14	14	13	53	94.6
STAR/ZAIN	14	13	14	14	55	98.4
STAR/ VISA	13	13	13	13	52	92.9
Total	**39**	**40**	**41**	**40**		$\bar{x}$**=95.3**
VISA/GLO	13	13	13	13	52	92.9
VISA/ZAIN	13	12	13	12	50	89.3
VISA/STAR	14	13	13	13	53	94.6
Total	**40**	**38**	**39**	**38**		$\bar{x}$**=92.3**

Inter connection from Starcomms is good from 8am till 18pm as 40 calls went successful though mid day calls went up to 41. On the contrary with Visafone calls are established easily between 6am and 8am where 40 calls are successful.

Star/zain is a better interconnection as up to 98.4% of the calls made were established, while for Visa/star is good among the other networks as 94.6 calls were established (table 4.71).

Table 4.70: Call Set Up Success Ratio, Intra Network connection for Kongo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	13	55	98.2
ZAIN	13	14	14	11	51	91.1
STAR	13	14	14	13	54	96.4
VISA	14	14	14	14	56	100
Total	**54**	**56**	**56**	**51**		

Table 4.70 reveals that a Set up success ratio here was good as all the established calls ended well from 8am to 14pm and 6-8am got 54 of the calls right.

Among the networks in use, Visafone played well with this KPI as 100% set up ratio was recorded; this was followed by globacom with 98.2%

Table 4.71: Call Set Up Success Ratio GSM Inter Network connection for Kongo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	14	14	14	13	55	98.2
GLO/ STAR	13	13	13	13	52	92.9
GLO/ VISA	14	13	14	13	54	96.4
Total	**41**	**40**	**41**	**39**		$\bar{x}$**=95.8**
ZAIN/GLO	13	13	14	13	51	90.1
ZAIN/STAR	12	13	14	14	53	94.6
ZAIN/VISA	11	13	12	12	48	85.7
Total	**36**	**39**	**40**	**39**		$\bar{x}$**=90.1**

From 6-8am 41 calls succeeded this skipped to 12-14pm when using globacom lines. Also, 12-14pm emerged the best time with 40 succeeded calls.

Glo/zain connection had a higher percentage value of 98.2 while Zain/star registered 94.6% (table 4.71)

Table 4.72: Call Set Up Success Ratio, CDMA inter Network connection for Kongo Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	12	13	14	14	53	94.6
STAR/ZAIN	14	13	13	13	53	94.6
STAR/ VISA	12	14	13	13	52	92.9
Total	**38**	**40**	**40**	**40**		$\bar{x}$**=94.0**
VISA/GLO	12	12	14	13	51	91.1
VISA/ZAIN	12	13	14	13	52	92.9
VISA/STAR	12	14	13	13	52	92.9
Total	**36**	**39**	**41**	**39**		$\bar{x}$**=92.3**

Starcomms registered a set up success ratio of 40 calls from 8am till 16pm but Visafone only had a higher value of 41 at 12-14pm.

Star/glo and star/zain plays good at 94.6% each while visa/zain and visa/star did it at 92.9% each. So, Starcomms is better than Visafone here in this KPI (table 4.72).

Table 4.73: Call Set Up Success Ratio, Intra Network connection for Samaru Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	13	13	14	14	54	96.4
ZAIN	13	13	12	14	52	92.8
STAR	11	13	12	14	50	89.2
VISA	12	13	12	14	51	91.1
Total	**49**	**54**	**40**	**56**		

Table 4.73 shows that all the attempted calls from all the networks went through at 16 -18pm. Of these networks the highest performance was established with calls from Globacom to Globacom where 96.4% of them went successful.

Table 4.74: Call Set Up Success Ratio GSM Inter Network connection for Samaru Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	13	13	14	12	52	92.8
GLO/ STAR	14	13	14	13	54	96.4
GLO/ VISA	13	13	12	12	50	89.3
Total	**40**	**39**	**40**	**37**		$\bar{x}$**=92.8**
ZAIN/GLO	13	13	12	12	50	89.3
ZAIN/STAR	13	12	11	12	48	85.7
ZAIN/VISA	12	13	14	14	53	94.6
Total	**38**	**38**	**37**	**38**		$\bar{x}$**=89.9**

Table 4.74 indicates that a higher number of successful calls (40) were obtained at 6-8am and 12-14pm when using Globacom line and for Zain line it was for the whole day (38) except at 12 -14pm with only 37 successfully attempted calls.

Of the 56 calls made from each network, the highest value (96.4%) was obtained between Glo/Star inter connection and 94.6% between Zain/Visa inter connection.

Table 4.75: Call Set Up Success Ratio, CDMA inter Network connection for Samaru Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	14	13	13	13	55	98.2
STAR/ZAIN	13	13	11	12	49	87.5
STAR/ VISA	13	12	12	12	49	87.5
Total	**40**	**38**	**36**	**37**		$\bar{x}$**=91.1**
VISA/GLO	13	13	13	12	51	91.1
VISA/ZAIN	13	13	14	13	53	94.6
VISA/STAR	14	13	14	12	53	94.6
Total	**40**	**39**	**41**	**40**		$\bar{x}$**=93.4**

40 out of the 42 calls made from each of the CDMA networks came up at 6-8am for both of them, then 16-18pm in addition for Visafone.

Star/Glo inter connection portrayed a higher performance yielding 98.2% then Visa/Zain and Visa/Star with 94.6% each success ratio (table 4.75).

Table 4.76: Call Set Up Success Ratio Intra Network connection for Basawa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	13	14	14	12	53	96.4
STAR	13	14	13	12	52	92.9
VISA	12	11	13	13	49	87.6
Total	**52**	**53**	**54**	**51**		

All the calls made at 6-8am were established this was followed by 12-14pm where 54 were also established. Globacom had 100% attempted calls were established (table 4.76).

Table 4.77: Call Set Up Success Ratio GSM Inter Network connection for Basawa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	13	13	13	11	50	89.3
GLO/ STAR	14	13	13	14	54	96.4
GLO/ VISA	11	12	12	12	47	83.9
Total	**38**	**38**	**38**	**37**		$\bar{x}$**=89.9**
ZAIN/GLO	14	14	13	14	55	98.2
ZAIN/STAR	14	12	14	11	51	90.1
ZAIN/VISA	13	13	13	14	53	94.6
Total	**41**	**39**	**40**	**39**		$\bar{x}$**=94.3**

Table 4.77 indicates that Calls from globacom line according to the table showed that 38 calls were established except at 16-18pm while 6-8am where 41 calls were established.

Glo/star had the highest percentage of 96.4 established calls while Zain/Glo stood at 98.2%

Table 4.78: Call Set Up Success Ratio, CDMA inter Network connection for Basawa Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	Total	%
STAR/GLO	13	13	13	13	52	92.8
STAR/ZAIN	12	12	14	13	51	91.1
STAR/ VISA	11	13	12	12	48	85.7
Total	**36**	**38**	**39**	**38**		$\bar{x}$**=89.9**
VISA/GLO	11	13	12	13	49	91.1
VISA/ZAIN	13	13	14	12	52	92.8
VISA/STAR	14	14	11	13	52	92.8
Total	**37**	**40**	**37**	**38**		$\bar{x}$**=92.2**

39 calls were established at mid day from Starcomms lines but 40 were established at 8-10am from Visafone lines

Star/glo calls that were established stood at 92.8%. This goes same to visa/zain and visa/star inter connection as highlighted in table 4.78.

Table 4.79: Call Set Up Success Ratio Intra Network connection for Gaskiya Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	13	14	14	14	55	98.2
STAR	13	13	12	14	52	92.9
VISA	12	12	12	13	49	87.6
Total	**52**	**53**	**52**	**55**		

From table 4.79, 55 attempted calls went through between 16-18pm. But Globacom demonstrated a perfect outcome with 100% of the attempted calls that went through.

Table 4.80: Call Set Up Success Ratio GSM Inter Network connection for Gaskiya Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	14	14	13	14	55	98.2
GLO/ STAR	13	14	13	13	53	94. 6
GLO/ VISA	13	14	12	14	53	94. 6
Total	**40**	**42**	**38**	**41**		$\bar{x}$**=95.8**
ZAIN/GLO	14	13	14	14	55	98.2
ZAIN/STAR	13	14	13	14	54	96.4
ZAIN/VISA	14	13	14	14	55	98.2
Total	**41**	**40**	**40**	**42**		$\bar{x}$**=97.6**

Table 4.80 shows that Globacom network experienced all the 42 attempted calls right at 8-10am while the same number was obtained from zain network in the evening time 16-18pm.

Of all these networks, glo/zain obtained 98.2% of the successfully attempted calls and zain/glo and zain/visa also got 98.2%.

Table 4.81: Call Set Up Success Ratio, CDMA inter Network connection for Gaskiya Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	13	12	12	14	51	92.8
STAR/ZAIN	14	14	14	14	56	100
STAR/ VISA	14	14	14	14	56	100
Total	**41**	**40**	**40**	**42**		$\bar{x}$**=97.6**
VISA/GLO	09	12	13	13	47	83.9
VISA/ZAIN	13	13	14	14	54	96.4
VISA/STAR	14	12	13	13	52	92.8
Total	**36**	**37**	**40**	**40**		$\bar{x}$**=91.0**

Just like above, table 4.81; also reveals here that between 16-18pm, 42 attempted calls went successful from Starcomms network but only 40 were obtained between 12 noon till 18pm.

At the same time, star/zain and star/visa scored 100 implying that all the calls attempted went successful, for visa/zain connection it portrayed a percentage value of 96.4%

Table 4.82: Call Set Up Success Ratio Intra Network connection for Shika Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	12	13	13	13	51	91.1
ZAIN	13	13	13	13	52	92.9
STAR	14	13	13	13	53	94.6
VISA	12	12	13	13	50	89.3
Total	**51**	**51**	**52**	**52**		

All the successfully attempted calls (52) made from mid day down to evening (18pm) were registered. In the same vein, Starcomms network had a higher percentage of 94.6% of these calls (table 4.82).

Table 4.83: Call Set Up Success Ratio GSM Inter Network connection for Shika Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	11	13	14	14	52	92.9
GLO/ STAR	14	14	13	13	54	96. 4
GLO/ VISA	11	13	14	13	51	91.1
Total	**36**	**40**	**41**	**40**		$\bar{x}$**=93.5**
ZAIN/GLO	12	14	12	13	51	91.1
ZAIN/STAR	13	14	13	13	53	94.6
ZAIN/VISA	12	14	14	12	52	92.9
Total	**37**	**42**	**39**	**38**		$\bar{x}$**=92.9**

It can be seen from table 4.83 that 12-14pm was a good time as 41 calls established were successful from glo network and from zain network, all the established call were successful.

Glo/star interconnection showed a higher percentage of 96.4 successfully attempted calls. This value also stood same for zain/star interconnection.

Table 4.84: Call Set Up Success Ratio, CDMA inter Network connection for Shika Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	14	12	13	12	51	91.1
STAR/ZAIN	13	12	13	13	51	91.1
STAR/ VISA	12	12	14	14	52	92.9
Total	**39**	**36**	**40**	**39**		$\bar{x}$**=91.7**
VISA/GLO	14	13	14	12	53	94.6
VISA/ZAIN	12	11	13	12	48	85.7
VISA/STAR	12	13	12	12	51	91.1
Total	**38**	**37**	**39**	**36**		$\bar{x}$**=90.5**

Results from table 4.84 shows that for CDMA inter network connection, calls from Starcomms network had a peak of 40 successfully attempted calls at about 12-14pm while at the same time instance Visafone had 39 of these calls.

Star/visa scored 92.9% of the successful call ratio whereas visa/glo scored 94.6%

Table 4.85: Call Set Up Success Ratio Intra Network connection for Muchia Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	14	13	14	14	55	98.2
STAR	14	14	13	13	54	96. 4
VISA	14	14	14	13	55	98.2
Total	**56**	**55**	**56**	**55**		

For this KPI, all the calls (56) at 6-8am and 12-14pm were through; meanwhile calls from glo network to other glo network registered a highest percentage of 100% (table 4.85).

Table 4.86: Call Set Up Success Ratio GSM Inter Network connection for Muchia Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	13	14	14	12	53	94.6
GLO/ STAR	14	14	13	13	54	96. 4
GLO/ VISA	14	13	14	12	53	94.6
Total	**41**	**41**	**41**	**37**		$\bar{x}$**=95.2**
ZAIN/GLO	12	14	13	14	51	90.1
ZAIN/STAR	12	13	13	14	53	94.6
ZAIN/VISA	13	14	13	13	52	92.9
Total	**37**	**41**	**39**	**41**		$\bar{x}$**=92.5**

As shown in table 4.86, Glo inter call experienced a success ratio of 41 calls out the 42 made. This was experienced from 6am till 14pm. The same 41 was observed at 8-10am and 16-18pm for zain internetwork calls. All the calls from Glo to Starcomms line experienced a success ratio percentage of 96.4% while zain/star scored 94.6%

Table 4.87: Call Set Up Success Ratio, CDMA inter Network connection for Muchia Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	13	13	13	14	53	94.6
STAR/ZAIN	13	14	13	12	52	92.9
STAR/ VISA	12	14	13	13	52	92.9
Total	**38**	**41**	**39**	**39**		$\bar{x}$**=93.5**
VISA/GLO	14	14	13	13	53	94.6
VISA/ZAIN	11	14	13	12	50	89.3
VISA/STAR	12	12	13	13	50	89.3
Total	**37**	**40**	**39**	**38**		$\bar{x}$**=90.1**

The highest value of 41 successfully attempted calls took place at 8-10am for Starcomms network and at the same time for Visa calls scored 40 successfully attempted calls. Star/glo had

94.6% of the successfully attempted calls, but for visa it the same value was observed for visa/glo connections (table 4.87).

Table 4.88: Call Set Up Success Ratio Intra Network connection for Deke Chi Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO	14	14	14	14	56	100
ZAIN	14	14	14	14	56	100
STAR	14	13	14	14	55	98.2
VISA	14	14	12	14	55	98.2
Total	**56**	**55**	**54**	**56**		

Table 4.88 shows that a good set up success ratio was experienced in the morning (6-8am) and evening (16-18pm) with all the established calls becoming successful.

Notwithstanding, calls from Globacom and Zain lines recorded a set up success ratio of 100%.

Table 4.89: Call Set Up Success Ratio GSM Inter Network connection for Deke Chi Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
GLO/ ZAIN	14	14	12	12	52	92.9
GLO/ STAR	14	13	14	13	54	96. 4
GLO/ VISA	13	13	13	13	52	92.9
Total	**41**	**40**	**39**	**38**		$\bar{x}$**=94.1**
ZAIN/GLO	12	14	14	14	54	96.4
ZAIN/STAR	14	14	14	14	56	100
ZAIN/VISA	14	14	14	14	56	100
Total	**40**	**42**	**42**	**42**		$\bar{x}$**=98.8**

From table 4.89, 41 calls from Globacom network established at 6-8am were successful while for zain, all of them from 8am to 18pm were successful.

Glo/star inter calls had a set up success value of 96.4% while only zain/glo inter calls fell below 100%.

Table 4.90: Call Set Up Success Ratio, CDMA inter Network connection for Deke Chi Area

Total Number of call attempts = 56 (14x4)

Network	6-8am	8-10am	12-14pm	16-18pm	total	%
STAR/GLO	13	13	13	13	52	92.9
STAR/ZAIN	12	14	13	14	53	94.6
STAR/ VISA	13	13	12	13	51	91.1
Total	**38**	**41**	**39**	**39**		$\bar{x}$**=92.9**
VISA/GLO	13	14	14	12	53	94.6
VISA/ZAIN	12	13	14	13	52	92.9
VISA/STAR	13	14	14	11	52	92.9
Total	**37**	**40**	**39**	**38**		$\bar{x}$**=93.5**

At 8-10am, 41 calls established from Starcomms network were successful, also 40 such calls at the same time instance were observed for Visafone.

Star/zain scored the highest percentage value of 94.6% set up success ratio while the same percentage was scored by Visa/glo interconnection as indicated in table 4.90.

4.4 CALL COMPLETION RATE TELEPHONY (CCR-CS-T) (In percentages)

The value for each of the intentionally terminated call for each of the time instances is taken from every location of data collection, for the study period of fourteen days the ratio of all those successfully attempted calls is also calculated and expressed in percentages as given in equation 3.4. The different values are recorded in tables 4.91 to 4.120 respectively.

Table 4.91: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Wusasa Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	14	14	13	14	53	55	96.4
ZAIN	14	14	14	14	54	56	96.4
STAR	12	13	14	13	50	52	96.2
VISA	14	13	14	14	52	55	94.5
Total	**54**	**54**	**55**	**55**			$\bar{x}$**=95.9**

Table 4.91 shows that generally nearly all the calls made ended successfully, because only a difference of two calls for 6-8am and 8-10am were short of the total of 56 calls made. At the same time a better result was experienced at 12-14pm and 16-18pm where only one call out of the total of 56 failed.

Concerning this KPI, it is seen that out of the 55 successful calls made for Globacom, 53 (96.4%) were intentionally terminated by either of the parties; Zain registered (96.4%) as well; Starcomms (96.2%) and Visafone (94.5%). Generally, GSM performance out-weighs that of the CDMA for this KPI with Globacom and Zain standing same position and Starcomms over shadowing Visafone**.**

Table 4.92: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Wusasa Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	12	13	13	14	52	53	98.1
GLO/ STAR	13	12	13	13	51	52	98.1
GLO/ VISA	13	13	13	13	52	54	96.3
Total	**38**	**38**	**39**	**40**			$\bar{x}$**=97.5**
ZAIN/GLO	14	14	12	14	54	55	98.2
ZAIN/STAR	14	12	11	14	51	54	94.4
ZAIN/VISA	13	13	12	14	52	54	96.3
Total	**41**	**39**	**35**	**42**			$\bar{x}$**=96.3**

From table 4.92 above, Globacom inter connects better at 16-18pm followed by 12-14pm with 39 completed calls and 38calls for the time period of 6-10am. Zain in turn interconnects better than Globacom. The best inter connection time stood at 16-18pm with 42 calls completely terminated, followed by 6-8am with 41, 39 at 8-10am finally poor at 12-14pm with only 35 successfully made calls. Zain inter connect better than Globacom.

The table also reveals that Globacom had a good inter connection with Zain and starcomms by scoring 98.1%. This went lower to 96.3% with Glo/visa connection. On the otherhand, Zain performance was higher at zain/glo interconnection (98.2%) then dropped to 96.3% for Zain/visa and then 94.4% for zain/star. Zain is still better placed in this KPI than Globacom but both of them interconnect with themselves better than with CDMAs.

Table 4.93: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Wusasa Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	13	12	14	12	51	51	100
STAR/ZAIN	14	13	13	14	54	56	96.4
STAR/VISA	14	13	12	13	52	55	94.5
Total	**41**	**38**	**39**	**39**			$\bar{x}$**=97.0**
VISA/GLO	12	12	13	13	50	52	96.2
VISA/ ZAIN	12	12	13	14	51	54	94.4
VISA/ STAR	13	14	14	14	55	56	98.2
Total	**37**	**38**	**40**	**41**			$\bar{x}$**=96.3**

From table 4.93, 6-8am Wusasa experienced more successful calls (41) from stacomms to Visa followed by 12-14pm and 16-18pm time instances but lowest number of calls (38) made at 8-10am. Visa on the other hand performed well in the after Noon 12 -14pm and evening 16 -18pm with 40 and 41 calls successfully made respectively. This implies that the morning period

experienced lower values of 37 and 38 successful calls at 6-8am and 8-10am respectively. Visa performs better in this KPI than starcomms.

The inter connection of Visa/glo is highest since all the calls made went through (100%), Starcomms has its highest performance of 98.2% with Star/visa connection. This is also followed by 96.2% for star/glo while visa/star stood at 96.4%. The lowest values are 94.5% for Visa/zain and star/zain, 94.4%. CDMAs inter connect well with Globacom.

Table 4.94: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Zaria City Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	14	14	14	13	54	55	98.2
ZAIN	12	12	13	13	50	52	96.2
STAR	13	13	13	14	52	53	98.1
VISA	13	13	12	14	52	54	96.3
Total	**52**	**52**	**52**	**54**			$\bar{x}$**=97.2**

The table 4.94, reveals that majority of the calls established were intentionally terminated by either of the parties especially at 16-18pm where value of 54 was obtained. The rest of the day from morning to after noon got 52 calls that were terminated voluntarily by the parties.

Again, the maximum percentages for Globacom and Starcomms stood at 98.2% and 98.1% respectively while their lower percentage values stood at 96.2% and 96.3% respectively for Zain and Starcomms. Both the GSM and CDMA are behaving the same relative to this KPI in this data collection area.

Table 4.95: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Zaria City Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	12	13	12	13	50	53	94.3
GLO/ STAR	13	14	14	14	55	55	100
GLO/ VISA	14	13	14	13	54	54	100
Total	**39**	**40**	**40**	**40**			$\bar{x}$**=98.1**
ZAIN/GLO	14	13	12	13	52	54	96.3
ZAIN/STAR	14	13	12	13	52	53	98.1
ZAIN/VISA	13	13	14	13	53	53	100
Total	**41**	**39**	**38**	**39**			$\bar{x}$**=98.1**

Table 4.95 shows that out of the 42 calls made from Globacom and Zain lines to other networks, only 6-8am time instances experienced a lower number (39) of completely established calls; the rest of the days got 40 calls. Then for zain 41 calls at 6-8am; while 39 calls came at 8-10am and 16-18pm. Only 38 calls were obtained at mid day. Globacom plays well than Zain.

GSMs inter connection is very good in Zaria city as Globacom and Zain interconnected the two CDMAs at 100% completion rate. This automatically entails that GSM inter connect with CDMA much better than with themselves.

Table 4.96: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Zaria City Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	13	14	13	14	54	56	96.4
STAR/ZAIN	13	14	14	12	53	53	100
STAR/VISA	14	13	14	13	54	55	98.2
Total	**40**	**41**	**41**	**39**			$\bar{x}$**=98.2**
VISA/GLO	14	12	14	13	53	53	100
VISA/ ZAIN	13	13	12	13	51	54	94.4
VISA/ STAR	13	13	13	13	52	53	98.1
Total	**40**	**39**	**38**	**39**			$\bar{x}$**=97.5**

All calls made from the starcomms line went through as they range from 39 at 16-18pm as the lowest and 41 at 8-10am and 12-14pm. In same vein, Visa has 38 as its value at 12-14pm and highest of 40 at 6-8pm**.**

The CDMAs played well with the GSM relative to this KPI as star/Zain and Visa/glo inter connections stood at 100% (table 4.96).

Table 4.97: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Angwua Godo Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	13	14	14	14	55	55	100
ZAIN	14	14	13	13	54	54	100
STAR	11	14	13	14	50	55	90.9
VISA	12	13	14	13	52	55	94.5
Total	**50**	**55**	**54**	**54**			$\bar{x}$**=96.4**

Table 4.97 shows that 8-10am contains the highest number of calls that went completely then followed by the rest of the day from 12 noon till 18pm. In this vein, it is seen that GSMs networks performed more than the CDMAs as they scored 100% for the GSMs and less than that for the CDMAs

Table 4.98: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Angwua Godo Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	13	14	12	14	53	54	98.1
GLO/ STAR	13	14	13	12	52	54	96.3
GLO/ VISA	14	14	14	13	55	56	98.2
Total	**40**	**42**	**39**	**39**			$\bar{x}$**=97.5**
ZAIN/GLO	14	12	13	12	51	56	91.1
ZAIN/STAR	14	12	13	12	51	54	94.4
ZAIN/VISA	12	13	13	12	50	51	98.0
Total	**40**	**37**	**39**	**36**			$\bar{x}$**=94.5**

Table 4.98 reveals that calling from globacom at 8-10m is good because all the calls went to completion, while from Zain line is 6-8am where 40 calls were completed.

Globacom calls to zain and visa lines are very good as they scored 98.1% and 98.2% of the calls that ended genuinely. Zain/Visa had 98.0% calls that were genuinely ended. So Globacom performs better than zain.

Table 4.99: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Angwua Godo Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	12	14	13	13	52	56	92.9
STAR/ZAIN	14	13	14	14	55	55	100
STAR/VISA	13	13	13	13	52	54	96.3
Total	**39**	**40**	**40**	**40**			$\bar{x}$**=96.4**
VISA/GLO	13	13	13	13	52	55	94.5
VISA/ ZAIN	13	12	13	12	50	52	96.2
VISA/ STAR	14	13	12	13	52	54	96.3
Total	**40**	**39**	**38**	**39**			$\bar{x}$**=95.6**

Most of the calls made from Starcomms from 8am to 18pm only two calls at each time instance terminated prematurely. Those from Visafone are good at 6-8am also two of the calls ended prematurely.

Starcomms interconnects best with zain as all the calls (100%) terminated genuinely, while Visafone proves to connect well with zain and Starcomms scoring 96.2% and 96.3% respectively for all genuinely terminated calls as shown in table 4.99.

Table 4.100: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Kongo Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	14	12	14	13	53	55	96.3
ZAIN	13	13	14	11	52	52	100
STAR	13	13	14	13	53	54	96.3
VISA	14	14	14	14	56	56	100
Total	**50**	**52**	**56**	**51**			$\bar{x}$**=98.1**

Table 4.100 shows that all the calls made at 12-14pm went through and terminated properly. Among these networks, all successfully established calls from Zain and Visafone were genuinely ended that is to say, Zain and Visafone played well.

Table 4.101: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Kongo Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	14	14	14	13	55	56	98.2
GLO/ STAR	13	13	13	12	51	55	92.7
GLO/ VISA	14	13	14	13	54	55	98.1
Total	**41**	**40**	**41**	**39**			$\bar{x}$**=96.3**
ZAIN/GLO	13	13	14	13	53	55	96.4
ZAIN/STAR	12	13	14	14	53	55	96.4
ZAIN/VISA	11	13	12	12	48	52	92.3
Total	**36**	**39**	**40**	**39**			$\bar{x}$**=95.0**

It is seen from table 4.101 that 6-8am and 12-14pm are good times to call with Globacom lines because 41 of the calls made from the line were ended by either of the users. 12 -14pm was also recorded for Zain network though a value of 40, just a unit less than that of Glo was gotten.

The inter connections with the best completion rate are glo/zain and glo/visa with 98.2% then Zain/glo and Zain/star with 96.4%

Table 4.102: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Kongo Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	12	12	14	14	52	55	96.4
STAR/ZAIN	14	13	13	13	53	54	98.1
STAR/VISA	12	14	13	13	52	53	98.1
Total	**38**	**39**	**40**	**40**			$\bar{x}$**=97.5**
VISA/GLO	12	12	14	13	51	53	96.2
VISA/ ZAIN	12	13	14	13	52	55	94.5
VISA/ STAR	12	13	13	13	51	54	94.4
Total	**36**	**38**	**41**	**39**			$\bar{x}$**=95.0**

CDMAs obtained the best inter connection time at 12-14pm and 16-18pm with Starcomms registering 40 and Visafone registered 41 calls genuinely ended by the either of the parties.

Notwithstanding, Star/zain and star/visa stood at 98.1% each but visa/glo at 96.2% (table 4.102).

Table 4.103: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Samaru Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	13	14	14	14	54	55	98.2
ZAIN	13	13	13	14	53	55	94.6
STAR	11	13	12	14	50	51	98.1
VISA	12	13	12	14	51	56	91.1
Total	**49**	**55**	**51**	**56**			$\bar{x}$**=95.5**

Only calls made at 16-18pm were terminated as required for the study period from this data collection area. The network with the majority of completely terminated calls is therefore, Globacom and Starcomms each scoring 98.2% completion rate as indicated in table 4.103.

Table 4.104: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Samaru Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	12	14	12	14	52	54	98.1
GLO/ STAR	13	14	13	12	52	55	96.3
GLO/ VISA	12	12	14	13	51	50	98.2
Total	**37**	**40**	**40**	**39**			$\bar{x}$**=97.5**
ZAIN/GLO	12	14	13	12	51	53	96.2
ZAIN/STAR	12	11	13	12	48	52	92.3
ZAIN/VISA	14	14	13	12	53	53	100
Total	**38**	**39**	**39**	**36**			$\bar{x}$**=96.2**

Table 4.104 indicates that as from 8 am to 14pm 40 calls terminated as required when the Globacom line was used meanwhile for zain line, this was obtained at same time but with 38 calls, two calls lower than those of globacom.

Glo/zain and Glo/visa had the highest percentage 98.1 and 98.2 respectively while Zain/visa recorded all the calls genuinely terminated with 100% score.

Table 4.105: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Samaru Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	14	13	13	13	53	54	94.6
STAR/ZAIN	13	13	11	12	49	52	94.2
STAR/VISA	13	12	12	12	49	52	94.2
Total	**40**	**38**	**36**	**37**			$\bar{x}$**=94. 3**
VISA/GLO	13	13	13	12	51	55	92.7
VISA/ ZAIN	13	13	14	13	53	55	96.4
VISA/ STAR	14	13	14	12	52	55	94.5
Total	**40**	**39**	**41**	**37**			$\bar{x}$**=94. 5**

The table 4.105 shows that for both networks lines, 6-8am recorded 40 successfully terminated calls but Visafone in addition recorded the highest of 41 calls at 12-14pm.

Of all the calls made from Starcomms lines star/glo was terminated as desired with a higher percentage value of 94.6 while Visa/Zain got the highest of 96.4%.

Table 4.106: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Basawa Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	14	14	14	14	56	56	100
ZAIN	13	14	14	12	53	55	96.4
STAR	13	14	13	12	52	53	98.1
VISA	12	14	13	13	52	53	98.1
Total	**52**	**56**	**54**	**51**			$\bar{x}$**=98.2**

From table 4.106 all the calls made at 8-10am were terminated as desired. Globacom calls all terminated genuinely that is 100%

Table 4.107: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Basawa Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	13	13	13	11	50	54	89.3
GLO/ STAR	14	13	13	14	54	54	100
GLO/ VISA	11	12	12	12	47	52	90.1
Total	**38**	**38**	**30**	**37**			$\bar{x}$**=93.1**
ZAIN/GLO	14	14	13	14	55	55	100
ZAIN/STAR	14	12	14	11	51	54	94.4
ZAIN/VISA	13	13	13	14	53	55	96.4
Total	**41**	**39**	**38**	**39**			$\bar{x}$**=97.0**

From 6am to 10am 38 of the calls from Globacom were ended as required while 41 from zain line at 6-8am end required. 100% genuinely ended calls were realised from Glo/Star and Zain/glo (table 4.107).

Table 4.108: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Basawa Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	13	13	13	14	53	55	96.4
STAR/ZAIN	12	12	14	13	51	53	96.2
STAR/VISA	11	13	12	12	48	53	90.1
Total	**36**	**38**	**39**	**39**			$\bar{x}$**=94.2**
VISA/GLO	11	13	12	13	49	50	98.0
VISA/ ZAIN	13	13	14	12	52	55	94.5
VISA/ STAR	14	14	11	13	52	53	96.9
Total	**38**	**40**	**37**	**38**			$\bar{x}$**=96.4**

Table 4.108 indicates that a good number of 39 terminated calls were realised from Starcomms lines from 12 noon till 18pm. For visa line; a total of 40 calls were obtained.

Star/glo connection had 96.4% of the calls terminated as required then visa/glo registered 98.0% of such calls.

Table 4.109: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Gaskiya Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	13	14	14	14	55	56	98.2
ZAIN	13	13	14	13	53	55	96.4
STAR	13	13	12	13	51	52	98.1
VISA	12	12	12	13	49	49	100
Total	**52**	**56**	**54**	**51**			$\bar{x}$**=98.2**

From table 4.109 all the 56 calls were completed genuinely. Visafone emerged to best network for this KPI with all the calls made from it ending as required.

Table 4.110: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Gaskiya Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	14	14	12	14	54	55	96.4
GLO/ STAR	13	13	12	14	52	52	100
GLO/ VISA	12	13	12	13	50	54	92.3
Total	**39**	**40**	**36**	**41**			$\bar{x}$**=96.2**
ZAIN/GLO	13	13	12	14	52	53	98.1
ZAIN/STAR	12	13	12	14	51	54	91.1
ZAIN/VISA	14	12	14	13	53	55	96.4
Total	**39**	**38**	**38**	**41**			$\bar{x}$**=94.6**

As indicated in table 4.110, 41 calls were completed at 16-18pm from both Glo and Zain lines, meanwhile all calls from globacom to Starcomms ended as required. 98.1% of them did so, from zain to globacom lines.

Table 4.111: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Gaskiya Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	13	12	14	12	51	53	96.2
STAR/ZAIN	14	14	13	13	54	56	96.4
STAR/VISA	14	13	13	14	54	56	96.4
Total	**41**	**39**	**40**	**39**			$\bar{x}$**=96.3**
VISA/GLO	09	12	13	12	46	51	90.2
VISA/ ZAIN	13	13	13	14	53	54	98.1
VISA/ STAR	14	12	13	10	49	52	94.2
Total	**36**	**37**	**39**	**36**			$\bar{x}$**=94.2**

For all Calls made Starcomms line at 6-8am, 41 of them ended well while 39 were genuinely ended from Visafone network at mid day.

Starcomms interconnections (star/zain and star/visa) got 96.4% of them completed genuinely. For visa/zain stood at 98.1% (table 4.111)

Table 4.112: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Shika Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	12	13	13	13	51	53	96.2
ZAIN	13	13	13	13	52	54	96.3
STAR	12	13	13	13	51	53	96.2
VISA	12	12	13	12	49	54	90.7
Total	**51**	**51**	**52**	**51**			$\bar{x}$**=94.9**

Table 4.112 shows that all the calls made from 12-14pm were genuinely ended, the rest of the day had only a call prematurely ended call each.

Zain scored the highest percentage of 96.3%, though globacom and star scored just slightly (96.2%) each below the value of Zain.

Table 4.113: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Shika Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	11	13	14	14	52	56	92.9
GLO/ STAR	14	14	13	13	54	56	96.4
GLO/ VISA	11	13	14	13	51	52	98.1
Total	**36**	**40**	**41**	**40**			$\bar{x}$**=95.8**
ZAIN/GLO	12	14	12	13	51	52	98.1
ZAIN/STAR	12	14	13	13	52	54	96.3
ZAIN/VISA	12	14	14	12	52	56	92.9
Total	**36**	**42**	**39**	**38**			$\bar{x}$**=95.8**

The table above (4.113) indicates that 41 calls from the Globacom network at 12-14pm were well ended and from zain line, all the 42 of these made between 8-10am were ended as required.

98.1%, the highest percentage was scored by both glo/visa and zain/glo inter-network connections.

Table 4.114: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Shika Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	14	12	13	12	52	54	96.3
STAR/ZAIN	13	12	13	13	51	52	98.1
STAR/VISA	12	12	14	14	52	54	96.3
Total	**39**	**36**	**40**	**39**			$\bar{x}$**=96.9**
VISA/GLO	14	13	14	12	53	54	98.1
VISA/ ZAIN	12	11	13	12	48	52	92.3
VISA/ STAR	12	13	12	12	49	53	92.5
Total	**38**	**37**	**39**	**36**			$\bar{x}$**=94.3**

From Starcomms lines, the calls made at 12-14pm (40 calls) ended completely and from the Visafone network, the same time instance registered 39 of similar calls.

Star/zain and visa/glo scored the same percentage of 98.1% of well ended calls (table 4.114).

Table 4.115: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Muchia Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	14	13	14	14	55	56	98.2
ZAIN	14	13	13	13	53	55	96.3
STAR	11	14	13	12	50	54	92.6
VISA	12	14	14	13	53	55	96.3
Total	**51**	**54**	**54**	**52**			$\bar{x}$**=95.9**

It is seen from table 4.115 that, between 8am and 14pm, 54 calls were completely ended. Out of these networks, Glo demonstrated a better connection by scoring 98.2%.

Table 4.116: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Muchia Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	11	14	13	12	52	55	94.5
GLO/ STAR	14	14	13	13	54	55	98.2
GLO/ VISA	14	13	14	12	53	56	94.6
Total	**39**	**41**	**40**	**37**			$\bar{x}$**=95.8**
ZAIN/GLO	12	14	12	14	52	53	98.1
ZAIN/STAR	13	14	13	14	54	54	100
ZAIN/VISA	13	14	13	13	53	55	96.4
Total	**38**	**42**	**38**	**41**			$\bar{x}$**=95.8**

Table 4.116 shows that, the only better best time for this KPI was 8-10am where 41 calls were ended as desired for Globacom line and 42 calls at the same time instance for zain lines.

98.2% of the calls from glo/star were completely terminated while for zain/star all the calls (100%) were well ended.

Table 4.117: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Muchia Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	13	13	13	14	53	56	94.6
STAR/ZAIN	12	14	13	12	51	55	92.7
STAR/VISA	12	14	13	13	52	54	96.3
Total	**37**	**41**	**39**	**39**			$\bar{x}$**=94.5**
VISA/GLO	14	14	13	13	54	56	96.4
VISA/ ZAIN	11	14	13	12	50	54	92.6
VISA/ STAR	12	12	13	13	50	54	92.6
Total	**37**	**40**	**39**	**38**			$\bar{x}$**=93.9**

41 calls at 8-10am from Starcomms line ended as required and 40 calls at the same time from Visafone line also ended completely as can be seen in table 4.117.

Star/visa calls possessed a higher value of 96.3% and visa/glo experienced similar but slightly higher value of 96.4%.

Table 4.118: Call Completion Rate Telephony (CCR-CS-T) Intra connection for Deke Chi Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO	13	13	14	14	54	56	96.4
ZAIN	14	14	14	14	56	56	100
STAR	14	13	14	14	54	55	98.2
VISA	14	14	12	14	53	54	98.1
Total	**55**	**54**	**54**	**52**			$\bar{x}$**=98.2**

The number of completely ended calls was 55 out of 56 between 6-8am but Zain network proved effective in this KPI was a total of 100% calls well ended (table 4.118).

Table 4.119: Call Completion Rate Telephony (CCR-CS-T) GSM Inter connection for Deke Chi Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
GLO/ ZAIN	14	14	13	13	54	56	96.4
GLO/ STAR	14	13	14	14	54	55	98.2
GLO/ VISA	13	14	13	14	52	55	94.5
Total	**41**	**41**	**40**	**41**			$\bar{x}$**=96.4**
ZAIN/GLO	12	14	14	14	54	54	100
ZAIN/STAR	14	14	14	14	55	56	98.2
ZAIN/VISA	14	14	14	14	53	56	94.6
Total	**40**	**42**	**42**	**42**			$\bar{x}$**=97.6**

From table 4.119, all the time instances for globacom network had just one prematurely ended call except at 12-14pm where two of such calls were observed. At the same time, from Zain line all were well ended for all the time instances except in the morning 6-8am where only 40 premature calls ended were observed.

98.2% of the call from Glo to Starcomms lines was genuinely terminated while all from zain to glo network were also ended as desired.

Table 4.120: Call Completion Rate Telephony (CCR-CS-T) CDMA Inter connection for Deke Chi Area

Network	6-8am	8-10am	12-14pm	16-18pm	$total_i$	$total_s$	%
STAR/ GLO	14	14	13	14	52	55	94.5
STAR/ZAIN	14	14	14	12	53	56	94.6
STAR/VISA	14	13	13	13	51	53	96.2
Total	**42**	**41**	**40**	**39**			$\bar{x}$**=95.1**
VISA/GLO	14	14	14	13	52	55	96.5
VISA/ ZAIN	14	14	14	13	52	55	96.5
VISA/ STAR	13	14	14	11	52	52	100
Total	**41**	**42**	**42**	**34**			$\bar{x}$**=97.7**

All the 42 call made from Starcomms network at 6-8am were well ended. This goes same for Visafone calls that were made from 8am to 14pm.

Star/zain interconnection obtained 94.6% well ended calls while visa/star obtained all the calls (100%) ended calls as shown in table 4.120.

4.5 PERFORMANCE OF INDIVIDUAL NETWORK IN EACH DATA COLLECTION AREA

The values for the tables below are generated from the performances of each network in the different KPIs in different data collection sites. These values for each data collection sites are compared for each network type to know the network with a better performance.

Line graphs are used to clearly bring out the performance values of each network for each site.

Table 4.121 KPI performance for Wusasa Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	94.7	97.1	94.8	95.3
Set up Time	7.0	6.9	7.1	7.2
Success Ratio	93.4	93.4	97.7	95.2
Completion Rate	97.5	96.3	96.3	97.0

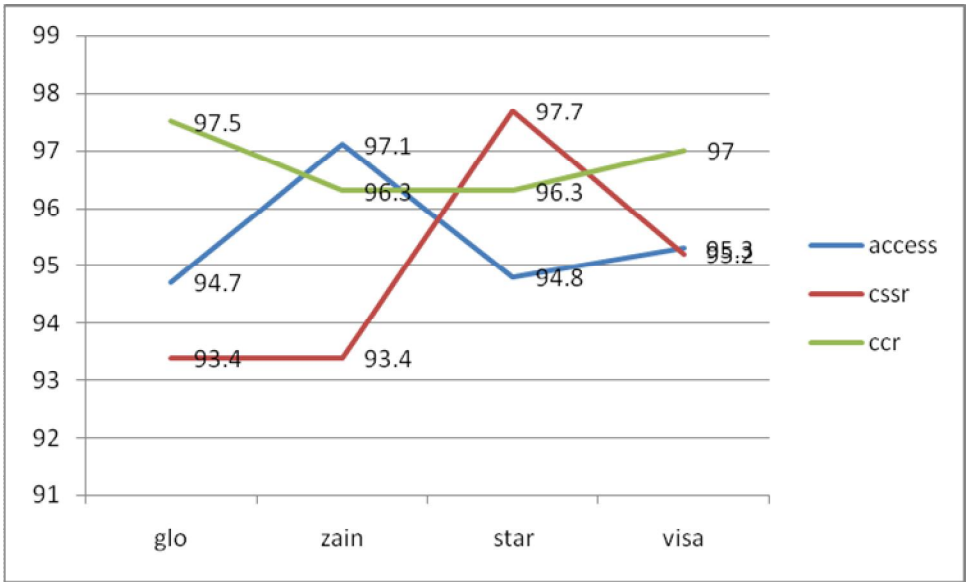


Figure 4.1: Graph of KPI performance for Wusasa Area

The graph shows that at Wusasa the most favourable network to use in making inter network calls is Zain for GSM network or Visafone for CDMA network interconnection.

Table 4.122 KPI performance for Zaria City Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	96.4	94.6	97.6	94.1
Set up Time	7.6	7.2	7.7	6.7
Success Ratio	96.5	94.6	97.7	95.2
Completion Rate	98.1	98.1	98.2	97.5

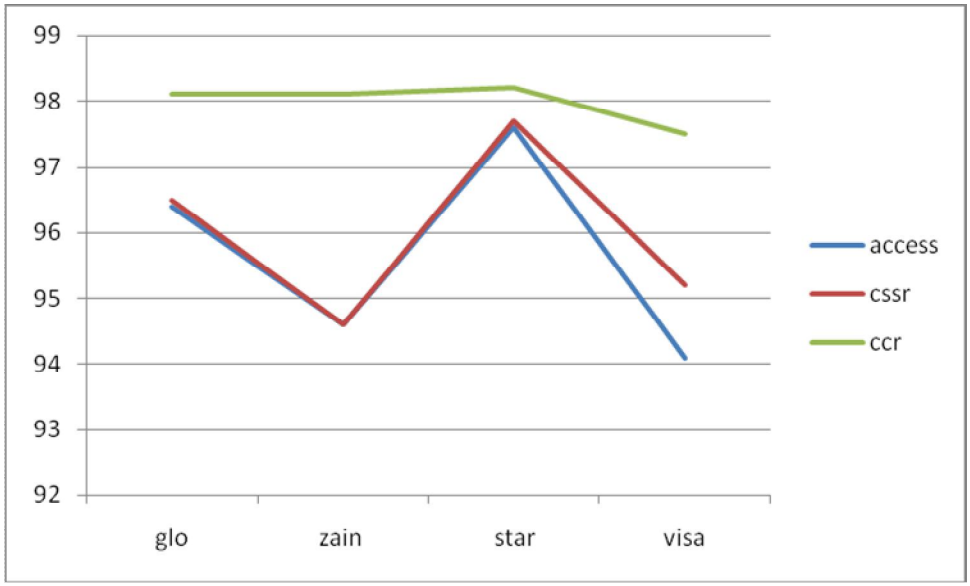


Figure 4.2: Graph of KPI performance for Zaria City Area

Starcomms has a better performance at around Zaria city area as calls from this network are all completed. This is followed by Globacom network for the GSM network type.

Table 4.123 KPI performance for Angwua Godo Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	97.6	95.8	97.6	95.8
Set up Time	7.2	7.3	7.2	8.4
Success Ratio	95.2	89.8	95.3	92.3
Completion Rate	97.5	94.5	96.4	95.6

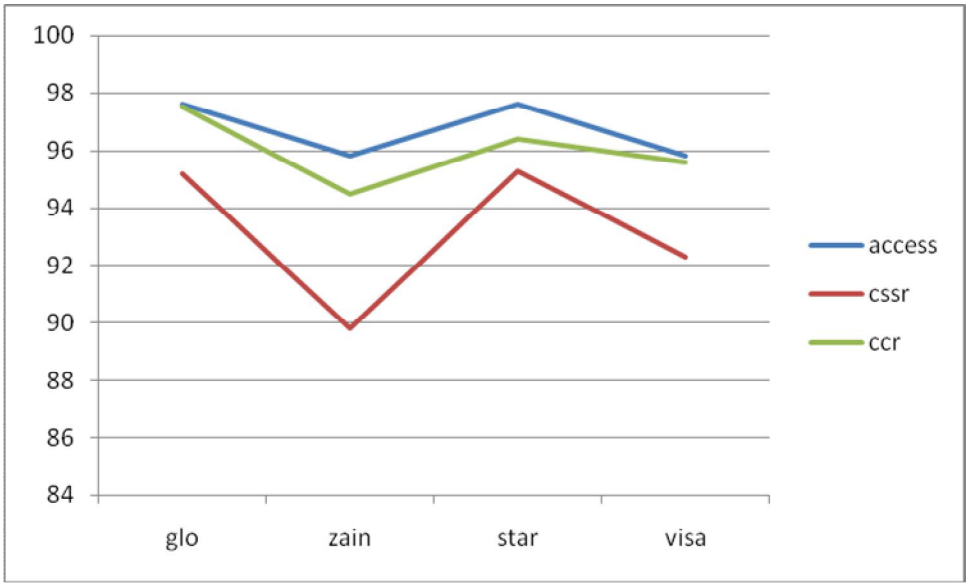


Figure 4.3: Graph of KPI performance for Angwua Godo Area

Looking at the graph it is seen that globacom and Starcomms are the most preferable networks to use while in Angwua Godo area of Zaria.

Table 4.124 KPI performance for Deke Chi Area

KPI	Globacom	Zain	Starcomms	Visafone
Set up Time	7.3	7.2	6.9	6.7
Accessibility	97.0	98.8	97.6	96.4
Success Ratio	94.1	98.8	92.9	93.5
Completion Rate	96.4	97.6	97.7	95.1

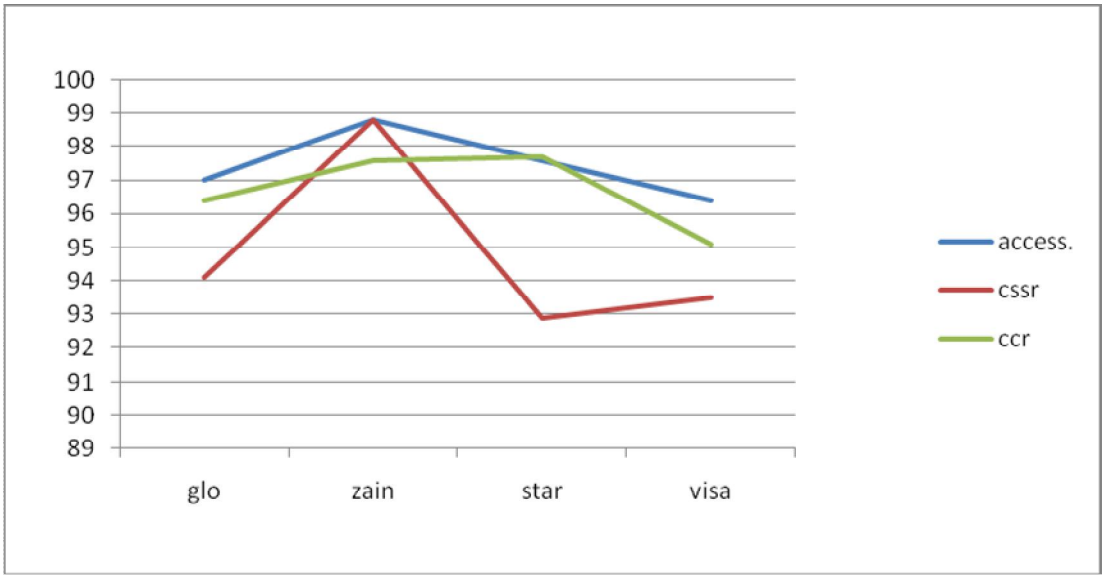


Figure 4.4: Graph of KPI performance for Deke Chi Area

All the KPIs under study perform well with Zain network than any other one of the networks under study. But for the CDMAs, Visafone is preferred to Starcomms network because many of the calls established will not be successful.

Table 4.125 KPI performance for Muchia Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	98.2	96.4	98.2	97.6
Set up Time	6.3	7.8	7.3	6.1
Success Ratio	95.2	92.5	93.5	90.1
Completion Rate	95.8	95.8	94.5	93.9

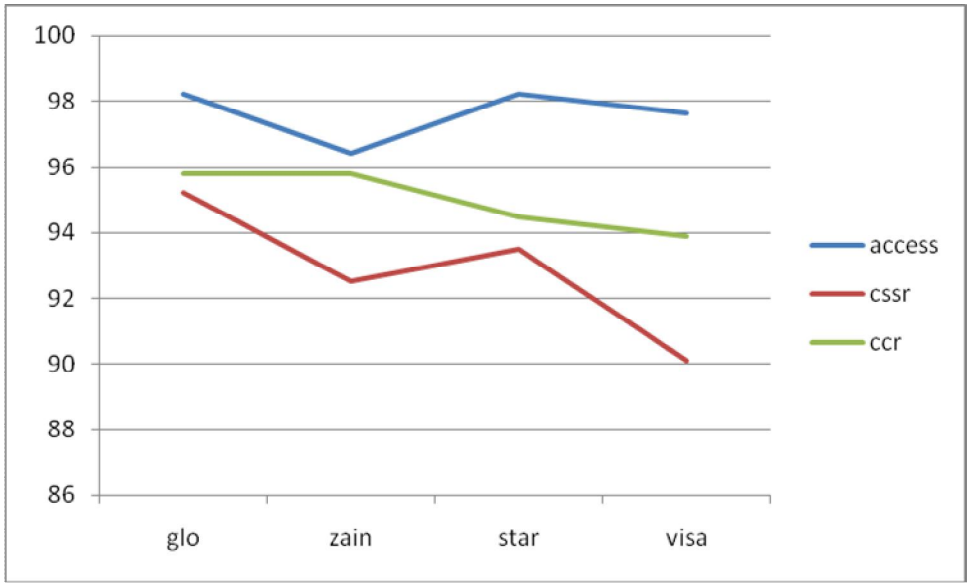


Figure 4.5: Graph of KPI performance for Muchia Area

Globacom network is the most preferred network here since its KPI values are high while it counterpart network; Starcomms is also scoring a high performance as concerns the CDMAs.

Table 4.126: KPI performance for Kongo Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	98.2	96.4	97.6	96.4
Set up Time	7.0	7.1	7.1	6.9
Success Ratio	95.8	90.1	94.0	92.3
Completion Rate	96.3	95.0	97.5	95.0

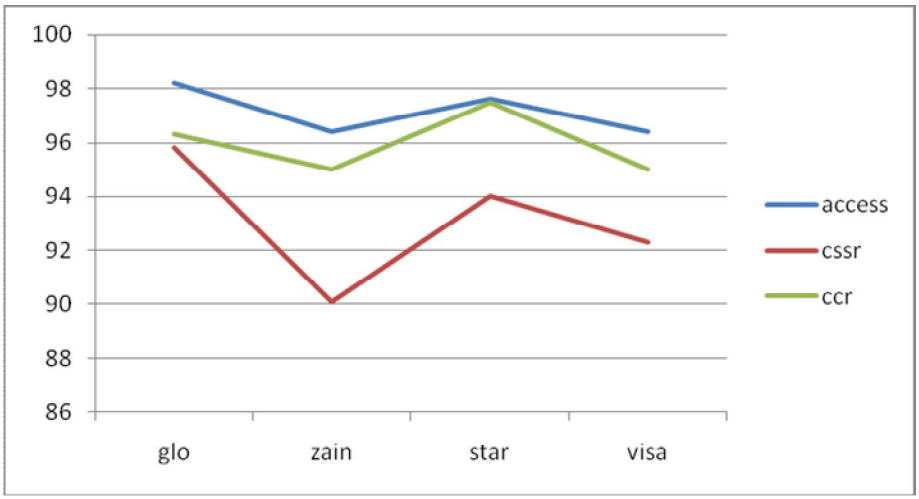


Figure 4.6: Graph of KPI performance for Kongo Area

GSM network type performs well here as can be seen from Globacom network while for the CDMA it is Starcomms that can be preferably used for interconnections.

Table 4.127: KPI performance for Gaskiya Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	95.8	97.6	97.6	91.1
Set up Time	7.0	7.0	7.2	6.7
Success Ratio	98.5	96.5	97.6	91.0
Completion Rate	96.2	94.6	96.3	94.2

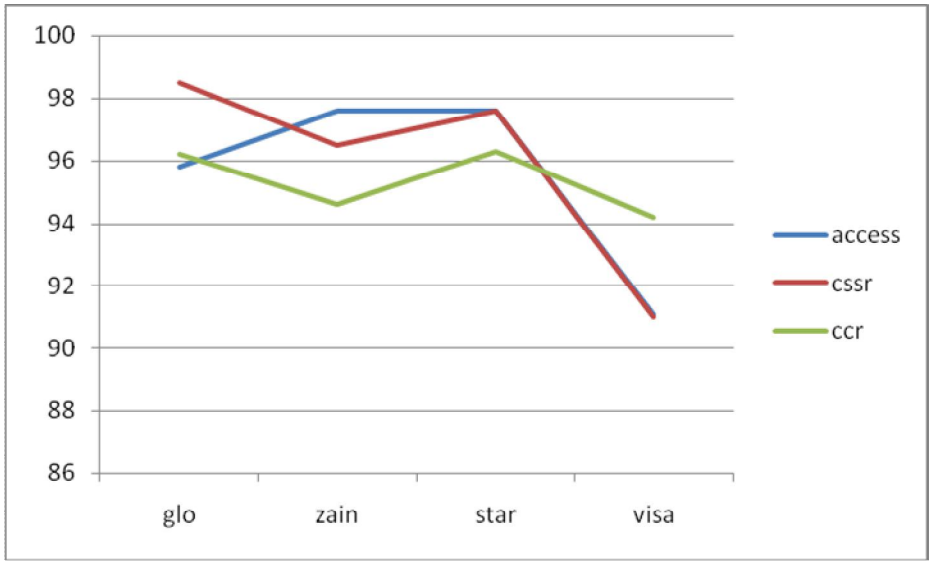


Figure 4.7: Graph of KPI performance for Gaskiya Area

Globacom network is rated higher here, it connects to other networks faster with an average set up time of 7.0 seconds, and it is briefly followed by Starcomms that also connects at the same 7.0 seconds set up time.

Table 4.128: KPI performance for Shika Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	95.2	97.6	95.8	94.0
Set up Time	7.1	7.1	7.4	6.6
Success Ratio	89.9	94.3	89.9	92.2
Completion Rate	93.1	97.0	94.2	96.4

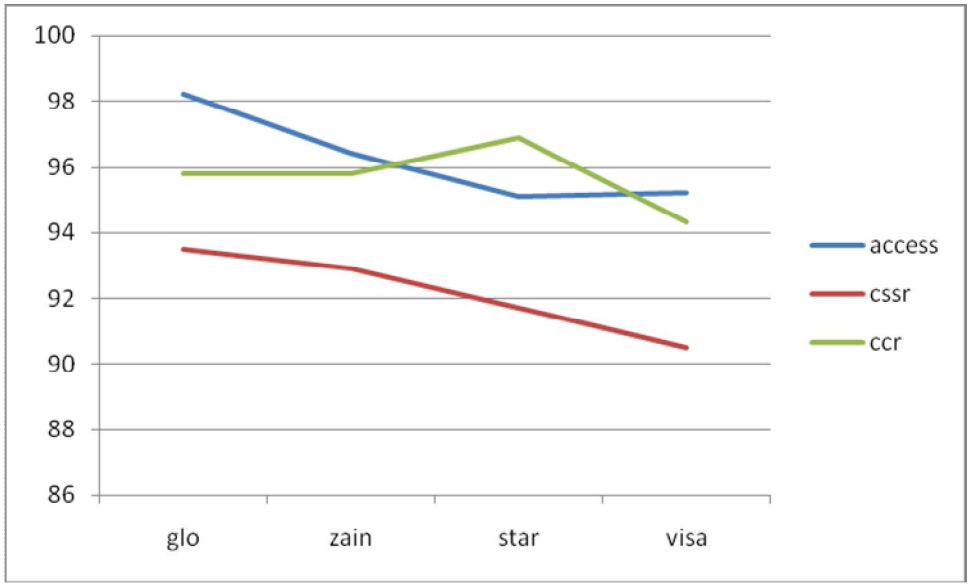


Figure 4.8: Graph of KPI performance for Shika Area

Again in this Shika area, globacom emerges a better network than zain while Starcomms performs better than Visafone.

Table 4.129: KPI performance for Basawa Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	98.2	96.4	95.1	95.2
Set up Time	7.1	7.3	7.2	6.8
Success Ratio	93.5	92.9	91.7	90.5
Completion Rate	95.8	95.8	96.9	94.3

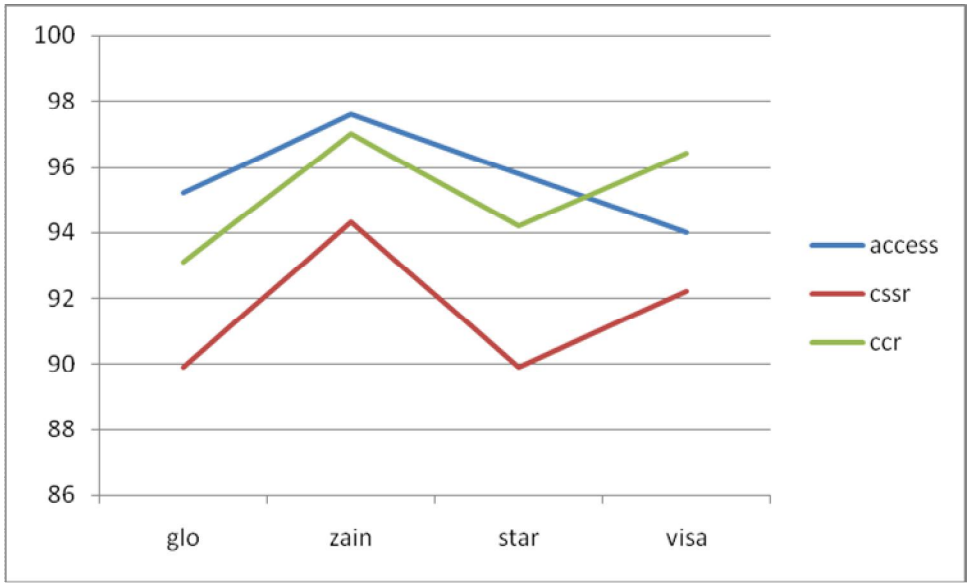


Figure 4.9: Graph of KPI performance for Basawa Area

Calls at Basawa were easily done with zain network and Visafone as can be seen from the graph. Both of them had a set up time of 7.3 and 6.8 seconds respectively to interconnect to other networks.

Table 4.130: KPI performance for Samaru Area

KPI	Globacom	Zain	Starcomms	Visafone
Accessibility	97.6	94.6	94.1	98.2
Set up Time	6.9	7.0	6.9	6.9
Success Ratio	92.8	89.9	91.1	93.4
Completion Rate	97.5	96.2	94.3	94.5

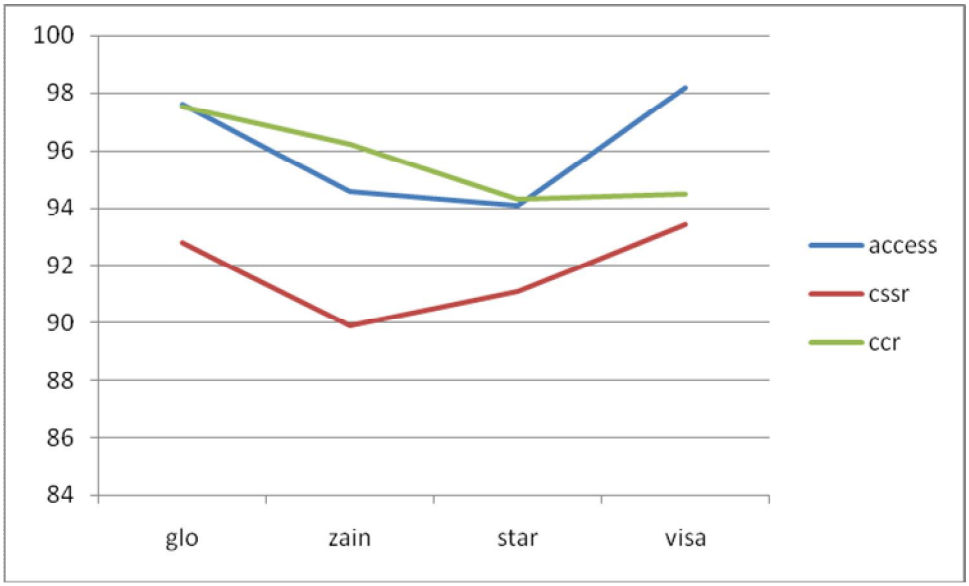


Figure 4.10: Graph of KPI performance for Samaru Area

In Samaru, it should be preferred to use a globacom network to zain which has a lowest call set up success ratio (89.9%) and connects 7.0 seconds or use Visafone network which has the highest service accessibility and connects at 6.9 seconds only.

Table 4.131: Table of preferred network for individual data collection Area

		GSM		CDMA	
	Location	**Globacom**	**Zain**	**Starcomms**	**Visafone**
1.	Wusasa		✓		✓
2.	Zaria City	✓		✓	
3.	Deke Chi		✓		✓
4.	Kongo	✓		✓	
5.	Gaskiya	✓		✓	
6.	Angwua Godo	✓		✓	
7.	Muchia	✓		✓	
8.	Basawa		✓		✓
9.	Shika	✓		✓	
10.	Samaru	✓			✓

4.6 GENERAL TABLE FOR INTRA AND INTER CONNECTIONS FOR ALL THE GSM AND CDMA KPIs UNDER CONSIDERATION

The values of this table are obtained by extracting the percentage (Service Accessibility, call set up success ratio and call completion success rate) and average time (Set up time) value for each inter and intra-connection of each of the networks, then the average percentages for all the KPIs are calculated and the results are recorded in the table (4.132) below. The various bar charts for each KPIs are drawn for the analysis.

Table 4.132: General outcome of all KPIs for both inter and intra GSM and CDMA connections.

KPI	GSM				CDMA			
	GLO		ZAIN		STAR		VISA	
	Intra	Inter	Intra	Inter	Intra	Inter	Intra	Inter
Service Accessibility (%)	96.2	96.8	97.5	96.1	97.3	95.9	96.4	95.5
Set up Time (secs)	7.1	7.2	7.1	7.1	6.9	7.2	6.5	6.8
Call Set up Success Ratio (%)	96.4	95.2	95.2	93.4	94.0	94.2	92.7	93.5
Call Completion success Ratio (%)	95.4	94.4	94.5	92.5	93.4	93.2	91.9	92.2

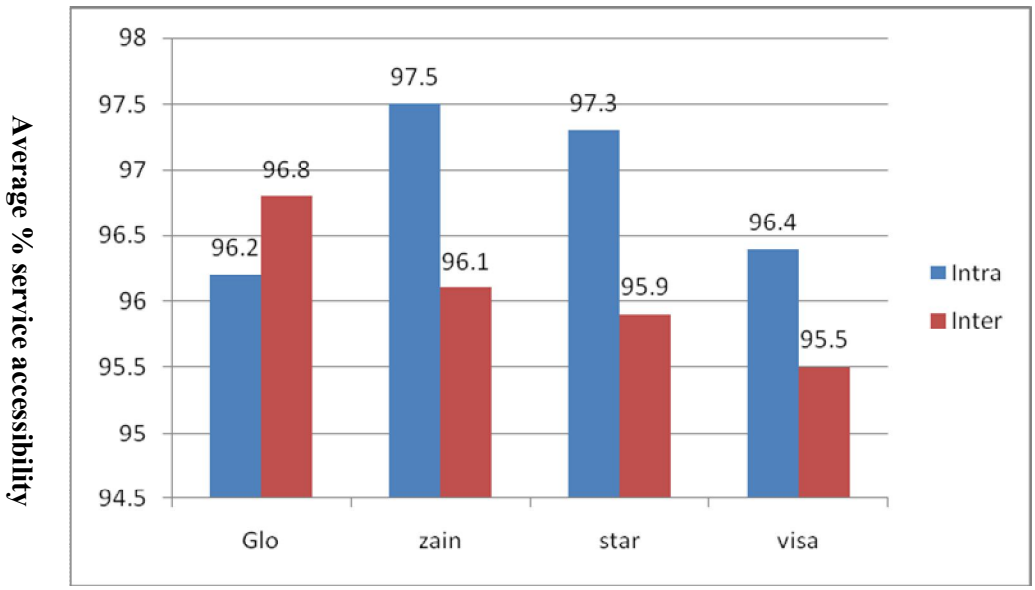


Figure 4.11: Graph showing Service Accessibility for GSM and CDMA Networks

The graph on figure 4.11 indicates that Zain and Starcomms have the highest intra connection service accessibility (97.5%) followed by Starcomms (97.3%) then Visafone that registers 96.4% followed by Globacom with 96.2%. Again Globacom connects to other networks with a service accessibility value of 96.8% seconded by Zain (96.1%). Starcomms score 95.9% then Visafone with 95.5%. While Zain is first for GSM, Starcomms is also ranked first for the CDMA networks thus; GSM networks have a good service Accessibility than the CDMA networks for both intra and inter-connections.

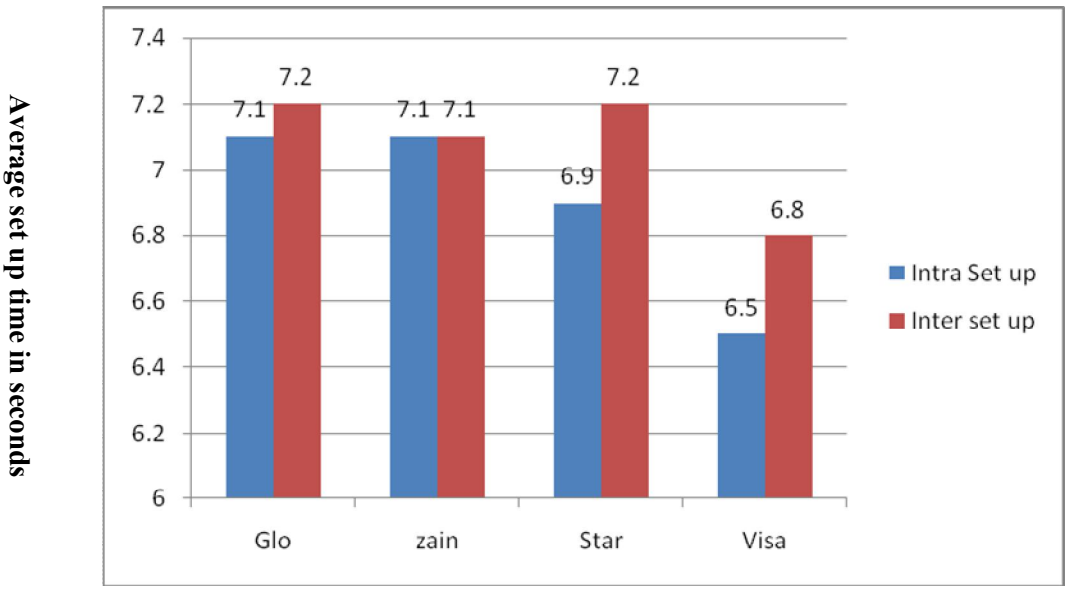


Figure 4.12: Graph showing Set up time for GSM and CDMA Networks

Figure 4.12 shows the set up time for GSM and CDMA networks. It reveals that Globacom and Zain have the best intra connection setup time of 7.1 seconds followed by Starcomms with 6.9seconds and lastly by Visafone 6.5seconds. On the other hand; Globacom and Visafone tied up with 7.2 seconds each for inter connections, then closely followed by Zain with 7.1seconds and lastly by Visafone with 6.8 seconds. It is an indication that GSM networks have a better aggregate set up time than the CDMA networks for the intra but showed a equal chances for inter network connections. Zain shows a stable connection rate for both intra and inter connections with a tie value of 7.1 seconds.

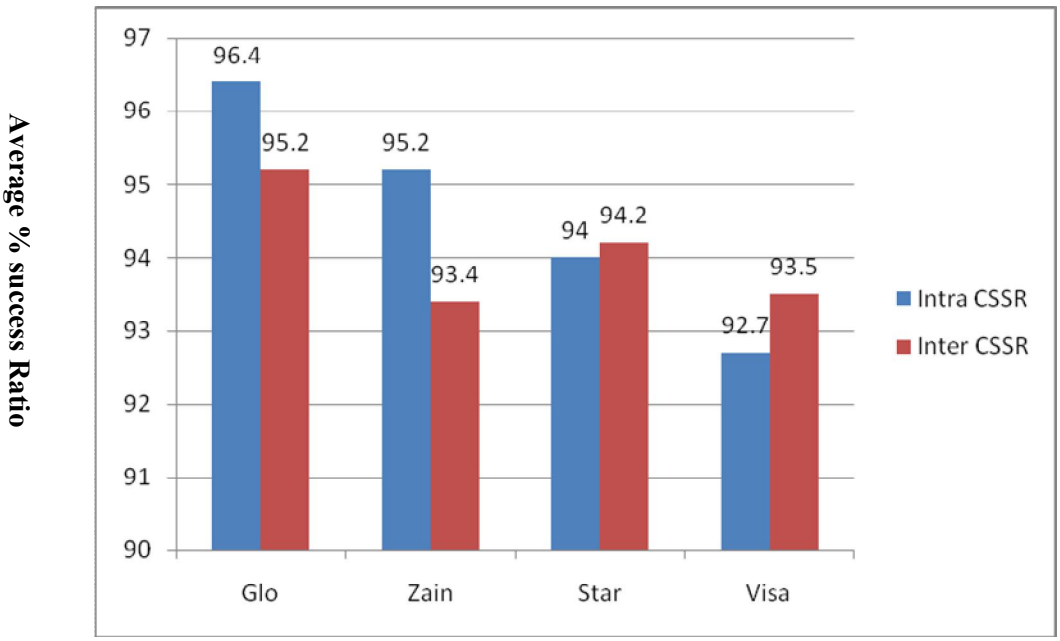


Figure 4.13: Graph showing Set up success Ratio time for GSM and CDMA Networks

Globacom has a highest set up success Ratio of 96.4% and closely followed by Zain with 95.2% and then Starcomms with 94% and lastly Visafone with an average percentage of 92.7% for intra connection while Globacom scored 95.2% for inter connections closely followed by 94.2% then Visafone with an average percentage of 93.5% and the trend falls down with Zain recording 93.4% and 72.9%. While Globacom show a good Set up success ratio time than Zain, for both intra and inter connections, Starcomms also shows good performance over Visafone for both intra and inter connections. Notwithstanding the GSM networks again demonstrate a good set up Set up success ratio telephony time than the CDMA networks.

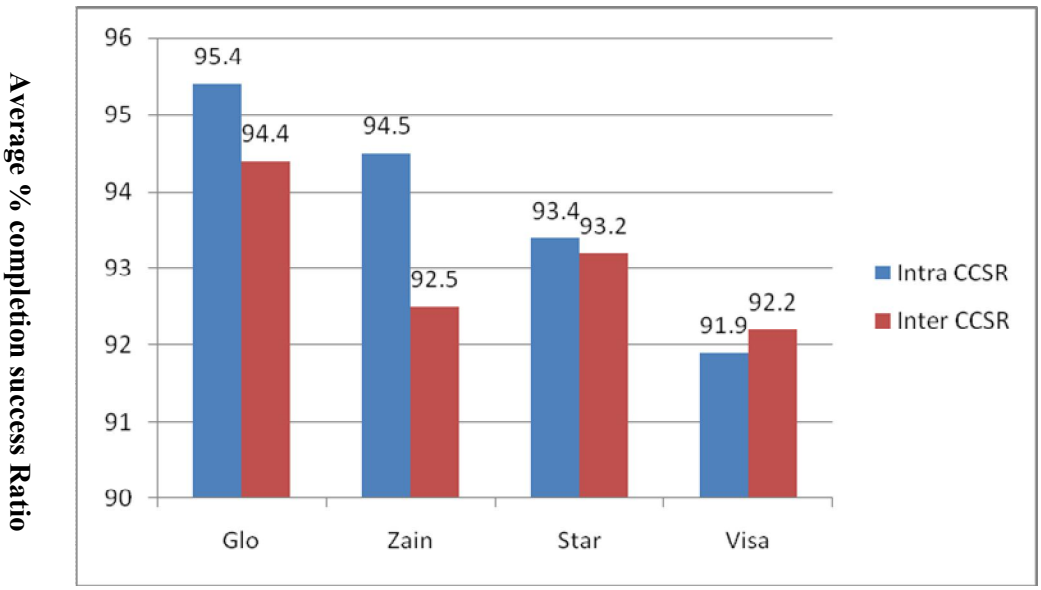


Figure 4.14: Graph showing Call Completion success Ratio for GSM and CDMA Networks

From the charts (figure 4.14), Globacom records the highest number of call completion success ratio with 95.4% followed by Zain with 94.5% then Starcomms with 93.4% and ending with Visafone that has 91.9% the intra connection call completion success Ratio. Considering the inter connections, Globacom shots up with 94.4% over Starcomms with a value of 93.2% hence Zain with 92.5% and Visafone with lowest value of 92.2%. Globacom does well than Zain especially in intra connections while Starcomms also out shadows Visafone in both intra and inter connections of the KPI in question.

Again the GSM networks performed better in so far as this KPI is concerned than does the CDMA. Though, the two networks type performed above average.

4.7 COMPARISON OF GSM AND CDMA CALLS FOR KPIs UNDER CONSIDERATION

The values for the comparison are obtained by finding the averages of values for each intra and inter connection of each KPI for each network as shown in table 4.132 and recording them in table 4.133 below. These values are used to compare the performance relative to QoS of both GSM and CDMA networks situation in Zaria. The values for the general comparison with those of other authors is gotten by finding the average of both intra and inter connections for each KPI and for each network type as shown in table 4.133 below.

Table 4.133: Table showing the average values of GSM and CDMA intra and interconnections as extracted from table 4.132

KPIs	GSM			CDMA		
	GLO	**ZAIN**	$\bar{x}$	**STAR**	**VISA**	$\bar{x}$
Service Accessibility (%)	96.5	96.8	**96.7**	96.6	92.0	**94.3**
Set up Time (secs)	7.2	7.1	**7.2**	7.1	6.7	**6.9**
Call Set up Success Ratio (%)	95.8	94.3	**95.1**	94.1	93.1	**93.6**
Call Completion success Ratio (%)	94.9	93.5	**94.2**	93.3	92.1	**92.7**

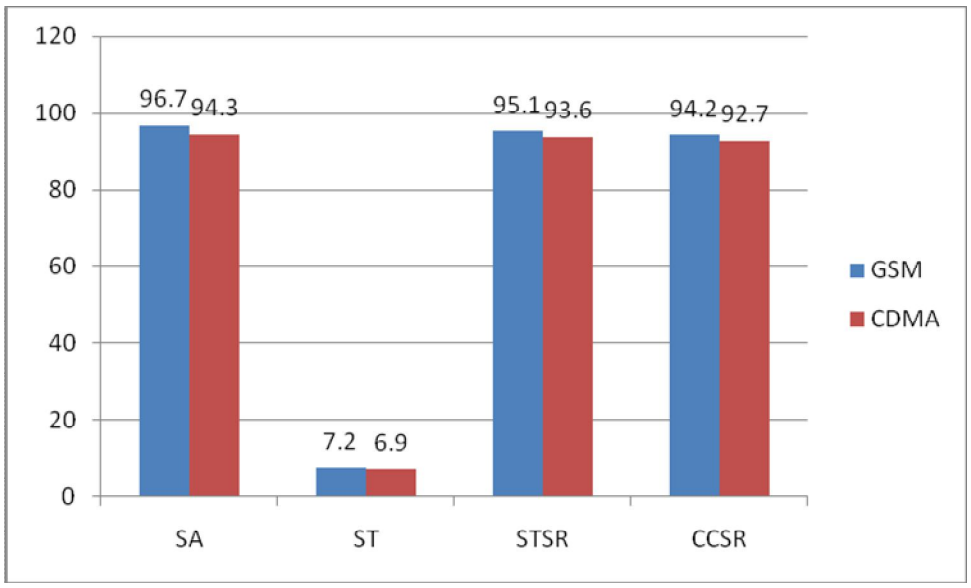


Figure 4.15: Graph Showing Performance Comparison of GSM and CDMA Networks

SA: Service Accessibility, ST: Set-up Time, STSR: Set-up Success Ratio, CCSR: Call Completions Success Ratio

Considering the intra calls values, GSM scores the highest values of 96.7%

It can be seen from the graph that higher values in each case of KPIs are experienced in the GSM networks from those of CDMA. It can be also be noted from the graph that the CDMA networks always have a shorter set up time than the GSM; but many of the calls do not go to completion as those of GSM.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

This research work on the Evaluation and Comparative Analysis of the QoS of GSM and CDMA Cellular Networks in Zaria was carried out from the user's perspective and using manual/statistical method. The data was collected from ten different locations around Zaria well spread enough so as to ensure that data was not collected from one and the same base station or transceiver. These areas included: Samaru, Shika, Kongo, Deke chi, Wusasa, Basawa, Muchia, Kofa Doka, Gaskiya and Angwa Godo. It was also made sure that the data was collected especially from those areas where network traffic is always very high such as in different campuses of Ahmadu Bello University, Samaru and Kongo campuses, Federal College of Education campus, Ameer Shehu Idris College of Advanced Studies campus, Nuhu Bamalli Polytechnic, Gaskiya campus, College of Agriculture campus, College of Chemical and Leather Research all in Samaru, by making use of full functioning and equipped mobile stations containing the various Subscribers' Identification Modules (SIMs) for different networks under study. The data was collected for a period of fourteen days , four times a day at an interval time of four hours Starting from 6am to 18pm. All the values obtained for both intra and inter calls were recorded on a researcher's designed form. A total of 8,960 calls were made at the final stage. The parameter considered for the research included strictly telephony and the associated KPIs under study for the telephony embodied the Service Accessibility, Call set up Time, Call setup Success Ratio and Call completion success ratio. Averages of the various data collected and recorded in appropriate tables, also lines graphs were plotted using MS Excel Office 2007

software package to determine the performance of each network relative to each KPI for different data collection areas. This helped to determine the most preferable network for each data collection area as shown in table 4.131.

To compare network types, the mean of the averages of each KPI was calculated and recorded on tables and their bar charts plotted

Regarding the different GSM operators as revealed in table 4.132, Globacom performance is better than that of Zain since most of its KPIs values are higher than those of Zain accept for the set up time where Zain performs better than that of Globacom. In the same manner Starcoms contain most the values greater than those of Visafone which contains a (6.7 seconds) set up time as the only indication of good performance over Starcomms.

From table (4.133), it was observed that this research obtained values for the different KPIs under studies as thus: a low service accessibility of 96.7% for GSM and 94.3%, lower than the 99.999% of (Monego, 2005), Set Up Time of 7.2 and 6.9 seconds respectively for GSM and CDMA. Also, Call Set up Success Ratio stood at 95.1 and 93.6% for GSM and CDMA networks respectively, while the Call Completion Success Ratio was 94.2% for GSM and 92.7% for CDMA which are higher than the 90% of (NCC, 2009).

5.2 CONCLUSION

The research results showed that GSM; especially Globacom is the most favourable network in Zaria while Starcomms stood same for the CDMA network type.

Considering individual KPIs, CDMA has a poor success ratio and completion rate. This implies that most calls that are successfully established did not go through and even end up prematurely either due to noise or other interferences.

Notwithstanding, the general trend and performance of the KPI in Zaria are fair enough; thus the QoS. This goes a long way to show that the general performance of both GSM and CDMA network type are permissible. This it was also seen from the research work that the values of individual KPIs are not just too different from those stipulated by the NCC and other GSM regulatory bodies.

Also, where Globacom network is most preferable, Starcomms on the side of CDMA will be the most preferable too, while zain and Visafone moved in the same way too.

5.3 RECOMMENDATIONS

From the evaluation and comparison of the cellular mobile networks, it was discovered that despite the fact that some KPI values fall within the recommended range, some are woefully below the agreed value. This leads to a loud cry from the subscribers because low and deplorable QoS is experienced. At this end, the following recommendations are made:

i The government, NCC and other regulatory bodies should enforce a regular monitoring of the network operators and submission of reports on their performances at very short intervals so that QoS can be established to meet up with demands of the subscribers.

ii. Government should also encourage competition by ensuring that all those that have been issued licenses should go operational if not their licenses should be revoked. This will go a long way to solve this QoS problem as subscribers will only patronize those with high QoS.

iii. The cellular network operators should also increase the base transmission stations and increase coverage areas rather than the current competitions or bonanzas they are doing in order to win more customers.

iv. Researchers should go into more researches so as to develop other means and algorithms to monitor, evaluate and address QoS and performance issues of cellular networks in all parts of the country.

REFERENCES

Adhicandra, I and Pattinson C., (2002): Performance Evaluation of Network Management Operations, in Proceedings of 3rd Annual Symposium of Postgraduate Networking Conference (PGNET), Liverpool, UK, pp 210 – 214.

Adhicandra, I., Pattinson C., and Shaghouei E. (2003): Using Mobile Agents to Improve Performance of Network Management Operations. In Proceedings of 4th Annual Symposium of Postgraduate Networking Conference (PGNET).

ANACOM, (2005): GSM Mobile Networks Quality of Service Survey, Globacombal Study. Mainland, ortugal.http://www.anacom.pt/template12.jsp?categoryId=186283

Baldi, M. and Picco G.P. (1998): Evaluating the Tradeoffs of Mobile Code Paradigms in Network Management Application, in Proceedings of the 20th International Conference on Software (ICSE'98), April, Kyoto, Japan, pp 146 – 155.

Bates, J (1994).: The Role of Emotion in Believable Characters, Communications of ACM, 37(7): pp 122 – 125.

Bieszczad, A., Raza S.K., Pagurek B. and White T. (1998a).: Agent-Based Schemes for Plug and Play Network Components, in Proceedings of the Third International Workshop on Agents in Telecommunications Applications (IATA '98), July 4-7, Paris, France, pp 89 – 101.

Bieszczad, A. and Pagurek B. (1998).: Network Management Application-Oriented Taxonomy of Mobile Code, in Proceedings of the EEE/IFIP Network Operations and Management Symposium (NOMS'98), Feb. 15 – 20, New Orleans, Louisiana, pp 659 – 669.

Bieszczad, A., Raza S.K., Pagurek B and White T. (1998b).: Mobile Agent for Network Management, IEEE Communications Survey, 1(1) pp 2 – 9.

Busuoic, M. and Griffiths D. (1993).: Cooperating intelligent Agents for Service Management in Communications Networks, in Proceedings of the 1993 Workshop on Cooperating Knowledge Based Systems (CKBS '93), University of Keel, UK, pp 213 – 226.

Chess, D., Grosof B., Harrison C., Levine D., and Parris C. (1995). Itinerant Agents for Mobile Computing, IEEE Personal Communications, 2(5): pp 34 – 49.

Chess D., Grosof. B., Harrison C., Levine D., and Parris C. (1995): Itinerant Agents for Mobile International Journal of Advanced Science and Technology Volume 7, in Newton P.C., 2009.

Calduwel P., Newton, D.R.. Arockiam. L. and Tai-hoon Kim (2009). A Quality of Service Strategy to Select Coding Schemes in General Packet Radio Service System

David S., (2006) “Means and Methods for Collecting and Analyzing QoE Measurements in Wireless Networks”, Proceedings of the International Symposium on a World of Wireless, Mobile and Multimedia Networks, IEEE CS.

Dushyanth, B. (2006): Washington University in Saint Louis, dushyanthb@gmail.com

Emmanuel T. O. (2009) in Daily Independence, Lagos

GSM Association Permanent Reference Document: IR.42 Unrestricted, (2009)

Jain (2006) Lecture Notes in QoS, http://www.cse.wustl.edu/~jain/cse57406/j_9qos.htm

Kajackas, A. and Danzeisen M., (2005). “Estimation of QoS Dynamics in the Wireless Networks” Proceedings of the 4th Management Committee Meeting, Wuerzburg, Germany, October 13-14,

Kovvuri, Kovvuri S., Vijoy P., Dipak G., Biswanath M. and Dilip S.,(2003)"A Call-Admission Control (CAC) Algorithm for Providing Guaranteed QoS in Cellular Networks,"http://www.springerlink.com/(rpophtf1vxmipbab1vtfyv45)/app/home/main.asp?

Kuboye, B. M., Alese, B. K., and Fajuyigbe, O. (2009). Congestion Analysis on the Nigerian Global System for Mobile Communications (GSM) Network, The Pacific Journal of Science and Technology, 10(1), 262-271.

Malaysian Technical Standards Forum Bhd (MTSFB) 009: (2005)

Monego H. I., Del Monego, E., Lucia B., Luiz N. Jr, and Richard D. S., (2005) "A Dynamic Resource Allocation Scheme for Providing QoS in Packet-Switched Cellular Networks," http://springerlink.metapress.com/(xxolql45nijqxu55b4eq5345)/app/home/main.asp?referrer=default

Nigerian Communications Commission Directorate of Technical Research & Standards, 2005

Popoola J. J., Megbowon I. O. and Adeloye V. S. A. (2009). Performance Evaluation and Improvement on Quality of Service of Globacombal System for Mobile Communications in Nigeria Journal of Information Technology Impact Vol. 9, No. 2, pp. 91-106.

Song W., Hai J., Weihua Z., and Xuemin (Sherman) S., (2005) "Resource Management for QoS Support in Cellular/WLAN Inter working," http://ieeexplore.ieee.org/iel5/65/32333/01509947.pdf?tp=&arnumber=1509947&isnumber=32333.

Thomson D., Nancy S., Mohammad M. (2000) A New Approach for Providing Quality of Service (QoS) in a Dynamic Network Environment, M i t r e p r o d u ct.

Uma, A. and. Padmavathi G. (2009). A comparative study and performance evaluation of reactive quality of service routing protocols in mobile ad hoc networks. Journal of Theoretical and Applied Information Technology.

Yang X., (2003) Architecture, Mobility Management, and Quality of Service for Integrated 3G and WLAN Networks Department of Computer Science The University of Memphis, 373 Dunn Hall, Memphis, TN 38152 USA.

Yusuf M. A. (2010): The influence of Regulatory Environment on Mobile Phone Service Quality: The Case of Bangladesh Mobile Phone Sector. ASA University Review, Vol. 6 No. 2, July–December, 2012

Yusuf, M. A., and Alam, Q. (2009). Market Concentration in Bangladesh. The Financial Express.

APPENDIX

Time: 6-8am Location: Shika

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM	-	
Star/zain	7.5	10	-	-	9	-	
	6.7	10	-	-	10	-	
	7.4	10	-	-	10	-	
	6.4	10	-	-	10	-	
	7.0	10	-	1	9	-	
	7.9	10	-	-	10	-	
	7.7	10	-	-	10	-	
	7.6	10	-	-	10	-	
	7.0	10	-	-	10	-	
	7.9	10	-	-	9	-	
	7.4	10	-	-	10	-	
	7.2	10	-	-	10	-	
	5.5	8	2	-	8	2	
	7.4	10	-	-	10	-	
	Ave =7.2	**138**	**2**	-	**135**	**2**	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM		
Visa/ Star	7.6	10	-	-	10	-	
	7.6	10	-	-	10	-	
	6.9	10	-	-	9	-	
	8.2	10	-	-	10	-	
	7.4	10	-	-	10	-	
	5.4	7	3	-	7	3	
	6.9	10	-	-	9	-	
	7.1	10	-	-	10	-	
	6.4	9	1	-	9	1	
	6.9	10	-	-	10	-	
	6.9	10	-	-	10	-	
	7.5	10	-	-	10	-	
	6.7	10	-	-	10	-	
	6.3	10	-	-	10	-	
	Ave=7.0	**136**	**4**	**0**	**134**	**4**	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM		
Star/star	7.1	9	1	-	8	1	
	6.7	9	1	-	8	-	
	7.4	10	-	-	10	-	
	7.4	10	-	-	8	1	
	6.8	10	-	-	10	-	
	7.2	10	-	-	10	-	
	7.1	10	-	-	9	-	
	7.5	10	-	-	9	-	
	7.0	10	-	-	10	-	
	5.1	7	3	-	7	3	
	7.0	10	-	-	10	-	
	7.0	9	1	-	10	-	
	6.5	10	-	-	10	-	
	6.7	9	1	-	9	-	
	Ave =6.9	**143**	**7**	0	**127**	**6**	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMENT	Speech Quality
		Y	N	INC	COM	-	
Zain/Zain	7.5	10	-	-	10	-	
	6.9	10	-	-	10	-	
	7.1	10	-	-	10	-	
	7.1	10	-	-	9	1	
	6.5	9	1	-	9	1	
	7.9	10	-	-	10	-	
	6.0	9	1	-	9	1	
	6.3	9	1	-	9	1	
	5.8	9	1	-	9	1	
	6.8	10	-	-	10	-	
	7.0	10	-	-	10	-	
	7.1	10	-	-	10	-	
	6.9	10	2	-	10	-	
	6.9	10	-	-	10	-	
	Ave =7.2	**136**	**2**	0	**135**	**4**	



APPENDIX

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM	-	
Star/zain	7.5	10	-	-	9	-	
	6.7	10	-	-	10	-	
	7.4	10	-	-	10	-	
	6.4	10	-	-	10	-	
	7.0	10	-	1	9	-	
	7.9	10	-	-	10	-	
	7.7	10	-	-	10	-	
	7.6	10	-	-	10	-	
	7.0	10	-	-	10	-	
	7.9	10	-	-	9	-	
	7.4	10	-	-	10	-	
	7.2	10	-	-	10	-	
	5.5	8	2	-	8	2	
	7.4	10	-	-	10	-	
	Ave =7.2	**138**	**2**	-	**135**	**2**	

Time: 6-8am Location: Shika

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM		
Star/star	7.1	9	1	-	8	1	
	6.7	9	1	-	8	-	
	7.4	10	-	-	10	-	
	7.4	10	-	-	8	1	
	6.8	10	-	-	10	-	
	7.2	10	-	-	10	-	
	7.1	10	-	-	9	-	
	7.5	10	-	-	9	-	
	7.0	10	-	-	10	-	
	5.1	7	3	-	7	3	
	7.0	10	-	-	10	-	
	7.0	9	1	-	10	-	
	6.5	10	-	-	10	-	
	6.7	9	1	-	9	-	
	Ave =6.9	**143**	**7**	0	**127**	**6**	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM		
Visa/ Star	7.6	10	-	-	10	-	
Zain/Zain	7.6	10	-	-	10	-	
	6.9	10	-	-	9	-	
	8.2	10	-	-	10	-	
	7.4	10	-	-	10	-	
	5.4	7	3	-	7	3	
	6.9	10	-	-	10	-	
	7.1	10	-	-	9	1	
	7.1	10	-	-	10	-	
	6.5	9	1	-	9	1	
	6.4	9	1	-	9	1	
	7.9	10	-	-	10	-	
	6.0	9	1	-	9	1	
	6.9	10	-	-	10	-	
	6.3	9	1	-	9	1	
	7.5	10	-	-	10	-	
	5.8	9	1	-	9	1	
	6.7	10	-	-	10	-	
	6.8	10	-	-	10	-	
	6.9	10	-	-	10	-	
	7.1	10	-	-	10	-	
	Ave=7.0	**136**	**4**	**0**	**134**	**4**	
	6.9	10	2	-	10	-	
	6.9	10	-	-	10	-	
	Ave =7.2	**136**	**2**	0	**135**	**4**	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM	-	
S	7.5	10	-	-	9	-	
	6.7	10	-	-	10	-	
	7.4	10	-	-	10	-	
	6.4	10	-	-	10	-	
	7.0	10	-	1	9	-	
	7.9	10	-	-	10	-	
	7.7	10	-	-	10	-	
	7.6	10	-	-	10	-	
	7.0	10	-	-	10	-	
	7.9	10	-	-	9	-	
	7.4	10	-	-	10	-	
	7.2	10	-	-	10	-	
	5.5	8	2	-	8	2	
	7.4	10	-	-	10	-	
	Ave =7.2	**138**	**2**	-	**135**	**2**	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM	-	
Glo/Visa	8.0	10	-	-	10	-	
	8.5	10	-	1	9	-	
	7.5	10	-	-	10	-	
	6.9	10	-	-	10	-	
	7.4	10	-	-	10	-	
	6.5	9	1	-	8	1	
	7.3	10	-	-	10	-	
	8.0	10	-	-	10	-	
	7.8	10	-	-	10	-	
	6.8	9	1	-	9	1	
	6.1	9	1	-	9	1	
	7.3	10	-	-	9	-	
	7.7	10	-	-	7	-	
	6.6	9	1	1	9	1	
	Ave =7.3	**136**	**4**	**3** 144	**130**	**4**	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM	-	
Star/zain	7.5	10	-	-	9	-	
	6.7	10	-	-	10	-	
	7.4	10	-	-	10	-	
	6.4	10	-	-	10	-	
	7.0	10	-	1	9	-	
	7.9	10	-	-	10	-	
	7.7	10	-	-	10	-	
	7.6	10	-	-	10	-	
	7.0	10	-	-	10	-	
	7.9	10	-	-	9	-	
	7.4	10	-	-	10	-	
	7.2	10	-	-	10	-	
	5.5	8	2	-	8	2	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM	-	
Glo/Glo	7.2	10	-	-	10	-	
	7.2	10	-	-	10	-	
	7.2	10	-	-	10	-	
	7.3	10	-	-	10	-	
	7.2	10	-	-	8	-	
	7.1	10	-	-	9	-	
	7.0	10	-	-	10	-	
	7.1	10	-	-	10	-	
	6.4	10	-	-	10	-	
	5.4	8	2	-	8	2	
	6.8	10	-	-	10	-	
	6.0	9	1	-	9	1	
	6.0	8	2	-	8	1	
	7.5	10	-	-	10	-	
	Ave =6.7	**125**	**5**	0	**132**	**4**	

TELEPHONY	CALL SETUP	SUCCESS STATE		TERMINATION STATE		OPERATOR'S COMMENT	Speech Quality
		Y	N	INC	COM	-	
Visa/visa	7.0	10	-	-	10	-	
	7.1	10	-			-	
	7.0	10	-	-	10	-	
	6.3	10	-	-	10	-	
	6.9	10	-		10	-	
	7.1	10		-	10	-	
	7.1	10	-	-	10	-	
	5.9	10	1	-	10	1	
	7.5	10	-	-	10	-	
	6.4	9	1	-	9	1	
	5.3	8	2	-	8	2	
	6.6	10	-	1	10	-	
	6.7	10	-	-	9	2	
	6.7	10	-	-	9	-	
	Ave =6.8	**137**	**4**	0 146	**133**		