

Performance Analysis of Quality of Service of GSM/CDMA Mobile Networks in Zaria

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Abstract: *This paper is focused on the Performance 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 some randomly selected areas in Zaria, 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. Tables, line graphs and bar charts were used for analysis at different instances. The paper revealed that GSMs operators' performance in Zaria is better than the CDMA's and at the same time Globacom's performance is better than Zain's while Starcomms is better than Visafone. The conclusion was drawn and recommendations made. All the works of other authors were fully referenced.*

Keywords: Quality of Service (QoS), Code Division Multiple Access (CDMA), Global System for Mobile Telecommunication (GSM), Performance.

1. Introduction

Communication as it is known universally is the exchange of messages from one person, medium or device to another through a channel. The effect of good communication is the development of the society, thus communication has become the backbone of every societal development. This has enabled the world to become a global village especially with the existence of Wireless ad hoc networks that are formed by a group of mobile users or devices spread over a certain geographical area. The major breakthrough has come up especially in the areas of Mobile wireless Ad Hoc Networks (MANETS) that embodies GSM and CDMA networks types which are used by many individuals for many different activities. According to [2] 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. The services they provide to the users must be qualitative enough for the aim not to be defeated since they have come to stay as they are not luxury anymore but a necessity. This is in line with [21] who said, many problems exist especially for MANETS. 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. [9] also stated that 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). This implies that QoS can be measured at different layers, from operators' perspective or at different levels from the users' perspectives.

Quality of Service has been defined by the [19] as "The collective effect of service Performance which determines a degree of satisfaction of a user of the service". Here 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.

Many users have been complaining of poor services such as "call diverts", "incomplete calls", "Network busy", "The number dialled is not does not exist on the said Network", "Error in connection", or difficulties in making calls generally with their mobile stations.

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 paper tried to provide answers to the following questions:

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

The intention of this paper therefore is 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.
- This paper delved into the Performance Analysis of the QoS of GSM/CDMA mobile Networks 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 was 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.

2. Related Literature

[11] carried out a 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, [22] 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, [13]. 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 its 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 [16]

[11] 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.

[20] 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, [18] 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 [4]. 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. 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.

[10], 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, [3], [4], [5]; [6] and [7] providing extremely crucial role in many of these approaches [8].

On the issue of the quality of service, [17] 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 [1]. 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 [23] 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 [23]. 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".

Further works by the [12], 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. Some of these QoS parameter also known as key performance indicators (KPI) will be considered for study in this research.

3. Methodology

This research considers some Key Performance Indicators (KPIs) that are defined by the Nigerian Communication Commission and [12]. 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.

$$\text{Service Accessibility (\%)} = \frac{\text{Number of successful call attempts}}{\text{Number of call Attempts}} \times 100 \quad \text{equation 1}$$

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

$$\text{Setup Time Telephony} = T_2 - T_1 \text{ in Seconds} \quad \text{equation 2}$$

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.

$$\text{CSSR (\%)} = \frac{\text{Number of successful call establishments}}{\text{Number of call attempts}} \times 100 \quad \text{equation 3}$$

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.

CCR-CS-T (%)

= $\frac{\text{Number of intentionally terminated calls} \times 100}{\text{Number of successful call attempts telephony}}$ **equation 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 and Procedure

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

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

Mobile cellular phones that are in full good working conditions, Subscribers Identification Modules (SIMs) for all the networks under consideration (ZAIN and Globacom) and an electronic stop watch as well as a researchers' 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.

The mobile cellular sets were each equipped with a different SIM card from each network under study. Assurance was 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 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 10 areas) calls were made while for the whole day, 640 (4 times x 160) calls were carried out. This gives a total of 8,960 (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.

Data for analysis was extracted from the data in the designed form 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 was 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 were able to reveal the network with a better QoS for intra and inter network telephony.

3.2 Data Presentation and Analysis

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

A total of 8,960 calls were made from the networks under study, 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. This reduces the data to a total of 640 calls. Furthermore, the averages for each intra and inter connections for each network and time instance are found. This was done same by finding the totals of the other KPIs. These averages were now used to determine the behavior of the networks for each site of data collection according to the equations 1, 2, 3 and 4 relative to the KPIs under consideration.

Table 1: KPI performance for Samaru Area

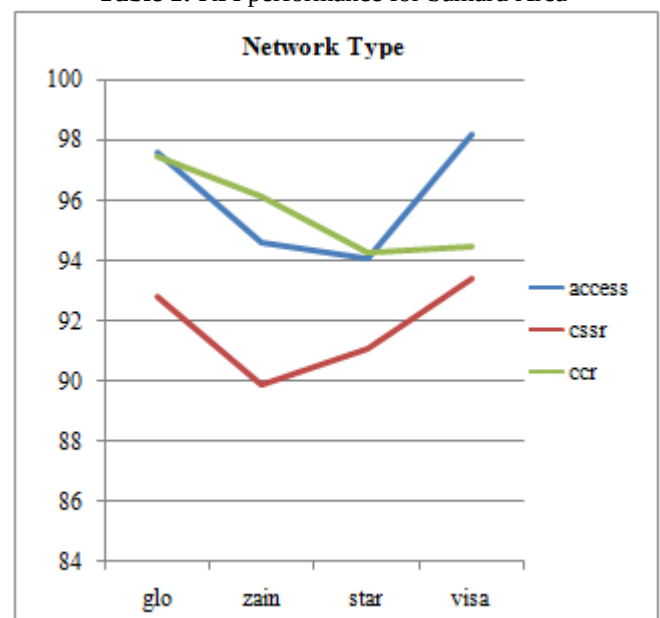


Figure 1: Graph of KPI performance for Samaru Area

The percentages of Service Accessibility, call set up success ratio and call completion success rate and the average Setup time values for each inter and intra-connection of each of the networks was done, then the average percentages for all the KPIs were calculated and the results were recorded in the table below.

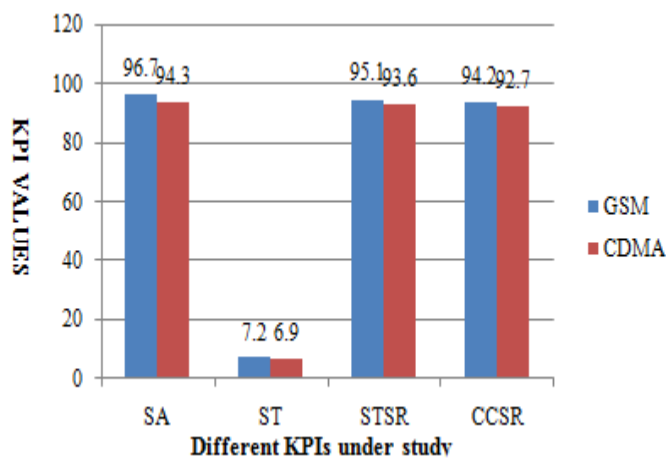
Table 2: General outcome of all KPIs for both inter and intra GSM and CDMA connections.

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

The values for the comparison were obtained by finding the averages of values for each intra and inter connection of each KPI for each similar network as shown in table 2 and recording them in table 4 below. These values were used to compare the performance relative to QoS of both GSM and CDMA networks situation in Zaria

Table 3: Table showing the average values of GSM and CDMA intra and interconnections as extracted from table 3

KPIs	GSM			CDMA		
	GLO	ZAIN	- X	STAR	VISA	- 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 2:** Graph Showing General Performance of GSM and CDMA Networks

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

It could be seen from the graph that higher values in each case of KPIs were experienced in the GSM networks than those of CDMA. It could be also be noted from the graph that the CDMA networks had a shorter set up time than the GSM; but many of their calls did not go to completion as those of GSM.

4. Summary

This paper on Performance 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 double data was not collected from one and the same base station or transceiver. This data was collected 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 6pm. 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 included; Service Accessibility, Call set up Time, Call setup Success Ratio and Call completion success ratio. Averages of the various data were calculated 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. 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 3, Globacom performance is better than that of Zain since most of its KPIs values are higher than those of Zain except for the setup time where Zain performs better than Globacom. In the same manner Starcomms contain most of 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 3, 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%, Setup 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.

5. 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. Thus, 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.

6. Recommendations

Despite the fact that the KPI values fall within the recommended range, some are woefully below the agreed values. This leads to a loud cry from the subscribers because low and deplorable QoS is experienced. At this end, the following recommendations are made:

- 1) 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.
- 2) Operators should upgrade and optimize the capacities of all existing base stations so that the network will be able to handle the demand from the subscribers. The outcome of this will be an improvement in the call set up time.
- 3) 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.
- 4) Similar researches should be carried out in other parts of the country as well using same or other QoS parameters so as to give a more detail picture of the network trend in the country as a whole.

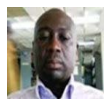
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