INVESTIGATION OF QUALITY OF SERVICE (QoS) OF GSM NETWORK PROVIDERS AT FEDERAL UNIVERSITY, GUSAU, ZAMFARA STATE

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ABSTRACT

Poor and unstable cell phone signal is a very common problem faced by GSM Network providers, which is at the expense of the customers. In this work Investigation of GSM Network Providers Quality of Service (QoS), a report on the QoS provided by three (3) GSM network operators within the Federal University, Gusau, Zamfara State is presented. The investigation is in terms of the ability to initiate and maintain call connections (accessibility) for a period of time; coveragae; intra and inter network calls for outgoing calls in the University. The campus is divided into three locations; these locations are used as Test points. In each of these locations a series of measurements were made. Three GSM operators designated as operator I (GLO), J (AIRTEL) and K (9MOBILE) were investigated for a period of eight weeks. The accessibility levels and call failure rate are expressed in percentages in order to compare the QoaS provided by these network operators. The result shows that operator J has better QoS compared with operators I and K for the period of investigation. The result is compared to the result obtained in a similar work carried out on the Network Signal Strength as provided by National Space Research and Development Agency (NASRDA) in the same State. Though there are variations in these results, there is need to improve on the QoS for the three networks investigated.

Keywords: Quality of Service, GSM, Service Accessibility, Call Failure Rate, Network Coverage, Signal Strength.

INTRODUCTION

Global System for Mobile Communication (GSM) is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA). Mobile services based on GSM technology were first launched in Finland in the year 1991. Today, more than 690 mobile networks provide GSM services across 219 countries and GSM represents 82.4% of all global mobile connections (Solomon et al, 2019). According to GSM World, there are now more than 6 billion GSM mobile phone users worldwide (Anton, 2003). Nigeria has a reasonable number of mobile phone users. All through the day and night, availability and complete coverage, coupled with acceptable quality at appropriate times are important factors that are used to characterize different service providers. However, all mobile and wireless systems have in common that the quality of their connectivity may vary rapidly with time. Still, users want to get the best quality possible or the quality they paid for. Rather, network subscribers hardly make or receive calls successfully without impediments. Instead of enjoying their hard earned money, they end up paying for services that are not rendered. In a quest to get a better service, virtually every adult Nigerian has all the SIM cards of all network providers in the country, and this is a major concern.

In the field of telephony, Quality of Service (QoS) is defined in the ITU standard X.902 as "a set of quality requirements on the collective behaviour of one or more objects". QoS compares requirements on all the aspects of a connection, such as service response time, loss, signal-to-noise ratio, cross-talk, echo, interrupts, frequency response, loudness level, and so on. A subset of telephony QoS is Grade-of-Service (GoS) requirements, which compares aspects of a connection relating to capacity and coverage of a network, for example, guaranteed maximum blocking probability and outage probability (ITU-T, 2001).

In the field of computer networking and other packet-switched telecommunication networks, in traffic engineering, the term QoS refers to resource reservation control mechanisms rather than achieved service quality. Quality of service is the capability to provide different priority to different applications, users, or data flows, or

to guarantee a certain level of performance to a data flow. Quality of service guarantees are important if the network capacity is insufficient, especially for real-time streaming multimedia applications such as voice over internet protocol (IP), online games etc, since these frequently require constant bit rate and are delay sensitive, and in networks where the capacity is a limited resource, for example in cellular data communication (ITU-T, 2001). Generally, Nigerians are not satisfied with the quality of service provided by the GSM operators in the country and are being extorted of their sweat. This problem could result basically from incompatibility of the computer-based radio propagation prediction tools with our environment. The quality of the service provided is usually poorer in the mountainous terrain, "shadowing effect" created by obstructions which includes tall building, trees, hills and rocks between the Base Transceiver station and the Mobile Station.

Federal University Gusau, Zamfara State is surrounded by tall trees and huge rocks. In an attempt to evaluate the QoS of GSM network providers in the University, this research work is embarked on.

This research presents an assessment carried out on whether or not call can be initiated, the quality of the call, intra and inter network as provided by operators I, J and K. Emphasis is laid on the call quality, number of calls attempted (failed and successful calls) and signal power received.

The main objective of this research is to evaluate the quality of service of GSM network providers, their network signal strength within the University, in order to advice staff and students on which network to use, as not to waste money and to make suggestions on how the providers can improve on their services.

LITERATURE REVIEW

Twelve years after the inception of GSM services in Nigeria, there has been a drastic change in the quality of service offered by the service providers. Researchers have done a lot of work on the causes of poor quality of service rendered by the operators and many are still on it because of its utmost importance to both the operators and customers.

Customer satisfaction is a personal feeling of either pleasure or disappointment resulting from the evaluation of services rendered by an organization to an individual in relation to expectations (Oliver, 1980) (Leisen and Vance, 20010).

A general survey research was carried out on QoS in GSM in Portugal (ANACOM, 2005). This survey's methodology is based on automatic end-to-end tests, thus identifying the QoS on the field and providing the most realistic perspective on the networks' performance, from the user's standpoint. The result of the study is limited to the behaviour of the networks on the places and moments of the measurements. It was revealed that there is continuous improvement in the QoS of the networks under study.

Ayeni (2007), in his PhD research work on "Quality of Service Profile of the Nigerian GSM Networks", discovered that relatively low call failure rates were recorded on intra and international routes as against the inter and public switched telephone networks (PSTN) routes. He also depicted that definite call failure patterns could not be observed when viewed over the hours of the day, as is expected in normal traffic studies. He therefore concludes that factors like infrastructural deficiencies other than trunk dimensioning, attributed to the excessive call failure rates on the network.

Salawu*et al*, (2013) carried out a study on the practical assessment of signal strength of GSM network service providers. Their research work assessed the signal strength of GSM network service providers in Kwara State polytechnic permanent site and Ara village. The latitude, longitude and elevation of the two reference locations where the study was carried out were picked with global positioning system. The signal strength of MTN, GLO, AIRTEL and ETISALAT networks were measured with TECNO D3 android mobile receiver from the base transceiver station (BTS) at intervals of 100 meters. The measured data were analyzed graphically and compared to see the performance of each of the GSM network operators in the study location. The result revealed that the performance of these network providers were yet to be adjudged satisfactory.

METHODOLOGY

Some Key Performance Indicators (KPIs) that are defined by the Nigerian Communications Commission (NCC) and GSM Association Permanent Reference Document: (IR.42, 2009) are considered in this research work. These include; Service Accessibility, Call failure rate and Network Availability (Coverage).

Service Accessibility (Voice)

Service Accessibility is the probability of the user having access to the service (voice or telephony), i.e. likelihood of success when establishing a (voice or Video-telephony) call. A call is considered to be "Set Up Successfully" if it reaches the call terminal (one hears the "calling signal" on the calling terminal) (ANACOM, 2010).

$$\text{Service Accessiblity (\%)} = \frac{\text{Number of successful call attempts} \times 100}{Number\ of\ call\ attempts}$$

Thus $\alpha\ (\%) = \frac{\beta}{\gamma}\ 100$ (1)

where,
α = service accessibility
β = number of successful calls
γ = total number of calls

Call Failure Rate
Call failure rate is another parameter utilized to evaluate the quality of service of GSM network providers at Gusau, Zamfara State. It is expressed as.

$$\text{Call Failure rate (\%)} = \frac{\text{Number of unsuccessful calls} \times 100}{Total\ number\ of\ calls}$$

Thus $\psi\ (\%) = \frac{\phi}{\gamma}\ 100$ (2)

where,
Ψ = call failure rate
Φ = number of unsuccessful calls
γ = total number of calls

For the purpose of this work the following materials were used:

1. Mobile cellular phones (GIONEE P4) that are in good working conditions.

2. Subscribers Identification Modules (SIMs) for all the networks under study.

3. A designed form to collect the data for the parameters under study.

Measurements were made within the University premises. Calls were made randomly from three selected locations (Administrative block, Faculty of Science and Faculty of Humanities and Education) within the institution to various parts of the country and within the University. These calls were made to other mobile users of the same network (intra) and other networks (inter) within and outside the Institution. At any location a sample number of three (3) trials of calls were made. The data gathered from this assessment included the number of call hold success rate for a period of two minutes. The data recorded were averaged daily and weekly for both intra and inter network connections using Microsoft Excel software package. If a call was initiated for three (3) consecutive trials and such call could not be established, no routes was recorded for such event as the maximum number of trials set out for such calls has been exceeded.

Sample Size Estimation
Each of the network providers is used to initiate three (3) different calls to a receiver within the University (i.e for operator I: there are I→I call, I→J call, I→K call) three (3) times daily (morning, afternoon and evening) at each of the three locations. Therefore, it is obvious that, each of the operators is used to initiate 9 different calls to a receiver within the university at each of these locations daily. Similarly, each of the operators is used to initiate the same number of calls outside the university at each of the locations daily. Data were collected from the selected spots that adequately covered the Institution. These data were collected for a period of eight weeks from 8th day of July, 2019 to 3rd day of August, 2019 and from 19th day of August, 2019 to 14th day of September, 2019. During the period of investigation, a total of seven thousand, seven hundred and seventy-six (7776) calls were made of which three thousand, eight hundred and eighty-eight (3888) call are for intra and inter networks each. Provided the location system gives totally consistent results from call to call resulting in large variance, the number of call made were adequate.

RESULTS AND DISCUSSION
Table 1 shows the number of calls within and outside the university for Day one (D1).

Table 1: Number of D1 calls

Network operators.	Location 1	Location 2	Location 3	Total calls(within)	Total calls(outside)	Total number of calls
I	9	9	9	27	27	54
J	9	9	9	27	27	54
K	9	9	9	27	27	54
Total number of D1 calls	27	27	27	81	81	162

Operator I SIM is inserted in a mobile phone Gionee P4 and the phone is powered, after the phone booted and indicated the recognition of the operator inserted, a voice call is then initiated to a receiver within the University and a receiver outside the University premises having the same network operator (intra network calls), after which the following observations were made:

i. If the initiated calls could not be established for three consecutive trials, such calls are said to have failed as the maximum number of trials set out for such calls has been reached, and therefore, Y = Z = 0 is recorded for such calls. Hence Y = 0, definitely Z = 0.
ii. For the initiated calls that is established in any of the 3 trials but could not last for two minutes, Y = 1 and Z = 0 is recorded for such calls. Y = 1 is for the fact that, the initiated call is established and Z = 0 is for the fact that, the call did not last for two minutes and such calls is also said to have failed as the aim of the calling is not achieved.
iii. For the initiated calls that is established in any of the 3 trials and communication could not take place (the caller could not hear the receiver or vice versa) within two minutes of call, Y = 1 and Z = 0 is recorded for such calls. Y = 1 is for the fact that, the call is established and Z = 0 is for the fact that, the communication does not take place and such calls were also said to have failed.
iv. For the initiated calls that is successfully established in any of the 3 trials and fluent/ uninterrupted communication process is enabled for two minutes, Y = 1 and Z = 1 is recorded for such calls. Y = 1 for the fact that, the call is established and Z = 1 for the fact that, the communication took place for two minutes and such calls are said to have succeeded.

In the same way, calls were repeated for J and K networks at each of the locations, three times daily for the period of investigation. Therefore, I→I, J→J and K→K calls are referred to intra network calls while calls from one network to another is termed inter network calls.

Table 2 and 3 are two out of numerous tables tabulated using data generated from this research and they represent week 1, day 3 calls (to receivers within and outside the University) at location 1. Letters A, B and C in the table represent morning, afternoon and evening respectively, where Y and Z stand for initiated calls and calls that hold success rate for two minutes respectively, where 1 and 0 stand for successful and unsuccessful calls respectively.

Table 2: Data for calls (receivers within the University) for week 1, day 3, at location 1

		OPERATOR I		OPERATOR J		OPERATOR K	
		Y	Z	Y	Z	Y	Z
OPERATOR I	A	1	1	1	0	1	1
	B	1	1	1	1	1	1
	C	1	1	1	1	1	1
OPERATOR J	A	1	1	0	0	1	1
	B	1	1	1	1	1	0
	C	1	0	1	1	1	1
OPERATOR K	A	1	1	1	0	1	1
	B	1	1	1	1	1	1
	C	1	1	1	1	1	0

Table 3: Data of calls (receivers outside the University) for week 1, day 3, at location 1

		OPERATOR I		OPERATOR J		OPERATOR K	
		Y	Z	Y	Z	Y	Z
OPERATOR I	A	1	1	1	1	0	0
	B	1	1	1	1	1	1
	C	1	1	1	0	1	1
OPERATOR J	A	1	1	1	0	1	1
	B	1	1	1	1	1	1
	C	1	1	1	1	1	0
OPERATOR K	A	1	1	1	1	1	1
	B	1	1	1	1	1	1
	C	1	1	1	1	1	1

Applying equation (1) above on the data collected, the accessibility levels in percentage for the period of eight weeks for each network operator were computed and tabulated as shown in Table 4-7.

Table 4: Intra network calls to receivers within the University

PERIOD	OPERATOR I (%)	OPERATOR J (%)	OPERATOR K (%)
WEEK1	79.6	72.2	83.3
WEEK2	88.9	75.9	88.9
WEEK3	25.9	77.8	85.2
WEEK4	85.2	94.4	94.4
WEEK5	64.8	88.9	72.2
WEEK6	66.7	88.9	70.4
WEEK7	70.4	90.7	68.5
WEEK8	66.7	88.9	77.8
AVERAGE	68.5	84.7	80.7

Table 5: Inter network calls to receivers within the University

PERIOD	OPERATOR I (%)	OPERATOR J (%)	OPERATOR K (%)
WEEK1	65.7	61.1	75.0
WEEK2	79.6	62.0	82.4
WEEK3	25.9	51.9	54.6
WEEK4	89.8	95.4	84.3
WEEK5	64.8	81.5	60.2
WEEK6	58.3	86.1	75.9
WEEK7	64.8	92.6	74.1
WEEK8	73.1	84.3	72.2
AVERAGE	65.3	76.9	72.3

Table 6: Intra network calls to receivers outside the University

PERIOD	OPERATOR I (%)	OPERATOR J (%)	OPERATOR K (%)
WEEK1	90.7	72.2	87.0
WEEK2	79.6	68.5	83.3
WEEK3	33.3	87.0	85.2
WEEK4	79.6	96.3	85.2
WEEK5	74.1	90.7	68.5
WEEK6	66.7	94.4	83.3
WEEK7	64.8	87.0	75.9
WEEK8	72.2	92.6	79.6
AVERAGE	70.1	86.1	81.0

Table 7: Inter network calls to receiver outside the University.

PERIOD	OPERATOR I (%)	OPERATOR J (%)	OPERATOR K (%)
WEEK1	67.6	65.7	77.8
WEEK2	75.9	70.4	77.8
WEEK3	27.8	86.1	87.0
WEEK4	77.8	93.5	83.3
WEEK5	56.5	87.0	66.7
WEEK6	69.4	91.7	80.6
WEEK7	68.5	88.0	73.1
WEEK8	71.3	89.8	75.9
AVERAGE	64.4	84.0	77.8

Similarly, applying equation (2) on the data collected, the call failure rate in percentage, for the period of eight weeks for each network were computed and tabulated as shown in Tables 8-11.

Table 8: Intra network call failure rate in percentage, for calls within the University.

PERIODS	OPERATOR I (%)	OPERATOR J (%)	OPERATOR K (%)
WEEK3	70.4	22.2	14.9
WEEK4	14.9	5.6	5.6
WEEK5	35.2	11.1	27.8
WEEK6	31.5	11.1	29.6
WEEK7	29.6	9.3	29.6
WEEK8	33.3	11.1	22.2
AVERAGE	30.8	15.3	19.7

Table 9: Inter network call failure rate in percentage, for receivers within the University.

PERIODS	OPERATOR I (%)	OPERATOR J (%)	OPERATOR K (%)
WEEK1	34.6	39.9	26.9
WEEK2	20.4	38.0	17.6
WEEK3	74.1	48.1	45.4
WEEK4	10.2	4.7	15.7
WEEK5	35.2	18.5	39.8
WEEK6	41.7	13.9	25.9
WEEK7	35.2	7.4	25.9
WEEK8	26.9	15.7	27.8
AVERAGE	34.8	23.3	28.1

Table 10: Intra network call failure rate in percentage, for receivers outside the University

PERIODS	OPERATOR I (%)	OPERATOR J (%)	OPERATOR K (%)
WEEK1	9.6	27.8	13.0
WEEK2	20.4	31.5	16.7
WEEK3	51.9	13.0	14.9
WEEK4	20.4	3.7	14.8
WEEK5	25.9	9.3	31.5
WEEK6	33.3	5.6	16.7
WEEK7	35.2	11.1	24.1
WEEK8	27.8	7.4	20.4
AVERAGE	28.1	13.7	19.0

Table 11: Inter network call failure rate in percentage, for receivers outside the University

PERIODS	OPERATOR I (%)	OPERATOR J (%)	OPERATOR K (%)
WEEK1	32.4	34.3	22.2
WEEK2	24.1	29.6	22.2
WEEK3	72.2	12.0	13.0
WEEK4	22.2	6.5	16.7
WEEK5	43.5	13.0	33.3
WEEK6	30.6	8.3	19.4
WEEK7	31.5	12.0	26.9
WEEK8	28.7	10.2	24.1
AVERAGE	35.7	15.7	22.3

The average accessibility levels obtained for intra and inter network calls to a receiver within and outside the University premises obtained using equation 1 are as presented in Table 4, Table 5, Table 6 and Table 7 for the respective GSM network providers. Similarly, call failure rate in percentage obtained for intra and inter network calls to a receiver within and outside the University premises using equation 2 are also presented in Table 8, Table 9, Table 10 and Table 11 for the respective GSM network providers. Therefore, interpret-

tations and understanding of the practical implications of those tables are hereby analysed and discussed as follows:

RESULTS

Data generated for intra network calls set up to a receiver within and outside the University premises are presented in Table 4 and Table 6 respectively for accessibility levels, while that of call failure rate are presented in Table 8 and Table 10 respectively. The tables show the comparison of intra network call accessibility levels and failure rate for the three networks under study. These tables are used for graphical illustration of charts of accessibility levels and call failure rates for the networks under study as shown in Figure 1 to Figure 4.

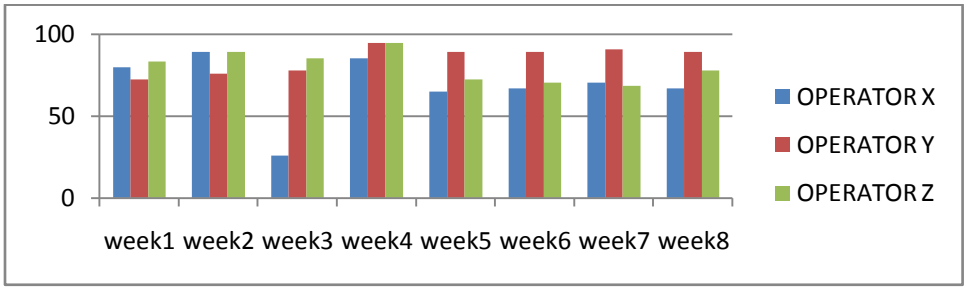

Figure 1: Accessibility levels (%) against period of the year for intra network calls within the University. (July-September. 2019).

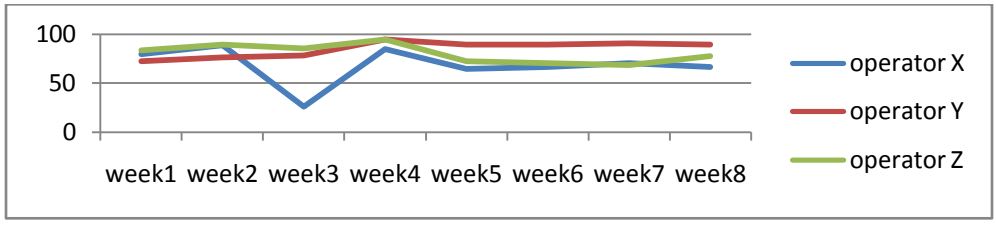

Figure 2: Accessibility levels (%) against period of the year for intra network calls to a receiver within the University. (July-September. 2019)

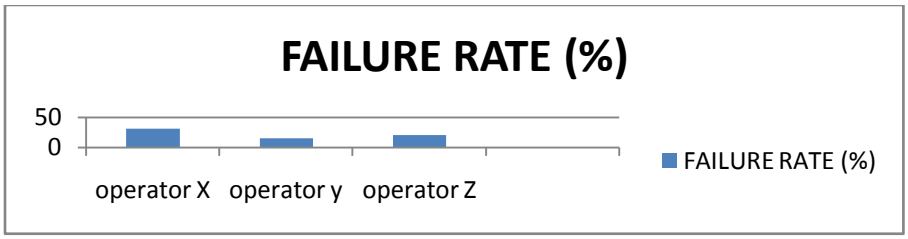

Figure 3: Call failure rate against GSM operators for intra network calls to a receiver within the University

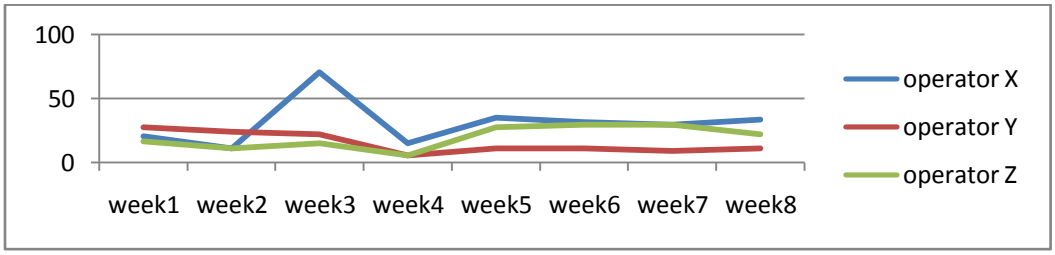

Figure 4: Call failure rate (%) against period of the year for intra network calls to a receiver within the University

DISCUSSION OF RESULTS

Accessibility Levels

Figure 1 contains information about percentage accessibility levels for each week of investigation for the respective GSM network providers, the results were also presented in graphical form as shown in Figure 2. Based on the results, the QoS provided for the outgoing calls in Federal University, Gusau, for both intra and inter network calls to receiver within and outside the University premises is thus discussed. For intra network calls, operator I seems to fall from 88.9% in week2 to 25.9% in week3 for receivers within the University and from 90.7% in week1 to 33.3% in week3 for receivers outside the University, operator J falls from 94.4% in week4 to 72.2% in week1 for receivers within the University and from 96.3% in week4 to 68.5% in week2, operator K falls from 94.4% in week4 to 72.2% in week5 for receivers within the University and from 87.0% in week1 to 68.5% in week5. While for inter network calls as contained in Table 5 and Table 7, operator I seems to fall from 89.8% in week4 to 25.9% in week3 for receivers within the University and from 77.8% in week4 to 27.8 in week3 for receivers outside the University, operator J falls from 95.4% in week4 to 51.9% in week3 for receiver within the University and from 93.5% in week4 to 65.7% in week1 for receivers outside the University, operator K falls from 82.4% in week2 to 54.6% in week3 for receivers within the University and from 87.0% in week3 to 66.7% in week 5, were observed. Comparing the result with the study carried out by Sa'adu, et al (2019), where they assessed mobile network signal strength in the same study area using data collected from the office of the National Space Research and Development Agency (NASRDA) in Federal University, Gusau, their result indicated that operator Z (ETISALAT) has better signal strength, followed by operator Y (GLO) and then followed by operator X (AIRTEL) but operator Y has better steady signal compared to the other two. The overall average evaluation for this research was such that operator J network has the best performance for the outgoing calls as compared to operator I and operator K with 84.7% and 86.1% for intra network calls connection to a receiver within and outside the University respectively and with 76.9% and 84.0% for inter network calls connection to receivers within and outside the University respectively. Therefore, it is obvious that despite the fact that the study area is the same for the two researches, there is variation in their findings, which could be as a result of interval in the periods of investigation. It should be noted that operator K (9MOBILE) in this research was ETISALAT in the other research.

Call Failure Rate

Call failure rate is another parameter utilized in evaluation of the QoS of GSM network providers in Federal University Gusau, Zamfara State. The averaged call failure rate is such that, operator I has failure rate of 30.4% and 34.9% for intra and inter network calls respectively, operator J has failure rate of 18.1% and 29.8% for intra and inter network calls respectively, where operator K has failure rate of 15.2% and 29.0% for intra and inter network calls respectively, for calls made to receivers within the University. While for calls set up to receivers outside the University, operator I has failure rate of 25.6% and 38.9% for intra and inter network calls respectively, operator J has failure rate of 17.0% and 19.1% for intra and inter network calls respectively, operator K has failure rate of 18.2% and 21.5% for intra and inter network calls respectively. The overall assessment is such that operator I network has the highest call failure rate followed by operator K network and operator J network has the least failure rate for the period of investigation.

CONCLUSION

In this research work, investigation of quality of service (QoS) of GSM network providers at Federal university Gusau, Zamfara State is achieved. Each of the network providers is used to initiate three different calls to receivers having the three investigated networks within the University, the same number of calls is put across at the same time to receivers having the three investigated networks outside the University, these calls were made at each of the selected locations in the University. The data collected were used to obtain the average of the service accessibility and call failure rate of these networks. The results depict that QoS of these network providers varies, despite these variations, operator J has the best QoS compared to operator I and operator K in the study area for the period of investigation. Therefore, operator J possess higher reliability in term of mobile/wireless communication in the University followed by operator K network and then operator I network. The call quality for outgoing intra and inter network calls was generally good for five weeks of investigation only for operator I in week3 that has less than 50%. However, from this study there is need for system optimization (i.e. increase in the number of base stations and effective signal amplifiers to facilitate signal transmission and reception and also to minimize attenuation respectively), so as to optimize and improve on the QoS to customers' satisfaction.

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