

EVALUATION OF THE QUALITY OF SERVICE AND BENCHMARKING OF GSM NETWORKS IN SOUTHWEST, NIGERIA: A CASE STUDY OF ADEKUNLE AJASIN UNIVERSITY CAMPUS AKUNGBA- AKOKO ONDO STATE, NIGERIA

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ABSTRACT

This study is an evaluation of quality of service and benchmarking of GSM networks in SouthWest, Nigeria: A case study of Adekunle Ajasin University campus Akungba- Akoko Ondo State, Nigeria. The study was evaluating the benchmarking performances of four major mobile networks including, MTN, Airtel, Glo and 9mobile with the standard key performance indicators (KPIs) set by the Nigeria, Communication Commission (NCC). All the parameter of GSMs were evaluated based on the quality of services (Qos) provided by mobile network operators (MNOs) in terms of cellular data or voice network. The statistical data generated by quality voice mobile 3G network analyser, and Specific network measurements was obtained from each mobile devices. The data collected by software's devices, were analysed using bar chart and pie chart. The four GSMs network results were ranking according to their performances aligned with NCC benchmark performance. The findings of the study revealed that handover success rate that enhancing the subscribers for enjoined quality of service was used as a determinant factor, 9mobile network provides the highest handover success rate for quality of service at 99.6% to their subscribers in AAUA campus, follow by Airtel, (98.7%) MTN, (98.3%) and Glo network (75.7%) as the least among the networks and the quality of service is poor. Finally, the study was concluded that the performance of each network operator needs to be improved, and recommended that, all network operators should review their networks and effect some optimization measure.

KEYWORDS: Electric vehicles EV charger Grid to vehicle Solar to vehicle Vehicle to vehicle PFC AC-DC converter DC-DC converter UPF DCM

1. INTRODUCTION

Global system for mobile communication (GSM) technology was introduced in Nigeria in 2001 to solve the problem associated with earlier mobile phone service which included the inability to handle the growing capacity needs in a cost efficient manner. The GSM uses Time Division Multiple Access (TDMA) which divides a radio channel into eight (8) times slots. That is user per time slot. Also, it used digital data which comes with ease of signaling lower levels interference, integration of transmission and switching, and increased ability to meet capacity demand (Jacob & Folasade, 2020). Over the years, Nigeria engaged in the use of GSM since 2001, focus shifted from providing good coverage and quality of service (Qos) and the euphoria of owning a phone is now gradually giving way to complaints of dropped calls and blocked calls, calls failed, which is mostly assumed may be caused by congestion (Ajayi *et al.*, 2021). The mobile network providers in Nigeria have witnessed a tremendous increase in their subscriber base.



Thus as the number of services and subscribers were increased, the demand for good quality of services (Qos) arose. Hence GSM has demonstrated the potential to transform society and business, academic environment and the evolution has only just commenced where commerce was forever changed, time and distance began to melt away as a barrier to doing business. Keeping in touch with loved ones and being able to respond immediately with major world event ([Akinola & Allison, 2015](#)). The fact is that communication without doubt is a major driver of any economy. The emerging trend in socio-economic growth shows a high premium being placed on information and communication technology (ICT) by homes, organizations, and nations. It became necessary for mobile network providers to monitor and measure the quality of service of their network accurately with a view to improving them. This is expected in the most effective and cost-efficient way to achieve customer's locality and maintain competitive edge ([Obi & Ekah, 2021](#)). According to [Akinola and Allison \(2015\)](#), customer satisfaction is very important to gain sustainable competitive edge in the market. Therefore no matter how well mobile network operators believe their networks are performing, they can still lose subscribers who are not satisfied or happy with the quality of service delivered. The significant place of performance benchmarking and evaluation of mobile networks cannot be overemphasized. It is inspired by the need to utilize the limited radio resources in the most efficient manner ([Okereke 2018](#); [Onyenwe et al., 2018](#)).

However, the needs for benchmarking performance and evaluation of quality of service of mobile networks might be done to continuous increases in demand for high-quality service, coupled with the future extension telecommunication network target of providing integrated services with multimedia application, over low-powered mobile computing devices, has further increased the need for evaluating the performance of mobile network ([Ojo et al., 2019](#); [Ajayi et al., 2021](#)). According to Abdulakereem, et al., (2020), the users' perspective is that the performance of a mobile network should be measured in subscribers' satisfaction index, network availability and efficiency. Therefore from all indications, GSM network performance evaluation is necessary for assessing and measuring the coverage, capacity and quality of mobile networks with respect to the service level agreement (SLA) signed with the regulators.

Quality of service is a set of technologies for managing network traffic in a cost-effective manner to enhance user experiences for house and enterprise environment. The traffic technological term quality of service (Qos) refers to resource reservation control mechanisms rather than the achieved service quality. 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 that is guaranteed service quality. High quality of service indicates to a large extent a high level of benchmarking performance which will give out good quality of service. Qos are critical for providing high quality network services and for being able to meet the Service Level Agreements (SLAs) that all network operators must have with their customers ([Akinola & Allison, 2015](#)). Okereke and Adewale (2019) argue that communication system quality of service usually defined in the (ITU) standard as a part of quality requirements on the collective behavior of one or more object.

However, quality of service compares requirement on all the aspects of a communication, such as service response time, loss, signal-to-noise ratio, cross-talk, echo, interrupts, frequency response, loudness levels, signal faded among others. Quality of service (Qos) generally can be defined as the level of satisfaction a customer or an end-user derives from a service. In cellular networks, it is the performance of a mobile network, particularly as perceived by the users of the network. The [Nigeria Communication Commission \(NCC, 2015 & 2019\)](#), stressed that the KPI must be used as standard in the assessment of Qos provided by mobile network operators, including call setup success rate (CSSR), radio signals quality and strength (RX), Call Drop Rate (CDR), Traffic Channel Congestion Rate (TCH-CONG) stand-alone, Dedicated Control Channel Congestion Rate (SDCCA-CONG), and Handover success Rate (HOSR) ([NCC 2015, & 2019](#); [Abdulkareem, et al., 2020](#)). Qos is normally measured via a set of metrics called key performance indicators (KPIs). KPIs are calculated from measurement of various network parameters. Such networks are MTN, Airtel, Glo and 9mobile. KPIs are a set of specific requirements provided by a mobile network to users, which are necessary in order to achieve the required functionality of a particular service. KPIs help define the benchmarking performance metric of a network ([Ewona & Ekah, 2021](#); [Ukoette & Chibuzo, 2021](#)).

In recent years GSM seems to be facing many problems. Some of the problems are instability in power supply, security of infrastructure, internet work connectivity, and network bottleneck, call setup failure and call retention or call drop. All these factors appear as a major constraint of good quality of service and benchmarking performance of GSM operators in Nigeria. Moreover these might cause a lot of setback in production of goods and services. The complaints lead to nations lawmakers (Senate) in year 2007 to set up a committee to investigate the inefficiency of the service providers. While this was going on, the house of representative invited the service providers to appear before its adhoc committee mandated to investigate the activities of the service providers. Hence they maintained that this become

necessary due to public outcry on the epileptic services as well as its economic and social implications (Akinola & Allison, 2015; Chukwuemeka, 2018; Mojisola, & Gbolahan, 2015).

The Nigeria communication commission (NCC) on their part made a statement at a forum in 2019, on Qos issues that their focus is to administer and monitor closely a performance management program to ensure that operating companies maintain minimum performance level jointly agreed between the GSM operators, consumer representatives and NCC in consistent with world class standard. At this forum, the commission outlined a benchmark of Qos indicators in form of technical parameters that must be followed by all operators. Based on the outcome of the NCC forum, the network providers were to be closely monitored and evaluated on quarterly basis while stiff penalties were also spelt out for any erring operators for non- compliance (Ajayi *et al.*, 2021).

1.1 Problem Statement

The adoption of the GSM in Nigeria is a long awaited development expected in the telecommunication industry. It was expected that its introduction will bring about effective telecommunication service that will support good speech quality. This development in the campus was well embraced by students and staff in SouthWest, Nigeria Universities, and found to be relatively efficient. Sadly, this service is now being hampered by some factors leading to a fall in quality of service offered by the mobile network provider, As GSM seems as facing many problems such as, instability in power supply, security of infrastructure, internet work connectivity, network congestion, call setup failure and call retention or call drop among other.

The network subscribers in Adekunle Ajasin University Campus Akungba Akoko, as a case study, for Southwest, Nigeria, mostly students in the campus complain about not satisfied with the quality of service delivery by the mobile network providers in their campus. These may be due to the geographical terrain of the campus surrounded by rocky hills. The hills are above the sea level in both within the campus and neighboring environment few kilometers around the institution. All these factors appears to be the causes of poor quality of service (Qos) offered by the mobile networks providers. Meanwhile, it seems that inadequate evaluation of quality of service and benchmarking performance might be the major constrain to effective delivery of quality of service to the subscribers in Adekunle Ajasin University Campus Akungba. Akoko, Ondo State, Nigeria.

1.2 Purpose of the Study

The purpose of the study was to evaluate quality of service and benchmarking of GSM networks in SouthWest, Nigeria: A case study of Adekunle Ajasin University Campus Akungba- Akoko Ondo State, Nigeria. The study will specifically;

- a. Examine the network operator that have best calls setup success rate for quality of service among mobile network in AAUA campus.
- b. Investigate the network operator that meet NCC benchmark of calls completed rate among mobile network in AAUA campus.
- c. Ascertain the network operators that have best received quality distribution of signals level among mobile networks in AAUA campus.
- d. Determine the network operators that is the best for received quality distribution of signals among mobile network in AAUA campus.
- e. Investigate the network operators that its received signal level is aligned with NCC KPIs standard among mobile network in AAUA campus.

1.3 Research questions

The following research questions were raised to guide the study

1. What are the network operator that have best calls setup success rate for quality of service among mobile network in AAUA campus?
2. What are the network operator that meet NCC benchmark of calls completed rate among mobile network in AAUA campus?
3. What are the network operators that is the best for received quality distribution of signals among mobile network in AAUA campus?
4. What are the network operators that its received signal level is aligned with NCC KPIs standard among mobile network in AAUA campus?

2 METHODOLOGY

The study adopted drive test, drive test was carried out in faculties and zenith building areas. In practice, one major way in which QoS is measured is through drive testing, this method is used by MNO



and monitoring bodies. Drive testing is also to measure and assess coverage and capacity of a network. This technique consist of using a hardware such as quality voice mobile 3G network analyzer, Mobile vehicle, Laptop/ tablet, 4 SIM cards, cell phones (android) GPS, Wi-fi , Ethernet cable/interface. While the software materials used are, Microsoft word, Microsoft Exel. The hardware equipment comprise of quality voice mobile 3G network analyzer, and four android phones with inserted SIM cards in each phone. Each GSM mobile SIM cards were inserted into each phone and placed on the quality voice mobile 3G network analyzer. The network was configured with required network parameters alongside with their KPIs. Their benchmark are;

- call setup success rate(CSSR)
- Call Drop rate(CDR)
- Call setup time(CST)
- Calls success rate(CSR) Calls attempt(CA)
- Calls completed(CC)
- Calls Dropped(CD)
- Handover success rate(HSR)
- RxQual(RxQ) Range
- Rxlev(RxL)

These parameters of the network signal were configured and the quality voice mobile 3G network also connected to laptop or tablet through interface cables on the device. Then, calls are selected, both long calls and short calls attempted. As the vehicle (RAV4) was driving across the routes the researcher help assistance was monitoring the devices when the calls ended the researcher's help assistance pulse the devices, the devices produced call statistical table automatically. And the table shown on laptop screen where it was transferred into the flash drive and relevant data were collected.

3 RESULTS AND DISCUSSION

Table 1: The Key performance Indicators for Minimum Acceptable Value Set by Nigeria Communication Commission.

GSM						
Networks	KPI	Airtel	9mobile	Glo	MTN	Ranking 1st
Calls Attempt		106	106	106	106	
Calls Completed		99	102	49	66	
Calls Failed		2	1	28	34	
Calls Dropped		5	3	29	6	
Call Release Failure		0	0	0	0	
Radio link Samples		74277	143950	68502	50217	
Call Set-up Success Rate (CSSR) (%)	≥ 98%	98.1	99.1	73.6	67.9	
Blocked Call Rate (BCR) (%)	≤ 2%	1.9	0.9	26.4	32.1	
Call Drop Rate (CDR) (%)	≤ 1%	4.7	2.8	27.4	5.7	
Call Set-up Time (CST) (Sec) Median	≤ 10s	5.51	6.39	7.88	6.75	
Call Completion Rate (CSR) (%)	≥ 97%	93.4	96.2	46.2	62.3	
Call Retention Rate (CRR) (%)	≥ 98%	95.2	97.1	62.8	91.7	
Speech Quality Index (SQI)(MOS) Med	≥ 3.6	3.11	3.52	3.07	3.37	
Handover Success Rate (HSR)	≥ 98%	98.7	99.6	75.7	98.3	
RxQual (RxQ) Range (0-5) (%)	≥ 95%	37.25	54.54	42.85	21.23	
RxLev (RxL) (-47 to -110dBm) Median	≥ -85dBm	-96	-88	-85	-88	

Table 2: Nigeria Communication Commission Key Performance Indicators

KPIs	CSSR	CCR	HSR	RxQuality	Rxlevel	CDR	CST
NCC Target	≥98%	≥97%	≥98%	≥95%	≥ -85%	≤ 1%	10sec

3.1 Question 1: What are the network operators that have best calls setup success rate for quality of service among mobile network in AAUA campus?

Call Setup Success Rate (CSSR): is a metric used to measure the effectiveness of a telecommunication network in establishing successful connections for voice calls. It can be calculated by dividing the total number of successful established calls by total number of calls attempt and multiply by 100.

$$\text{CSSR} = \frac{\text{Total number of successful established} \times 100}{\text{Total number of calls attempt}}$$

From the calls statistical table of long calls (LC), the key performance indicator given by NCC for expected GSM performances is >-85dBm

Figure 1

From **figure 1**. Both bar chart and pie chart was used for analysis, the calls setup success rate. It was revealed that 9mobile (Etisalat) attained the highest value of 99% completed calls and

have 1% calls failure, follow by Airtel which have 98% of completed calls with 2% of calls failed, follow by MTN, have 66% completed calls and calls failed of 34%, while Glo network have 64% of completed calls with 36% of calls failed.

3.2 Question 2: What are the network operators that meet NCC benchmark of calls completed rate among mobile network in AAUA campus?

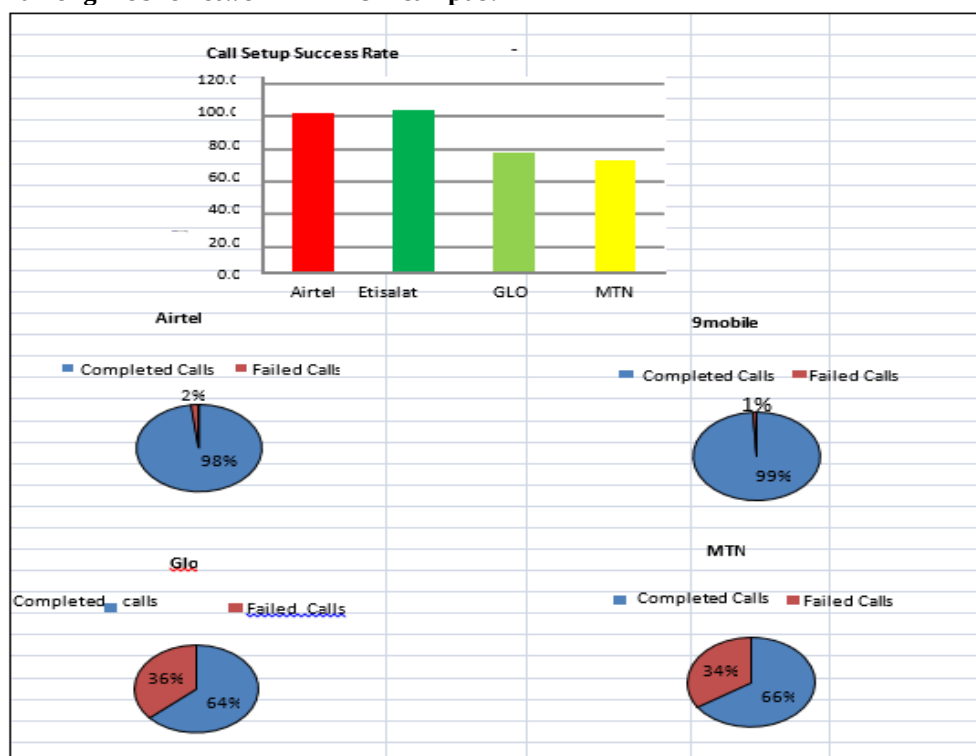


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Call Completion Rate

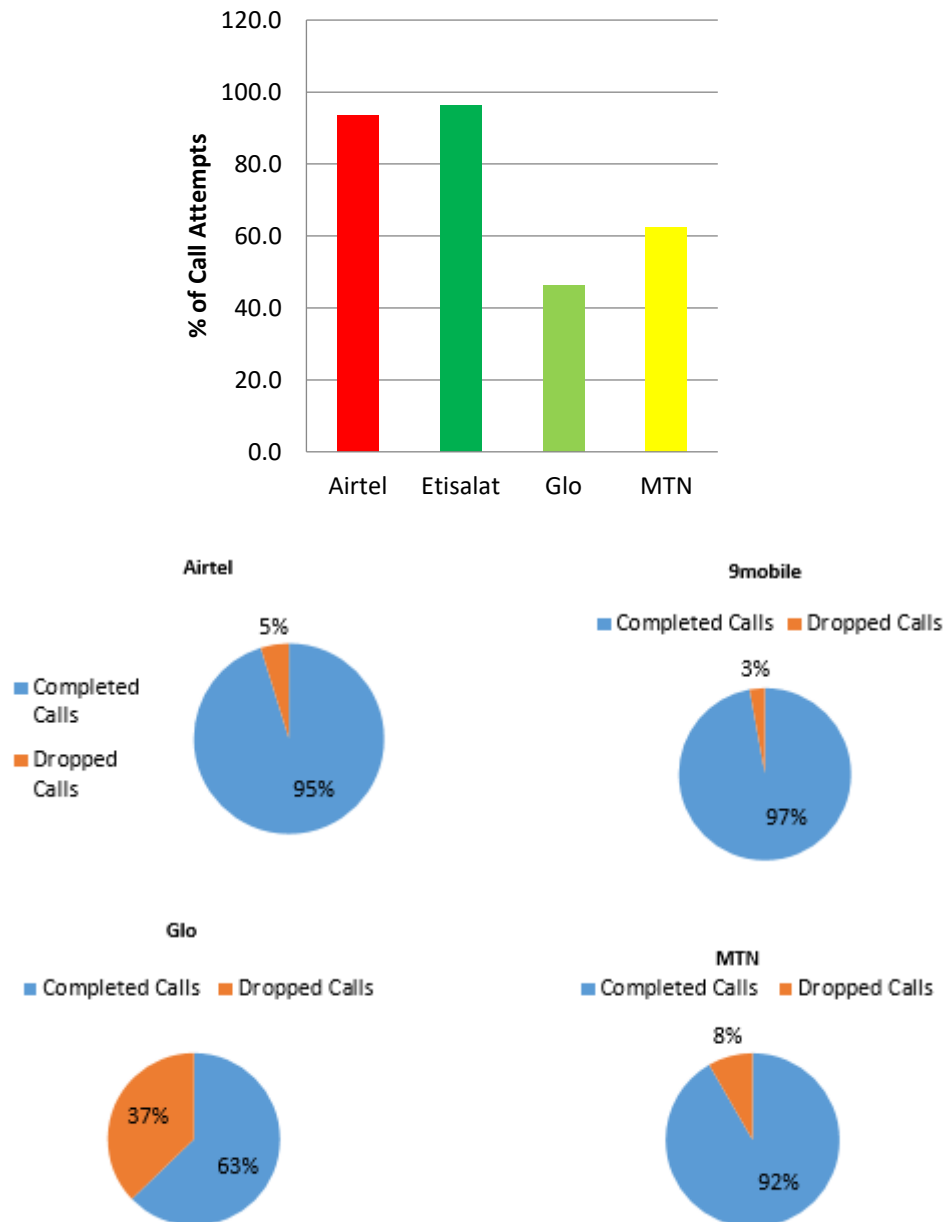


Figure 2

This is the ratio of calls completed over ratio of calls attempt multiply by hundred percent

$CCR = \text{Calls Completed} \div \text{Total numbers calls attempt} \times 100 \%$

Figure 2 Show that **9mobile** have highest call completed rate of 96% and calls dropped of 4%, follow by **Airtel** with 95% of calls completed rate and 5% of calls dropped, follow by **MTN**, it have 92%of completed with 8% of calls dropped, while **GLO** have 63% of completed calls and 37% of calls dropped. Therefore, none of the networks operators meet the given KPIs (97%) by NCC for calls completed rate.

3.3 Question 3: What are the network operators that have best received quality distribution of signals level among mobile networks in AAUA campus?

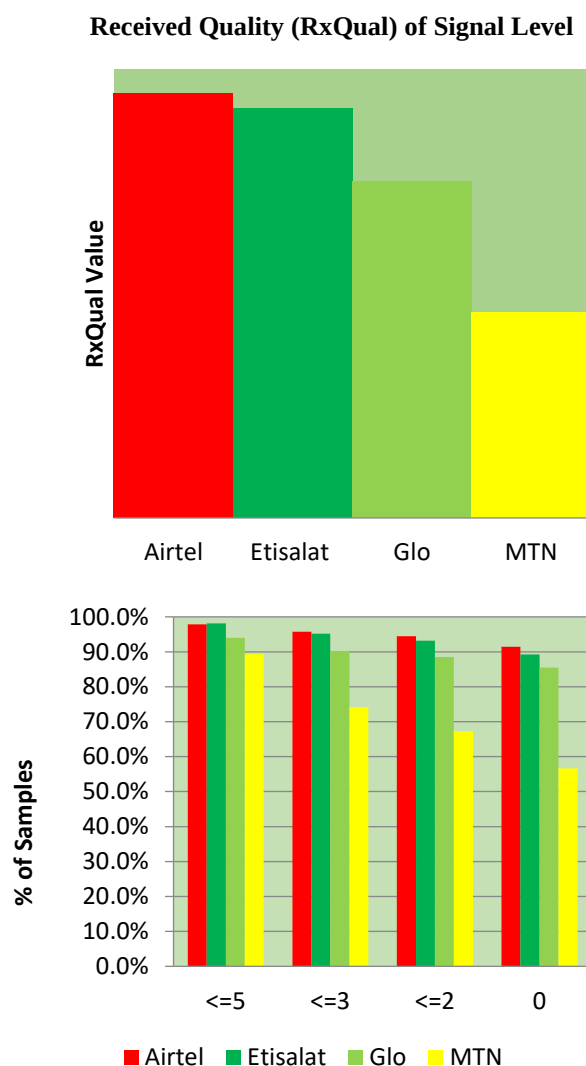


Figure 3

According to Figure 3, the chart show that Airtel and 9mobile have (98%) good quality of receiving signal, while MTN and Glo, receiving signal level are(93%and 92%) show that both networks does not meet the NCC standard required of 95% hence both MTN and Glo networks signal are poor in their operation.

And their customers are not too satisfied with their service. Figure 3 shows the Average Rx level quality for Airtel, 9mobile, Glo and MTN, in AAUA main campus areas only Rx Quality values that are less or equal to 5 are acceptable. The figure shows that all the operator networks have most of their Rx Quality between 0-5Db. The counts and percentage of Airtel, 9mobile, Glo, and MTN, Rx Quality are (98%'.98%, 93%, 89%) respectively.

3.4 Question 4: What are the network operators that is receiving signal level is aligned with NCC KPIs standard among mobile network in AAUA campus?

Received level signal (RxLev) at AAUA Campus

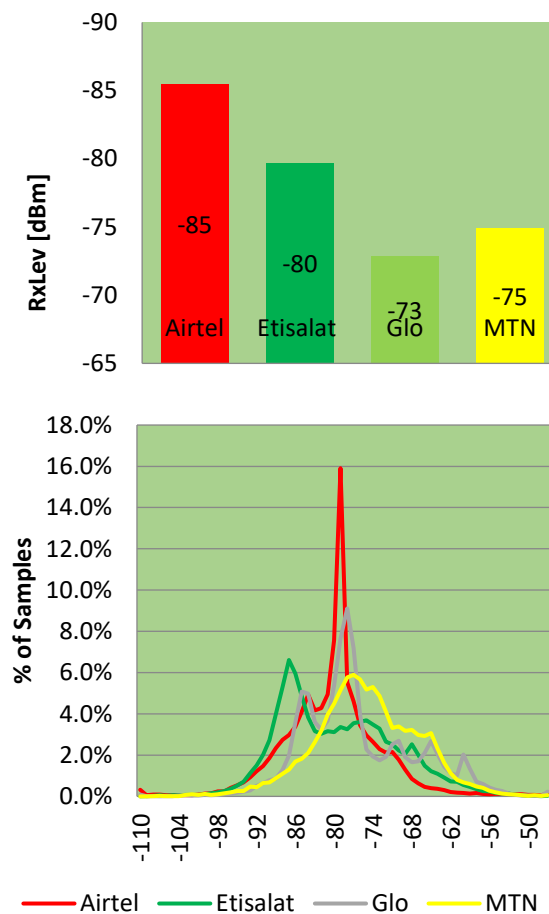


Figure 4a

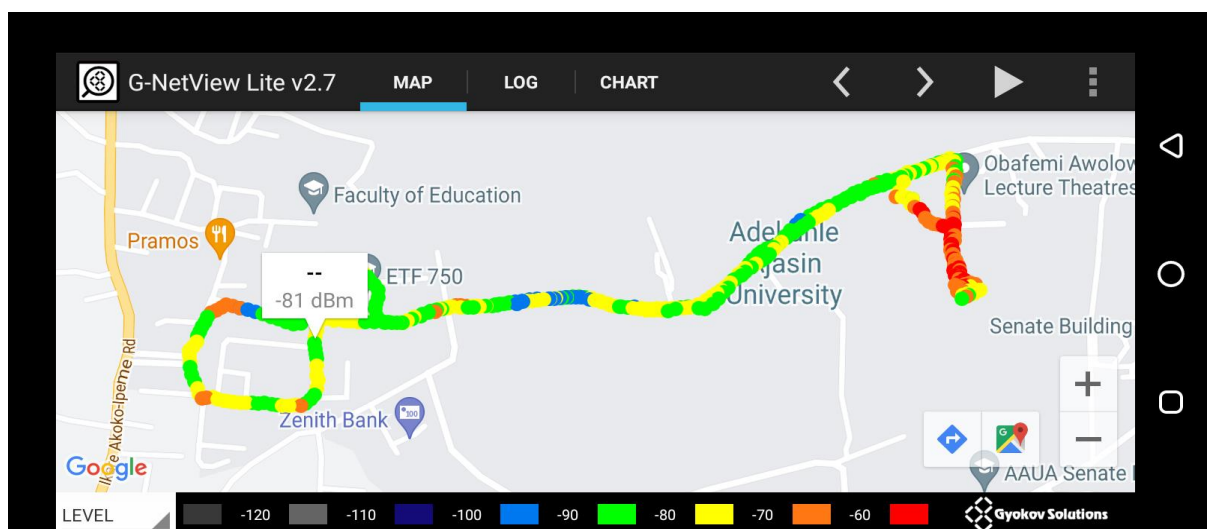


Figure 4b

Driving Test Map

From Figure 4a, the level of signal received by Airtel Operator network which is (-85dBm) is aligned with NCC KPIs of (-85dBm). Follow by 9mobile of (-80dBm), while Glo and MTN have -73dBm and -75dBm respectively. Hence the signals in 9mobile, Glo and MTN networks needs improvement.

4 LEVEL OF QUALITY OF SERVICE (LONG CALLS)

The level of quality of service (Qos) among the mobile network service operator are presented using analysis through graphical method, bar chart on the values of the Rxlevel and Quality distribution. Figure 4 shows the average Rxlevel for Airtel, 9mobile, Glo and MTN, in Adekunle Ajasin University Campus Area. Only Rxlevels that are greater or equal to -85dBm are acceptable. Thus only Airtel network has the best Rx levels while that of 9mobile, Glo, and MTN are poor. According to the drive test map Figure 4b, it revealed that Network Coverage (NC), where there is blue colour indicated good signals with signal range of 90 to 100levels followed by green colour with range of 80 to 90 signal levels while red and orange colour are poor signal with 60 to 70 levels below the NCC standard for receiving signal level. Thus, 9 mobile have best quality of signal level, followed by Airtel network, and followed by Glo network and MTN.

4.1. Results

Table3: Shown the Comparative Analysis of KPIs GSM Networks Quality of Service by Ranking their Parameters Performance.

GSM main campus							Ranking		
Network	Airtel (A)	9mobile(B)	Glo(C)	MTN (D)	A	B	C	D	
Variables									
Calls Attempt	106	106	106	106	-	-	-	-	
Calls completed	99	102	49	66	2 nd	1st	4 th	3rd	
Calls failed	2	1	28	34	3 rd	4th	2 nd	1st	
Calls Dropped	5	3	29	6	3 rd	4th	1 st	2nd	
Calls setup success rate	98.1%	99.1%	73.6%	67.9%	2 nd	1st	3 rd	4th	
Calls completed rate	93.4%	96.2%	46.2%	62.3%	2 nd	1st	4 th	3rd	
Handover success rate	98.7%	99.6%	75.7%	98.3%	2 nd	1st	4 th	3rd	
Rx	37.25%	54.54%	42.85%	21.23%	3 rd	1st	2 nd	4th	
Quality(RxQ)Range									
Rxlevel(Rxl-47110dBm)	-96%	-88%	-85%	-88%	1 st	2nd	4 th	2nd	

Call setup: This is an exchange of signaling information in the call process that leads to traffic channel (TCH) seizure.

Call Setup Success Rate (CSSR): is a metric used to measure the effectiveness of a telecommunication network in establishing successful connections for voice calls. It can be calculated by dividing the total number of successful established calls by total number of calls attempt and multiply by 100.

$$\text{CSSR} = \frac{\text{Total number of successful established} \times 100}{\text{Total number of calls attempt}}$$

Call Drop Rate (CDR): This metric is used to evaluate the retain ability of a network when a call is established on a channel. Call drop rate is mathematically calculated as:

$$\text{CDR} = \frac{\text{Number of dropped calls} \times 100}{\text{Total number of call established}}$$

$$\text{Retain ability} = 100 - \text{CDR}$$

Handover Success Rate (HSR): Handover success rate is used to evaluate the performance of network operators relative to user mobility. It is mathematically calculated as:

$$\text{HSR} = \frac{\text{Number of successful handover} \times 100}{\text{Total handover attempt}}$$



Call Setup Time (CST): This is the time taken to establish a call after a successful call attempt.

Handover Failure Rate (HFR): Is an important indicator for monitoring mobility, handover failure means that the mobile station tries to make a handover (inter/intra cell) but for some reasons it fails. (Ajayi *et al.*, 2021).

Network Coverage (NC): This is the measure of the downlink coverage penetration. Voice, SMS and data services depend on the penetration of the downlink coverage. It has a performance threshold of at least – 85dbm (Ekah, & Emeruwa, 2021).

Network Quality (NQ): This is the measure of the signal quality during a call. It is measured and used to evaluate a networks quality of reliability and it measures the amount of bit errors received by the Mobile Station. (MS).

4.2 Discussion

The results in Table 3 shows that 9mobile has (102) as highest call completed, follow by Airtel with value of 99, MTN has 66, while Glo has the least value of 49. For Calls failed, MTN has the highest calls failed of 34, Glo has 28 calls failed, Airtel network has 2 calls failed while 9mobile has 1 calls failed. Hence this result revealed that 9mobile is the best network operator that has call setup success rate, follow by Airtel, while both Glo and MTN have worst calls setup success rate. For call completed rate, 9mobile has the highest calls completed of (96.2%), and Airtel has (93.4%), follow by MTN network has (62.3%) while Glo has the least calls completed rate of (46.2%) thus the result revealed that both 9mobile and Airtel have best quality of service for calls completed rate.

Handover success Rate: 9mobile network has highest handover success rate of (99.6%) , Airtel has (98.7%) , MTN has (98.3%),while Glo network has (75.7%) below benchmark of NCC for standard handover success rate for quality of services to their customers.

Rx Quality level in table 3 shows that, Airtel, 9mobile, Glo and MTN have (37.25%, 54.54%, 42.85%, 21.23%) respectively. Hence 9mobile has the best quality of service among the other network operators.

Received level signal (Rxlev), as shown in the ranking in table 3, Airtel networks is the best, both 9mobile and MTN are ranked for 2nd, while Glo network ranked in fourth position.

From table 3, all the major networks were ranking according to their performances aligned with NCC benchmark performance. The study revealed that 9mobile network provides the highest quality of service to their subscribers in AAUA campus, follow by Airtel, MTN, and Glo network as the least among the networks and the quality of service is poor.

4.3 Conclusion

Based on the findings of the study, it was therefore concluded that the study address the problems faced by mobile network users or subscribers in Adekunle Ajasin University Campus Akungba Akoko, in Ondo State, Nigeria. The study was analysed and evaluated with bar chart and pie chart, the performance of each network operator needs to be improved. In terms of service, 9mobile rates the best and met the expectation of NCC in calls completed rate, calls setup rate, handover success rate, received level of signals and received quality distributions. Similarly Airtel network operators, has good quality of services, in terms of calls completed rate, calls setup success rate, handover success rate, and received levels of signal, but poor in received quality distribution. Moreover, MTN network operators is good in handover success rate, and received level of signals only but poor in calls setup success rate, calls completed rate, and received quality distribution. Glo network was the least among the four major network existing in AAUA, it only better in the expectation of NCC in aspect of received level of signal with value of (-85dBm).

4.4 Recommendations

Based on the findings of the study, the following recommendations were made:

- The mobile network operators should focus on building more base stations in order to increase their network coverage and reduce gaps and blind spots.
- They should also review their networks and effect some optimization measure.
- Handover should also be incorporated due to the “break and make” of handover to reduce calls dropped calls.
- Glo network operator should strengthen their signal level with aid of repeaters so that customer would be satisfied with their service.



- The evaluation and analysis of QoS among the mobile network service providers in this study only covered calls completed rate, calls setup success rate, handover success rate, and received levels of signal. Data service, short calls were not considered. This might be done by the future researchers.

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