Journal of the Nigerian Association of Mathematical Physics
Volume 61 **(July – September** *2021 Issue***), pp41 – 46**

A PERFORMANCE EVALUATION OF 4G MOBILE NETWORK

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Abstract

In this research, the performance of three mobile network operators (MNOs) was measured, analyzed, and evaluated using the mobile network service in Ibogun, Ogun State, Nigeria as case study. Drive test was performed using transmission environment monitoring software's (TEMs) and statistical analysis was done for performance evaluation. The results show that the receive signal strength level was between the range of -50dBm to -110dBm as against the standard range values of -30dBm to -70dBm recommended by the Nigerian Communication Commission (NCC) and is responsible for poor network quality of the Mobile Networks. Data services provided by the network service provider in terms of short message service (SMS), upload and download speed performed differently among the service provider with GLO having the least performance and MTN network was observed to be the best network.

Keywords: Quality of service, mobile network operators, key performance indicators (KPIs), drive test, Mobile Internet Service.

1.0 Introduction

Communication is the exchange of messages or information 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. 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. GSM is used by Nigerians mostly to communicate with one another [1]. Performance and quality of service (QoS) evaluation are the most important to the mobile operators as the revenue generation and customer satisfaction are directly related to network performance and quality. Quality of Service has been defined in [2] 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. QoS is usually measured via a set of metrics called Key Performance Indicators (KPIs).

1.1 Problem Statement

Mobile Service provided by Mobile Network operators in Ibogun area of Ogun State has not been satisfactory with poor services almost becoming a norm. This research article aims to determine the performance of 4G Mobile network in Ibogun community to guide a mobile subscriber the best network to use in the vicinity.

2.0 Literature Review

According to the Nigerian Communications Commission (NCC,) the KPIs used as standards in the assessment of QoS provided by Mobile Network operators include: Call Setup Success Rate (CSSR), Radio Signal Quality and Strength (RX), Call Drop Rate (CDR), Traffic Channel congestion Rate (TCH-CONG), Standalone Dedicated Control Channel Congestion Rate (SDCCH-CONG), Handover Success Rate (HOSR) [3]. The figures 1 to 4 present the monthly recorded KPIs of Nigeria's operating GSM mobile networks (**Airtel, 9mobile**, **Globacom** and **MTN)** from December 2019 to November 2020. Data points that fall within the target threshold region indicate a failure to meet the QoS KPI target for the relevant month.

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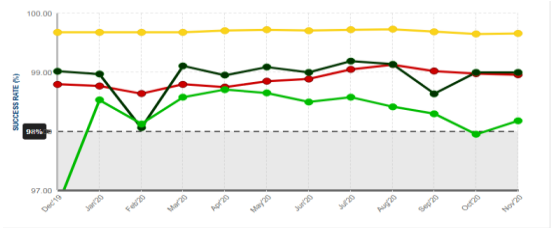
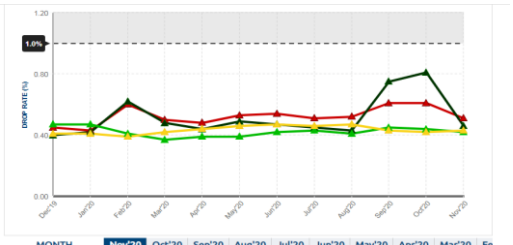


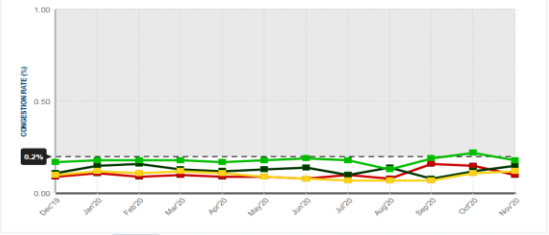
MONTH	Nov'20	Oct'20	Sep'20	Aug'20	Jul'20	Jun'20	May'20	Apr'20	Mar'20	Fe
Airtel	98.96	98.98	99.02	99.13	99.05	98.89	98.85	98.75	98.80	
9mobile	99.00	99.00	98.64	99.14	99.19	99.00	99.09	98.95	99.11	
Globalcom	98.18	97.95	98.30	98.42	98.58	98.50	98.65	98.71	98.58	
MTN	99.66	99.65	99.69	99.73	99.72	99.71	99.72	99.71	99.68	

Fig. 1. Call Setup Success Rate (CSSR) (December 2019-November 2020), Source: NCC



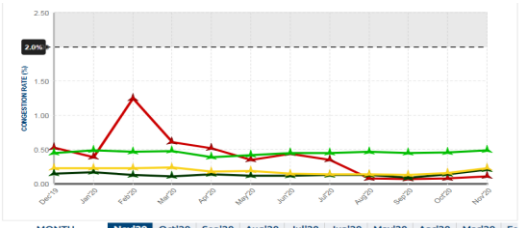
MONTH	Nov'20	Oct'20	Sep'20	Aug'20	Jul'20	Jun'20	May'20	Apr'20	Mar'20	Fe
Airtel	0.51	0.61	0.61	0.52	0.51	0.54	0.53	0.48	0.50	
9mobile	0.46	0.81	0.75	0.43	0.45	0.47	0.49	0.44	0.48	
Globacom	0.42	0.44	0.45	0.41	0.43	0.42	0.39	0.39	0.37	
MTN	0.43	0.42	0.43	0.47	0.46	0.47	0.46	0.44	0.42	

Fig. 2. Drop Call Rate (DCR) (December 2019-November 2020) Source: NCC



MONTH	Nov'20	Oct'20	Sep'20	Aug'20	Jul'20	Jun'20	May'20	Apr'20	Mar'20	Fe
Airtel	0.10	0.15	0.16	0.08	0.10	0.08	0.09	0.09	0.10	
9mobile	0.15	0.12	0.08	0.14	0.10	0.14	0.13	0.12	0.13	
Globacom	0.18	0.22	0.19	0.13	0.18	0.19	0.18	0.17	0.18	
MTN	0.12	0.11	0.07	0.07	0.07	0.08	0.09	0.11	0.12	

Fig. 3. Standalone Dedicated Control Channel Congestion (SDCCH CONG) (December 2019-November 2020) Source: NCC



MONTH	Nov'20	Oct'20	Sep'20	Aug'20	Jul'20	Jun'20	May'20	Apr'20	Mar'20	Fe
Airtel	0.11	0.08	0.07	0.08	0.35	0.44	0.35	0.52	0.61	
9mobile	0.21	0.14	0.09	0.13	0.13	0.12	0.12	0.14	0.11	
Globacom	0.49	0.46	0.45	0.47	0.45	0.45	0.42	0.39	0.48	
MTN	0.23	0.16	0.13	0.14	0.14	0.15	0.19	0.18	0.24	

Fig. 4. Traffic Channel Congestion (TCH CONG) (December 2019-November 2020) Source: NCC

On the issue of the quality of service, the authors in [4] determined that the 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.

In addition, a research conducted differentiated between Quality of Service (QoS) and Quality of end-user Experience (QoE) which are the two major techniques used for judging the performance of GSM services [5]. While the former is adjudged by service providers, the latter is determined by reaction from end-users (subscribers). The study utilized five major KPIs namely: Call Setup Success Rate (CSSR), Call Drop Rate (CDR), Handover Success Rate (HOSR), Traffic Channel Congestion Rate (TCHCR) and Control Channel Setup Failure (CCSF). Likewise, the authors in [6] evaluated the performance of GSM operators in Nigeria, examined the problems facing the industry as well as suggest methods of improvements. The study focused on Network accessibility, Network retainability and voice quality for major operators in Nigeria. The study revealed that all the networks performed fairly well in terms of network accessibility but did poorly in terms of network retain-ability and voice quality. The paper identified instability in power supply, security of infrastructure, call setup failure, call retention and congestion as the problems facing the industry.

A study in [7] examined the relationship between service quality and customer satisfaction in the utility industry (telecom) in Ghana. The study adopted the SERVQUAL model as the main framework for analyzing service quality. Multiple regression analysis was used to examine the relationships between service quality variables and customer satisfaction. The results showed that all the service quality items were good predictors of customer satisfaction. A further study reviewed the service quality dimensions established in various empirical studies conducted across the world specifically applied to Telecommunications services [8]. The study reviewed only empirical studies based on survey data and statistical methods of analysis since 2001 till 2017. The findings revealed that the meaning of service quality may have some universal aspects, as demonstrated by the similarities in the underlying dimensions as proposed in the different studies. The study also lent support to the contention that the dimensionality of SERVQUAL and importance of the dimensions vary with the cultural and country context even within the Telecommunications industry.

This study aimed to determine the performance levels of three network providers in Ibogun, a suburb of Ogun state. Rantcell network analyzer was used to determine the Quality of Service of the Mobile Network Operators through several tests at on-peak periods.

3.0 Theory and Methodology

To achieve the aim of this study, drive tests were conducted throughout Ibogun at various times during the peak and off-peak hours using transmission environment monitoring software's (TEMs). Data obtained from the test were recorded against the listed Key Performance Indicators (KPIs). The outputs were tabulated and graphs were plotted from the recorded data. Graphs representing the RSSI, upload speed, download speed, call setup time and network type were plotted. Table 1 shows the NCC standard KPIs for mobile network operators in Nigeria.

The following KPIs are used for analyzing the QoS of the mobile networks.

1. Traffic Channel Congestion Rate (TCHCR) which is a measure of how busy a cell is in setting up a call due to traffic congestion. TCH congestion rate is the proportion of the TCH assignment failures to the number of TCH seizure requests. A higher TCH congestion rate indicates difficulty in establishing a channel. Every BTS has a definite number of channels that can run simultaneously. Once the channels are exhausted, it becomes impossible for a new user to establish a call with the other party.

$$TCH\ Congestion\ Rate = \frac{Failed\ TCH\ Seizures\ due\ to\ Busy\ TCH}{TCH\ Seizure\ Requests} \times 100\% \quad (1)$$

2. Call Set-up Success Rate (CSSR) is the ratio of the number of successful calls initiated by callers to the total number of attempted calls. The higher the CSSR, the better the performance of a cell. High call setup success rate is achieved when standalone dedicated control channel (SDCCH) seizures and traffic channel (TCH) allocation are easily achieved to set up a call [9].

$$CSSR = \frac{number\ of\ successful\ calls}{total\ number\ of\ call\ attempts} \times 100\% \quad (2)$$

3. Received Signal Strength Indicator (RSSI) is a measurement of the power present in a received radio signal. It is an estimated measure of power level that an RF client device is receiving from an access point or router.
4. Upload and Download Speed refers to the speed at which the internet connection is able to send and retrieve data to or from the internet measured in bits per second.
5. SMS Delivery Time is the amount of time taken for a short message service (SMS) to be delivered to the recipient.
6. Call Setup Time is the overall length of time required to establish a circuit-switched call between end users. It is the time from initiation of a call request to the beginning of the call message.

Table 1 shows the NCC standard KPIs for mobile network operators in Nigeria.

Table 1. NCC Standard KPI for Mobile Network Operators

Key Performance Indicator	CSSR	DCR	SDCCH Cong	TCHCR
NCC Target	98%	1%	0.2%	2%

4.0 Result and Discussion

The coverage penetration level of signals of MTN (62130), GLO (62150), and AIRTEL (62120) network in different parts of Ibogun is shown below. Some of the KPIs plotted are RX level (RSSI), upload speed, Download speed, SMS delivery time, call setup time network type penetration, as shown in Figures 5 to 9 and tables 2 to 8. The Rx Lev values between 0 to -65dBm indicates excellent coverage; 65 to -75 dB m is very good; -75 to -85dBm is good; -85 to -95dBm is average and -95 to -110dBm is poor. Below -110dB m it is assumed there is no coverage.

Table 2. Received Signal Strength Indicator outcome of the three Network Provider

RSSI/RSCP	**AIRTEL (62120)**	**MTN (62130)**	**GLO (62150)**
>= -89dBm	93.7500 % (count : 150)	68.4211 % (count: 91)	0 % (count : 0)
B/w -99dBm to -90dBm	5.6250 % (count : 9)	30.0752 % (count: 40)	100.0000 % (count : 817)
B/w -112dBm to -100dBm	0 % (count : 0)	0 % (count: 0)	0 % (count : 0)
<= -113dBm	0.6250 % (count : 1)	1.5038 % (count: 2)	0 % (count : 0)
Total Geo samples	160	133	817

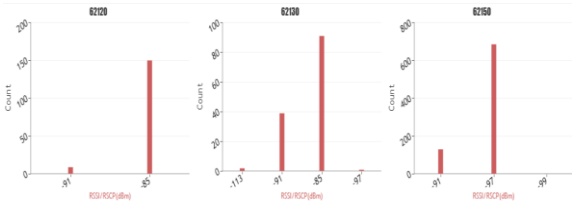


Fig. 5. Received Signal Strength Indicator (RSSI) graph of three Networks provider

Table 3. Upload Speed outcome of the three Network Provider

Upload Speed	**AIRTEL (62120)**	**MTN (62130)**	**GLO (62150)**
Above 0.5Mbps	0 % (count : 0)	100.0000 % (count : 18)	19.0909 % (count : 21)
0.2Mbps - 0.5Mbps	0 % (count : 0)	0 % (count : 0)	52.7273 % (count : 58)
Below 0.2Mbps	100.0000 % (count : 5)	0 % (count : 0)	28.1818 % (count : 31)
Average (mbps)	0.00	2.07	0.32
Peak Speed (mbps)	0	3.35	1.25
Lowest Recorded (mbps)	0	0.92	0
Total Geo samples	5	18	110

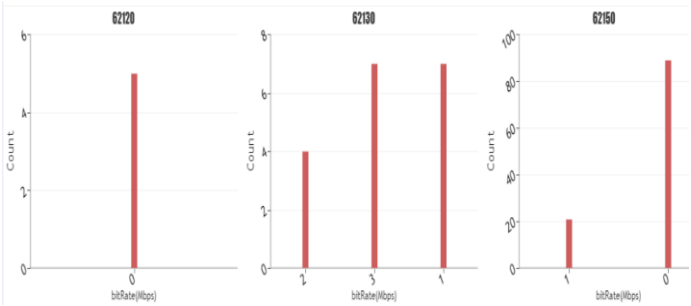


Fig. 6. Upload Speed graph of three Network provider

Table 4 Download Speed outcome of the three Network Provider

Download Speed	**AIRTEL (62120)**	**MTN (62130)**	**GLO (62150)**
Above 1.2Mbps	0% (count: 0)	100.0000 % (count : 21)	67.0330 % (count : 61)
0.4Mbps - 1.2Mbps	0 % (count: 0)	0 % (count : 0)	30.7692 % (count : 28)
0Mbps - 0.4Mbps	100.0000 % (count: 5)	0 % (count : 0)	2.1978 % (count : 2)
Average (mbps)	0.00	7.23	1.91
Peak Speed (mbps)	0	13.93	5.31
Lowest Recorded (mbps)	0	1.42	0.34
Total Geo samples	5	21	91

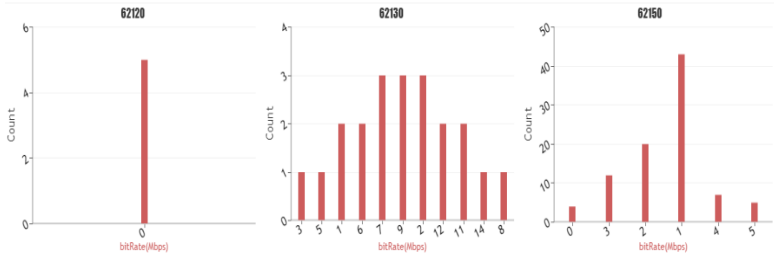


Fig. 7. Download Speed graph of three Network provider

Table 5. SMS Delivery Time outcome of the three Network Provider

SMS	**AIRTEL (62120)**	**MTN (62130)**	**GLO (62150)**
Total SMS sent success	5	5	5
Total SMS sent Failed	0	0	0
Total SMS Sent/Received Attempt	5	5	5
Total SMS Received Success	0	0	0
Total SMS Received Failed	5	5	5
Highest sent/receive Time (sec)	30.515	31.634	43.018
Lowest sent/receive Time (sec)	30.303	30.26	38.375
Total Geo samples	5	5	5

Table 6. Call Setup Time for the three Network Providers

Call Setup Time	AIRTEL (62120)	MTN (62130)	GLO (62150)
0 to 4.5secs	0 % (count : 0)	0 % (count : 0)	0 % (count : 0)
B/w(4.5 to 6.5secs)	0 % (count : 0)	0 % (count : 0)	0 % (count : 0)
< 0secs || > 6.5secs	100.0000 % (count : 5)	100.0000 % (count : 5)	100.0000 % (count : 3)
Highest Setup Time (sec)	12.12	15.72	27.56
Lowest Setup Time (sec)	10.11	11.79	20.26
Total Geo samples	116	123	100
Total Calls Success	5	5	3
Total Calls Attempted	5	5	5
Total Calls Failed	0	0	2
Dropped Calls	0	0	0
Aborted Calls	0	0	0
Call Setup Failed	0	0	2
No Network	0	0	0
Attempted Voice call on 2G	0	0	0
Attempted Voice call on 3G	0	0	5
Attempted Voice call on 4G (VoLTE)	0	0	0
Attempted Voice call on 2G/3G	0	0	0
Attempted Voice call on 3G/2G	0	0	0
Successful CSFB call to 2G	0	0	0
Successful CSFB call to 3G	5	5	0
SRVCC call to 3G	0	0	0
SRVCC call to 2G	0	0	0
CSFB call to 2G Failed	0	0	0
CSFB call to 3G Failed	0	0	0
Not Determined (Voice Call Type)	0	0	0

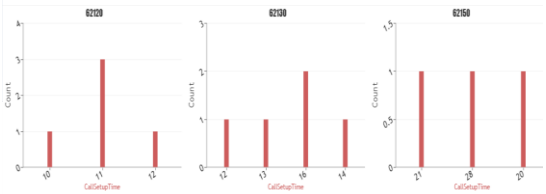


Fig. 8. Call Setup Time graph of three Network provider

Table 7. Network Type outcome of the three Network Provider

Network Type	AIRTEL (62120)	MTN (62130)	GLO (62150)
5G	0.0000%	0.0000%	0.0000%
4G	76.1550%	73.2394%	0.0000%
3G	23.8450%	26.7606%	100.0000%
2G	0.0000%	0.0000%	0.0000%
CDMA	0.0000%	0.0000%	0.0000%
NO NETWORK	0.0000%	0.0000%	0.0000%
Total Geo samples	671	497	817

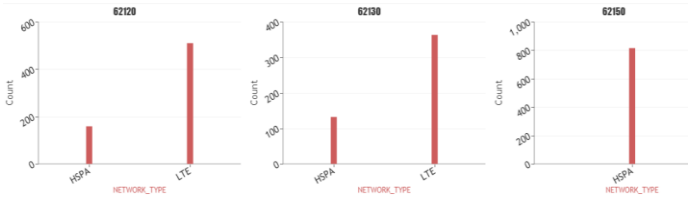


Fig. 9. Network Type graph of three Network provider

The summary of the result of the performance evaluation shows that MTN has a better performance while Globacom had the least performance as presented in table 8.

Table 8. Summary of KPIs

KPIs	**AIRTEL (62120)**	**MTN (62130)**	**GLO (62150)**
CSSR	100%	100%	60%
SMS DELIVERY TIME	30.515 SEC	31.634 SEC	43.018 SEC
RSSI	-85DBM	-85DBM	-97DBM
UPLOAD SPEED	0	3.35MPS	1.25MPS
DOWNLOAD SPEED	0	13.93MPS	5.31MPS
CALL SETUP TIME	12.12 SEC	15.72 SEC	20.26 SEC
CCA TIME	50 SEC	40 SEC	60 SEC

5.0 Conclusion

In this research, we judge the network performance and evaluate the Quality of Service (QoS) regarding end user perspective using Key Performance Indicators (KPIs). Various parameters have been mentioned and in order to evaluate performance, we mainly outlined these parameters applicable to find the formulation to all of them. Using the TEMS application software we are able to obtain the RSSI, upload and download speed, call set up time, SMS delivery time, signal penetration of the three network across Ibogun. From the data collected and the analyses network 62130 (MTN) is observed to be the best network in Ibogun as it outperformed all other network providers in terms of the RSSI, upload and download speed, call set up time, SMS delivery time, signal penetration of the three network across Ibogun.

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