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NETWORK PERFORMANCE AND QUALITY OF SERVICE EVALUATION OF GSM PROVIDERS IN NIGERIA: A CASE STUDY OF LAGOS STATE

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ABSTRACT

Network performance and quality of service evaluation of GSM Providers in Nigeria is presented in this paper.. The study used Lagos State of Nigeria as a case study in which three major towns – Ikoyi, Abule-Egba and Agege were covered. Since the commencement of GSM services in the country, the quality of service (QoS) being delivered by the four major Operators - MTN, GLO, Etisalat and Airtel, has been an issue of concern both to the subscribers and the national regulatory body. For this reason a study on the performance of these Operators in terms of service delivery is relevant. To achieve this, Radio Frequency (RF) measurements were made using the standard drive test method. Data collected were evaluated using QoS metrics as the key performance indicators (KPI) for determining the performance of each of the network provider. Using call drop rate (CDR), one of the performance indicators, it was observed that Etisalat had the least value of 0.6% of all the calls initiated during the test.

KEYWORDS: Call drop, drive test, GSM, quality of service, RF measurement

INTRODUCTION

The year 2001, marked the advent of GSM (Global System for Mobile Communication) technology in Nigeria. Three major players were licensed by the national regulator - Nigerian Communication Commission (NCC) to commence provision of GSM service. This heralded the dawn of a new era - the era of GSM technology. The three players initially were MTN, ECONET (now Airtel) and Mtel. GLO Mobile was later licensed as the fourth Operator. Etisalat, another GSM provider, became the latest entrant and took the place of Mtel which became moribund and non-operational. Network expansion became massive and aggressive. Subscribers were increasing as mobile penetration reached new heights.

Since the inception of GSM technology, its growth has been so rapid that Nigeria has been rightly described in various media as one of the fastest growing GSM markets in the world. One of the most important features of GSM operation noticed in the country is the constant growth of the number of subscribers. This trend has the potential to pose serious problems if the growth of mobile subscribers is not adequately backed up with a corresponding growth in network infrastructure. In Nigeria, this has been the case which has resulted to subscribers' frequent complaints of the quality of service (QoS) rendered by the Operators [1].

It is because of these complaints that NCC as a regulator has been putting pressure on the Operators to improve on the quality of service offered to their numerous customers and had in several occasions threatened to sanction any Operator that fails to comply. The QoS provided has now become an issue which should be addressed by the Operators in other to retain their respective customer base. It is based on this that this paper is undertaken.

Evaluation or assessment of the performance of GSM service has been reported in several literatures. Both empirical and technical methods have been used in different studies by different authors. The study carried out in [2] was based on the experience of mobile phone users of the service providers that were being studied. The survey made use of well structured questionnaires that were administered to telephone users, GSM Operators and professionals in Lagos and Ekiti States of Nigeria. The study used four major assessing parameters-accessibility, interconnectivity, through-switch and service availability.

A similar method was also used by [3] in their study of four different service providers in Lagos and Oyo States, Nigeria. Their report assessed the available telecommunication facilities over a period and the corresponding annual increment in facilities and subscribers. Although the methods used in these papers are known methods of research, the final findings were based on personal opinions of telephone users randomly selected whose judgments at the time of response were subjective rather than facts based on some technical reasons.

Intelligent Optimization method was reported in [4]. By this method, measurement report data were created by subscribers' handsets and the information obtained were processed and analyzed at the monitoring center. This type of test is purely an indoor test and is different from the drive test technique which has to do with physical coverage of the area under test.

Drive test is a method of measuring and assessing the coverage, capacity and QoS of a mobile radio network [5]. It is conducted for checking the coverage criteria of the cell site with a radio frequency(RF) drive test tool. The data collected by drive test tool in form of Log files are assessed to evaluate the various RF parameters of the network [6]. This method was used by [7] as a data collecting method in their study.

In [8], network performance and QoS evaluation were carried out using data obtained from drive test. Using the key performance indicator (KPI) obtained they were able to determine the speech quality of the mobile network under test.

In [9], an analytical approach was used in evaluating the performance of mobile wireless network. This method demonstrated how simple mathematical techniques can be used to obtain outstanding analytical results for many performance metrics including call blocking and probabilities.

In this study, like many other similar works, drive test was used as a data collecting method. However, unlike the reviewed materials, different performance indicators such as the rate of call drops, hand over success rate, etc, are the performance metrics used to examine the performance of each of the network.

The objective of the study therefore, is to investigate the performance of GSM service providers in relation to the QoS being rendered to the end users in the country. The four GSM Operators are MTN Nigeria Ltd, GLO, Airtel and Etisalat. Field measurement results obtained from some selected areas in Lagos on all the GSM Operators were evaluated using GSM QoS metrics. The paper is presented as follows: section 1 is the introduction, section 2 is the research methodology, data presentation and discussions are in section 3 and finally conlusion and aknowldgement are in sections 4 and 5 respectively.

RESEARCH METHODOLOGY

Real time RF measurements were made using the standard drive test method for data collection. By this technique, a motor vehicle containing mobile radio network air interface measurement equipment that can monitor, detect and record a wide variety of network parameters of mobile cellular service in a given geographical area was used. This equipment was the TEMS Pocket Professional W995 loaded with TEMS Software V13.1. The Pocket Professional is a convenient and powerful device used for verification, monitoring and troubleshooting of mobile networks. It is also used for basic cell-planning tasks. It performs real-time monitoring of the mobile network with results displayed directly via graphical symbols.

Three major towns in Lagos State were covered during the exercise. The vehicle used in the test travelled on predetermined routes during which the towns of Ikoyi, Abule-Egba, and Agege including their suburbs were covered. These areas were chosen because they are high density areas where various range of user profiles could be measured. The test routes covered the roads and streets closed to the sectors of the various sites that were monitored.

Technical details of the measurement are:

(i) Measurement Environment 1: Ikoyi.

- Network monitored : 3G
- Procedure for data collection : Drive test – RF measurement
- Instrument used: TEMS 13.1
- Type of Test: Benchmark analysis

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The network coverage area of Ikoyi is shown in Figure 1.From the figure, GSM radio parameters such as System Mode, RxLev (receive level), RxQual (receive quality) etc, can be seen. The figure also shows details of Call Analysis indicating events undertaken and information obtained during the test.

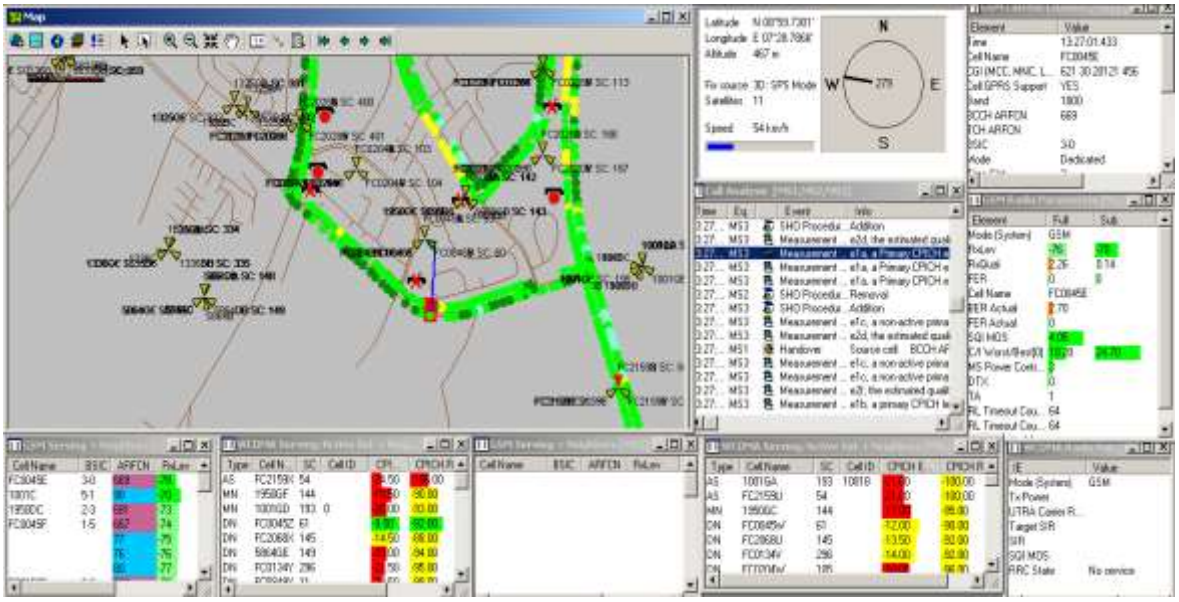

Figure 1. Ikoyi network area. The Screenshot depicts drive testing in dedicated mode on TEMS software. The dark green patches indicate areas of strong received signal compared to the yellow and red patches. The fan-like symbols depict the cell sites with their cell name. (Courtesy: Airtel Benchmark Analysis Report)

(ii) Measurement Environment 2: Abule-Egba

- Network used: 2G/3G
- Procedure for data collection : Drive test – RF measurement
- Instrument used: TEMS 13.1
- Type of Test: Benchmark analysis

Figure 2 is the network coverage area of Abule-Egba. The figure shows WCDMA (wideband code division multiple access) Radio Parameters segment that indicates the values for the system mode, TxPower (transmit power), etc, during the test. Another segment shown is the WCDMA Serving/Active Set – Neighbors, used for monitoring neighboring channels

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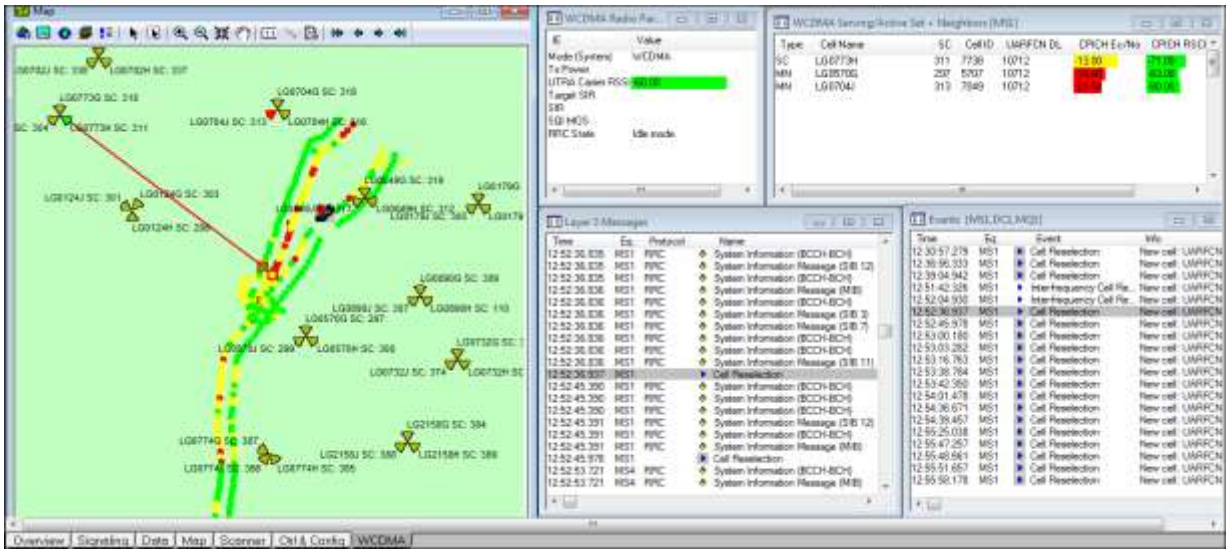

Figure 2. Abule-Egba network area. The Screenshot depicts drive testing in dedicated mode on TEMS software.The green potions on the screen indicate areas of strong received signal compared to the yellow and red portions. The fan-like symbols depict the cell sites with their cell names. The red line shows the distance from a point along the route to cell LG 0773H SC 311. ***(Courtesy:Airtel Benchmark Analysis Report)***

Figure 3 illustrates the drive test routes for Abule-Egba.

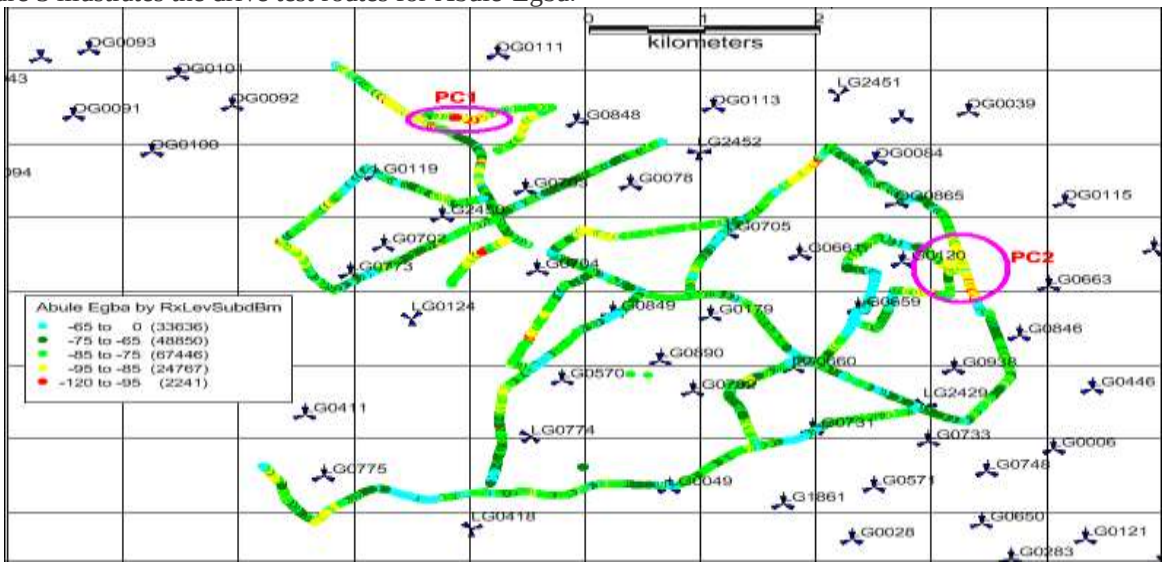

Figure 3. Abule Egba Drive Test route overview. The red spots depict weak signal areas with RxLev as low as $-120\ dBm$*. The dark green and blue patches depict strong signal regions with RxLev from* -75 *to* $0\ dBm$*. The fan-like symbols represent the cell sites with their respective cell names. (Courtesy: Airtel Benchmark Analysis Report).*

(iii) Measurement Environment 3: Agege,

- Distance covered was 59.15 Km
- Network used: 2G/3G
- Procedure for data collection : Drive test – RF measurement
- Instrument used: TEMS 13.1
- Type of Test: Benchmark analysis

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Figure 4 illustrates the drive test route for Agege.

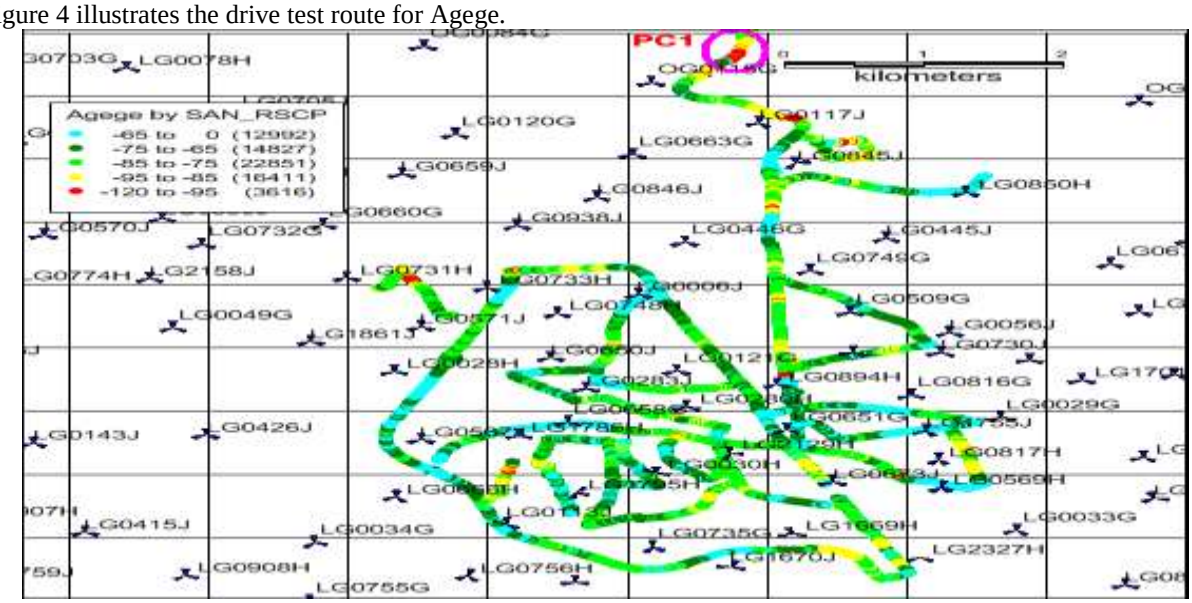

Figure 4. Agege Drive Test routes overview. The red spots depict weak signal areas with RxLev as low as -120 to $-95dBm$. The dark green and blue patches depict strong signal regions with RxLev from -75 to 0 dBm. The fan-like symbols represent the cell sites with their respective cell numbers. (Courtesy:Airtel Benchmark Analysis Report).

DATA PRESENTATION AND ANALYSIS

The drive test data for each of the locations were collected through TEMS data collecting software. Table 1 contains data for Ikoyi network area indicating the network event for all the Operators

Table 1. Network Events (Ikoyi)

Event name	Airtel	MTN	GLO	Etisalat
Blocked Call	3	1	1	5
Call Attempt	111	111	110	100
Call End	107	109	97	84
Call Established	108	109	101	86
Call Setup	108	109	101	86
Cell Reselection	17	11	9	19
Dropped Call	1	0	4	2
Handover	211	264	292	266
Handover Failure	1	8	13	5
Location Area Update	6	9	13	5
Location Area Update Failure	0	0	0	0

KPIs for each network were obtained using Qos metrics [10] and the results tabulated in Table 2.

Table 2. KPI summary of Ikoyi network coverage are

KPI	Qos metrics	Airtel	MTN	GLO	Etisalat
CCR	$\frac{Callend}{Call\ attemt}$	96.4	92.2	88.2	84
ASR	$\frac{Numberofsuccessful\ calls}{Total\ numberofcalls\ established}$	99.1	100	96	97.7
CSSR	$\frac{call\ \ established}{Call\ \ attempt}$	97.3	98.2	91.8	86

CDR	$\frac{Number\ of\ drop\ \ calls}{Total\ \ numberof\ call\ attempts}$	1	0	3.6	2
HOSR	$\frac{Successful\ handovers}{Total\ numberof\ initiated\ handovers}$	99.5	97.1	95.7	98.2

Table 3 shows data obtained from Abule-Egba coverage area for all the networks.

Table 3. 2G Network Events (Abule Egba)

Event name	Airtel	MTN	GLO	Etisalat
Blocked Call	0	1	2	12
Call Attempt	66	66	67	99
Call End	62	64	63	87
Call Established	66	65	65	87
Call Setup	66	65	65	87
Cell Reselection	29	15	22	33
Dropped Call	4	1	2	0
Handover	131	202	279	216
Handover Failure	4	3	9	2
Location Area Update	19	19	23	21
Location Area Update Failure	0	0	0	0

The calculated KPIs for Abule-Egba are shown in Table 4

Table 4. KPI summary for Abule-Egba network coverage area

KPI	Qos metrics	Airtel	MTN	GLO	Etisalat
CCR	$\frac{Callend}{Callattemt}$	93.9	96.9	94.0	87.9
ASR	$\frac{Numberofsuccessfulcalls}{Totalnumberofcallsestablished}$	93.9	98.5	96.9	100
CSSR	$\frac{callestablished}{Callattempt}$	100	98.5	97.0	87.9
CDR	$\frac{Numberofdropcalls}{Totalnumberofcallattempts}$	6.1	1.5	3.0	0
HOS	$\frac{Successfulhandovers}{Totalnumberofinitiatedhandovers}$	97.0	98.5	96.9	99.1

The test for Agege network area was conducted and the data obtained are shown in Table 5. The calculated KPIs are tabulated in Table 6.

Table 5. 2G Network Events (Agege)

Event name	Airtel	MTN	GLO	Etisalat
Blocked Call	0	1	3	1
Call Attempt	65	61	59	73
Call End	62	56	54	72
Call Established	65	60	56	72
Call Setup	65	60	56	72
Cell Reselection	20	28	31	14
Dropped Call	3	4	2	0
Handover	256	263	395	201
Handover Failure	7	14	9	2
Location Area Update	39	34	18	27
Location Area Update Failure	0	0	0	0

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Table 6. KPI summary for Agege network coverage area

KPI	Qos metrics	Airtel	MTN	GLO	Etisalat
CCR	$\frac{Callend}{Callattemt}$	95.4	91.8	91.5	98.6
ASR	$\frac{Numberofsuccessfulcalls}{Totalnumberofcallsestablished}$	95.4	93.3	96.4	100
CSSR	$\frac{callestablished}{Callattempt}$	100	98.3	94.9	98.6
CDR	$\frac{Numberofdropcalls}{Totalnumberofcallattempts}$	4.6	6.6	3.4	0
HOS	$\frac{Successfulhandovers}{Totalnumberofinitiatedhandovers}$	97.3	94.9	97.8	99.0

RESULTS AND DISCUSSION

The average value for each of the KPIs (KPI_{AV}) and their corresponding values (x) for that network were obtained by:

$$KPI_{AV} = \frac{\sum x}{n} \quad \text{..... (6)}$$

Here, n is the number of geographical areas. The results obtained for all the networks are tabulated in Table 7.

Table 7: Average percentage value for each network's KPI

Service provider	CCR	ASR	CSSR	CDR	HOSR
Aitel	95.2	96.1	99.1	3.9	97.9
MTN	93.6	97.3	98.3	2.7	96.8
GLO	91.2	96.4	94.6	3.3	96.8
Etisalat	90.1	99.2	90.8	0.6	98.8

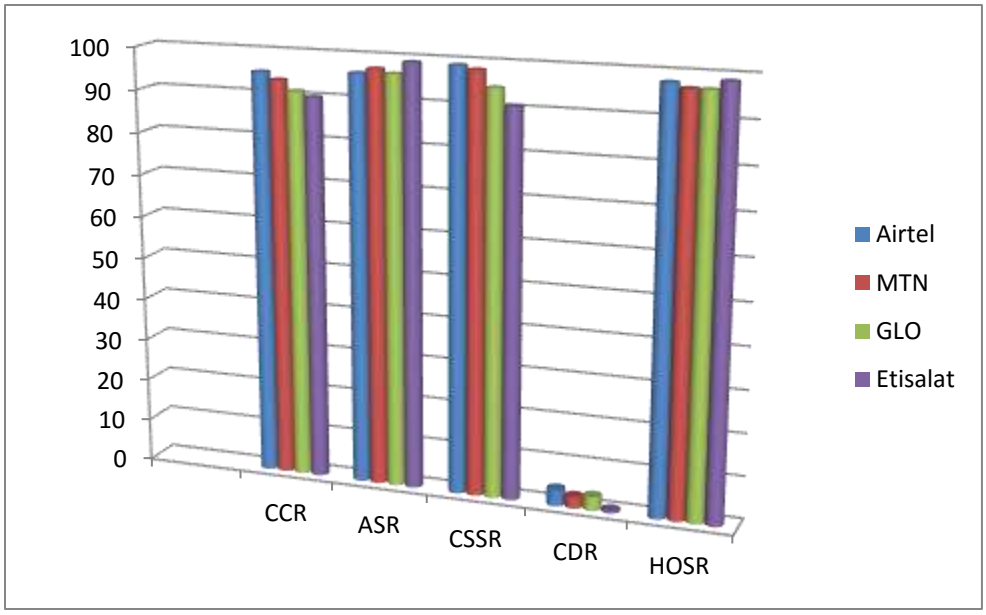

Figure 6. 3D Graphical representation of each Network's performance

The performance of each of the network based on their respective KPIs is represented in Figure 6. The figure is a 3D representation with the KPIs on the x-axis and the percentage values on the y-axis. All the service providers have a high Call Completion Rate of above 90%. Airtel however, had the highest call completion rate indicating highest number of successful calls to the total number of calls initiated. All the providers had a good record of ASR. In this case, Etisalat had 99.2% while Airtel had 96.1%. Airtel and MTN stood out in CSSR. They had the least number of unblocked calls. CDR indicates the number of dropped calls monitored during the test. Etisalat had the least number of drop calls. Of all the calls initiated during the test, it had 0.6% of them as drop calls. For HOSR, Etisalat and Aitel had similar outcome of 98% as well as MTN and GLO that had 96.8% each.

CONCLUSION AND RECOMMENDATION FOR FURTHER WORK

The performance of all the service providers has been evaluated using QoS metrics as the KPIs in evaluating the quality of service rendered by each of the Operators. To the users, dropped calls are the most irritating because this is experienced when an already established link is abruptly terminated. Using CDR to rate the performance of the Operators, it was observed that all four Operators had less than 4% of their established calls terminated during the test period. Unsuccessful handovers of calls between cell sites is one known cause of dropped calls. A high handover success rate results to less dropped calls. This was exhibited by Etisalat with the highest HOSR and the least CDR.

It should be noted that this study is not to compare or suggest to Nigerian mobile phone users which of the service providers is the best in terms of performance but was undertaken to highlight areas that needed attention by the various for better service delivery to their numerous customers.

This study concentrated on Lagos State of Nigeria alone. A densely populated area with thousands of base stations. Futher work may be done by including some other major and highly populated cities in the country to give a wholistic picture of the performance and Qos of GSM Operators in the country.

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