Performance Evaluation of a selected Cellular Mobile Operator in Ibadan Metropolis, Nigeria

Oluyemi John Ojo
Department of Electrical and Electronics Engineering, Federal University of Technology, Akure, Nigeria
e-mail: ojojo@futa.edu.ng

Samson Adenle Oyetunji
Department of Electrical and Electronics Engineering, Federal University of Technology, Akure, Nigeria
e-mail: saoyetunji@futa.edu.ng

Jide Julius Popoola
Department of Electrical and Electronics Engineering, Federal University of Technology, Akure, Nigeria
jjpopoola@futa.edu.ng

Yekeen Olajide Olasoji
Department of Electrical and Electronics Engineering, Federal University of Technology, Akure, Nigeria
e-mail: yoolasoji@futa.edu.ng

Michael Rotimi Adu
Department of Electrical and Electronics Engineering, Federal University of Technology, Akure, Nigeria
e-mail:mradu@futa.edu.ng

***Abstract*—This paper investigates the performance of a selected cellular mobile operator in Ibadan metropolis, Nigeria. Data used for this study were gathered in two phases. In the first phase, data captured from network management system counter of the network were collected. In the second phase, real time data on the network were gathered through drive test conducted in the metropolis. The data collected in the two phases were analyzed based on standard or acceptable key performance indicators (KPIs) adopted by the Nigerian Communications Commission, the body responsible for monitoring of cellular network performance in Nigeria. The results of the analysis show that the considered network performed moderately well with 33.97%, 29.97% and 17.53% of its signal strength being classified as excellent, good and fair respectively. In addition, the result of the analysis conducted has established the fact that quality of service in cellular communication system can best evaluate only by using real time data rather than corresponding data from the network management system counter.**

Keywords—Global System for Mobile Communications, Quality of service, Quality of Experience, Drive Test, Key Performance Indicators

I. INTRODUCTION

One of people's desires is to have the right information at the right time and in the right place. Similarly, another people's desire is to reach others and being reached by others. These desires have made mobile telephony, especially the global system for mobile communications (GSM), the fastest growing as well as the most demanding wireless application. This is because GSM cellular mobile phone has the ability to provide right information even on motion. Currently in Nigeria and most countries of the world, GSM represents and enjoys continuous growing and subscription of all telephone around the globe. For instance in Nigeria, GSM has assumed a leading position in telecommunications market and become the prime mover of the country socio-economic development. In order to maintain this growth as well as to retain the existing customers, GSM providers need to be more reliable, consistent and economical [1].

According to [2], one of the criteria for having a sustainable edge in competitive market is customer satisfaction. Thus, in telecommunication networks, customers' satisfactions with the service depend on numbers of factors. Crucial among these factors, as reported in [2], are: quality of service (QoS) assessments, quality and performance of the network and measurements of network performance. This makes QoS prediction and characterization one of the principal activities in present-day GSM networks. Generally, in telecommunication networks, according to [3], the QoS provided and the quality of the end-user experience, which are defined and assessed on technical and business perspectives respectively, cannot be overlooked. While quality of experience (QoE) is normally used to characterize end-users' perceptions of the services' performance, QoS is normally used to characterize the quality between the radio access network and user equipment as well as the core network.

Ideally, QoS in wireless communication system, according to [4], is the competence of a service provider to provide satisfactory end-to-end service for its customers, which includes the following: signal strength, voice quality of telephony service, low call blocking and dropping probability, service availability, minimum delay, high data rates for data service and multimedia applications. According to the International Telecommunication Union (ITU) as reported in [4], QoS is equally defined as totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service. It is the ability of a network to provide required service at a guaranteed service level [2]. On the other hand, QoE as reported by [2] is the degree of delight or annoyance of the user of an application or service. QoE, as reported in [4], is obtained from the fulfillment of end-users' expectations with respect to the utility and/or enjoyment of the application or service in the light of the users' personality and current state. These definitions show clearly that there are vast differences between QoE and QoS. The definitions equally show that while QoE is concerned with end user assessment of a system or network, QoS is concerned with the performance aspects of the system or network.

Basically, measurement of network performance and assessment of QoS are primarily important because end-user satisfaction with the service provided is directly dependent on the quality and performance of network. Thus, according to [5], a network service provider or operator that provides better QoS compare with a network service provider that provides poor QoS will indeed have assurance of retaining old and attracting new customers for longer period of time. Therefore, it is important for a network service operator to frequently evaluate their service QoS and consequently solve the possible challenges as well as dealing with the grievances of their end-users. Actually, determination of QoS offers organizations strategic benefit of enhancing their competitiveness as well as knowing their position in the market. This is because determination of QoS enables organizations opportunity to ascertain their areas of weaknesses and strengths in order to proffer appropriate solution to refocus and improve relevant attributes of customer perceived service quality. However, measurement and analyzing process of QoS, according to [4], is a challenging task for cellular network service providers.

One of the methods currently employs in solving this problem of QoS in cellular communications network is drive test method. According to [6], drive test is a current measurement tool commonly employed in determining the quality state of wireless networks as well as in solving problems in wireless network. Primarily, the aim of the drive test is to gather information or data, which can be analyzed in real-time during the test in order to determine the field assessment of the network. It is thus, a technique for assessing and measuring a mobile radio network's capacity, coverage and QoS [6]. It is broadly divided into two classes: pre-design drive test and post-design drive test [7]. While the pre-design test is conducted at the beginning of design phase, the post-design drive test is conducted at site to either verify or optimize the network performance.

Basically, drive test method usually consists of a test mobile phone, a global positioning system and software to control and log data from a test mobile phone. The term comes from the fact that the measurement tools are being driven around in a vehicle. Generally, drive test methods are built around two major components, which are measurement receivers and instrumented mobile phones also known as test engineering phones. One of the primary reasons why drive test is being used in measuring cellular mobile networks is because it measures the real-time or actual network performance and coverage that a user on the driven route is experiencing. Another reason for its generally acceptability and usage in measuring cellular mobile networks QoS is because its gives real-time information on changes that take place as network parameter settings alter as a result of interactions between mobile user equipment and environment. Based on these aforementioned potentials of drive test method, it was used in in this study in conjunction with network management system method in evaluating the QoS, network coverage and network performance of a selected mobile cellular network in Ibadan metropolis, Nigeria.

In enhancing coherent presentation of the study reported in this paper, the remaining parts of the paper is organized in the following order. In Section II, brief literature review on related studies on GSM QoS evaluation in Nigeria was provided. Also, the section contains, in tabular form, brief review of some commonly use key performance indicators (KPIs) thresholds set by Nigerian Communications Commission (NCC), the government's organ controlling GSM operation and performance in Nigeria. Section III contains detailed information on series of activities involved in carrying out the study presented in this paper. The results obtained from the study were presented, analyzed and discussed in Section IV. The findings from this study were summarized in Section V, which is the conclusion section of this paper.

II. REVIEW OF RELATED STUDY

In Nigeria, GSM was launched in 2001. The launch indeed liberated Nigerians from the shackles of then government owned Nigerian Telecommunication (NITEL), which its operation and services were not only epileptic but also too expensive for majority of the populace. This act made telephone a luxury for few privileged Nigerians. However, with introduction of GSM in Nigeria, the owners and users of telephone in Nigeria have increased tremendously. This increase in telephone subscribers in the country has indeed led to drop in QoS and performances of all the GSM providers in the country. This necessitates series of studies conducted on how and ways to improve both the QoS and overall performances of all the GSM providers in the country.

According to [8], there are four primary methods for measuring QoS parameters relating to voice services offered in cellular mobile network. These methods, as reported in [8], include crowdsourcing, network management system (NMS), questionnaire and drive test. For instance in [9], a crowdsourcing platform was designed to gather data, which when analyzed showed that the three networks considered performed below average especially during the busy hours of the day. On the other hand, NMS technique was used by [10] to determine GSM QoS in Abuja, Nigeria. These authors' study revealed that QoS and network performances of the four major GSM service providers in Abuja, Nigeria varied in the three locations considered.

On the other hand, [11] through instrument of structured questionnaire investigated network performance and QoS of GSM services in Nigeria. The study, which was conducted in Nigeria Federal Capital Territory, Abuja) and some selected cities in all the six geo-political zones of the country revealed that networks accessibility and call retainability for all the four GSM networks considered were unsatisfactory. The authors thus offered series of measures to be taken in improving GSM QoS in the country based on responses obtained from the respondents. Similarly, in a related study conducted in Edo State, Nigeria by [12] revealed that GSM providers' performance evaluation varied from one network to another. The overall result of this study revealed that all the three networks considered need to improve their respective QoS to their customers. Furthermore, in a related study presented in [13] in three different locations in Ekiti State, Nigeria using questionnaires revealed that QoS of the GSM providers in the State was neither reliable nor stable but fluctuating between fair and good.

On the other hand, [14] carried out a drive test to evaluate the QoS of GSM networks in Abeokuta, Nigeria. The analysis of the data gathered during the test revealed poor outright QoS degradation and poor network coverage in the city. The authors thus proposed additional base stations deployment in the city in order to optimize both the QoS and network coverage in the city. Similar drive test assessment on GSM performance in Lagos by [15] revealed that operations of GSM networks in Lagos is far below subscribers' expectations and NCC benchmark. Similarly, [16] conducted drive test in Umuahia, Nigeria to determine the signal strengths of six cellular networks providers in the city. The result of the study revealed that both the number of users and bandwidth is equally affecting network congestion used in evaluating the QoS of the cellular network providers. In a similar drive test study conducted in Port Harcourt, Nigeria by [17], it was established that the three GSM service providers investigated performed differently in the different locations of the study area. Similar drive test assessment on GSM performance in Kano metropolis by [18] revealed that operations of the four major GSM networks in Kano were far below subscribers' expectations and NCC benchmark. Furthermore, result of the similar drive test conducted in Eagle Square, Abuja, Nigeria by [19] revealed that KPIs, presented in Table 1, employed in evaluating the QoS of the GSM service in the study area deviate from the recommended values.

In addition, [20] used drive test technique to investigate the performance of networks of four major GSM providers in Owerri, Nigeria. The result of the study revealed that all the four operators' networks did not meet the stipulated performance threshold, presented in Table 1, set by NCC for GSM network operators in Nigeria. Also, the study presented in [8] using drive test technique to investigate QoS of GSM networks in Akure metropolis revealed the performances of the GSM providers varied from one network to another based on time of the day and locations. Furthermore, similar study conducted by [21] using drive test technique in Osogbo metropolis, Nigeria between MTN and Globalcom showed that there is variation in traffic congestion values for the two network providers. From this survey, it is obvious that no study had been conducted in Ibadan, Nigeria. This highlighted research gap indeed justifies the need for this study base on economic advantage of Ibadan city in Africa continent. Furthermore, the daily complains of subscribers on degradation of GSM voice and data services, need for subscribers to get value for their money and the mobile network operators (MNOs) to get more revenue as well as gaining and retaining more customers, equally justifies the importance of the study presented in this paper. The objective of the study was to establish the level of compliance of a selected MNO with the key performance indicators (KPIs) set by NCC using both NMS and drive test methods. The reasons behind the choice of the study site, the network used and detailed information on series of activities involved in carrying out this study are presented in the next section under methodology.

III. METHODOLOGY

In carrying out the study presented in this paper, the activities involved were divided into two stages. In the first stage, the reason behind the choice of the MNO used and the reason behind the choice of the experimental site were provided. In the second stage, detailed information on the materials and methods employed in carrying out the study were presented. Details on each of the two stages are presented in the following subsections.

A. *Choice of Experimental Site and Network*

The study presented in this paper was conducted in Ibadan, the capital of Oyo State, Nigeria. Firstly, the city was used because surveyed literature revealed that similar study had not been conducted in the city despite the fact that it is currently the third most populous city in Nigeria with a population of over 3 million after Lagos and Kano where similar studies had been conducted. Secondly, the city was used because is currently the nation's largest city by geographical area. These two profound reasons necessitate the used of the city. Similarly, the choice of the MNO, Globacom, used was born out of the claim by [12] that Globacom is the best-acclaimed MNO operator in their experimenter site. This study was carried out using some KPIs and some measured technical parameters. Actually, KPIs provide understanding about how each specific service is performing from the end-user point of view. However, observations have shown clearly that KPIs have direct impact on end-user performance; they do not provide figures that address the performance that the end-users usually experience. Thus, this study was conducted using both KPIs and drive test. Details on the materials and methods used in carrying out the study reported in this paper are presented in the next sub-section.

TABLE I. KPIS DEFINITIONS WITH NCC SET THRESHOLDS (ADAPTED FROM [22])

S/N	Key Performance Indicator	Acronym	Definitions	Target (%)
1.	Call Setup Success Rate	CSSR	CSSR is the number of the unblocked call attempts divided by the total number of call attempts or (1 - Blocking Probability) x 100%	≥ 98%
	According to [11] CSSR is defined mathematically as; $CSSR = \frac{Number\ of\ unblocked\ call\ attempts}{Total\ number\ of\ call\ attempts} = (1 - Blocking\ probability) \times 100\%$ (1)			
2.	Traffic Channel Congestion {with Handover (WHO) and without Handover (WOH)}	TCHCon	TCHCon is the ratio of the number of unsuccessful TCH requests to the total number of TCH request attempts expressed as percentage	≤ 2% WOH ≤ 4% WHO
	TCHCon is defined mathematically in [18] as; $TCHCon = \frac{Number\ of\ calls\ blocked\ due\ to\ unavailable\ resources}{Total\ number\ of\ requests} \times 100\%$ (2)			
3.	Call Completion Rate	CCR	CCR is the ratio of successfully completed calls to the total number of attempted calls	≥ 96%
	CCR is defined mathematically in [11] as; $CCR = \frac{Total\ number\ of\ completed\ call}{Total\ number\ of\ call\ attempts}$ (3)			
4.	Call Drop Rate	CDR	CDR is the number of dropped calls divided by the total number of call attempts or (1 - Call Completion Ratio) x 100%	≤ 2%
	CDR is defined mathematically in [11] as; $CDR = \frac{Number\ of\ dropped\ call}{Total\ number\ of\ call\ attempts} = (1 - Call\ complete\ probability) \times 100\%$ (4)			
5.	Standalone Dedicated Control Channel	SDCCH	SDCCH is a logical signaling channel that is used for call set-up. Once a cell is, successfully setup SDCCH is released and RTCH is assigned for the conversation.	
	According to [18] SDCCH Congestion rate is defined mathematically as; $SDCCH\ Congestion\ rate = \frac{1 - CSSR}{TCH\ Assignment\ rate} \times 100\%$ (5)			
6.	Handover Success Rate	HoSR	Is the ratio of successfully handover calls to the total number of attempted handover calls	≥ 96%
	According to [18] HoSR is defined mathematically as; $HoSR = \frac{Number\ of\ successfuly\ completed\ handovers}{Total\ number\ of\ initiated\ handovers} \times 100\%$ (6)			

B. *Materials and Methods*

The methodology employed for data collection in this study was in two categories. In the first category, captured data were collected from network management system (NMS) counter in Ibadan Globacom switch. The switch consists of five base station controllers (BSCs), two hundred and twenty-eight sites and one thousand one hundred and sixty-two cells. The counter is embedded in operation and maintenance centre for radio network (OMCR), which counts any event triggered in the network. The data were captured on hourly, daily, monthly and yearly basis. The captured daily data were collected for this study. The collected data were used for determining four KPIs thresholds for the MNO using equations (1), (2), (3) and (6). The obtained KPIs graphical results were later analyzed and the results obtained were presented and discussed in next section.

Since KPIs only have direct impact on end-user performance, drive test was also conducted in order to capture real time coverage and the QoS of the network considered as experience by users in the studied environment. Thus, eight different materials were used in performing the drive test. The materials are laptop, inverter, transmission environmental monitoring system (TEMS) pocket professional phones (W995 Phones), TEMS investigation software version 13.1, TEMS discovery software, global positioning system (GPS), radio frequency (RF) scanner and a vehicle. The used TEMS investigation setup employed is as shown in Fig. 1. The test procedure involved driving a test vehicle on a pre-determined route. The pre-determined test route with contours is shown in Fig. 2 while corresponding terrain site is shown in Fig. 3. As a reason of its importance, the choice of the pre-determined test route was made in such a way that it covered various road types, such as main, minor and feeders as well as highways and trade or business centre.

Fig. 1. *Drive test measurement set.*

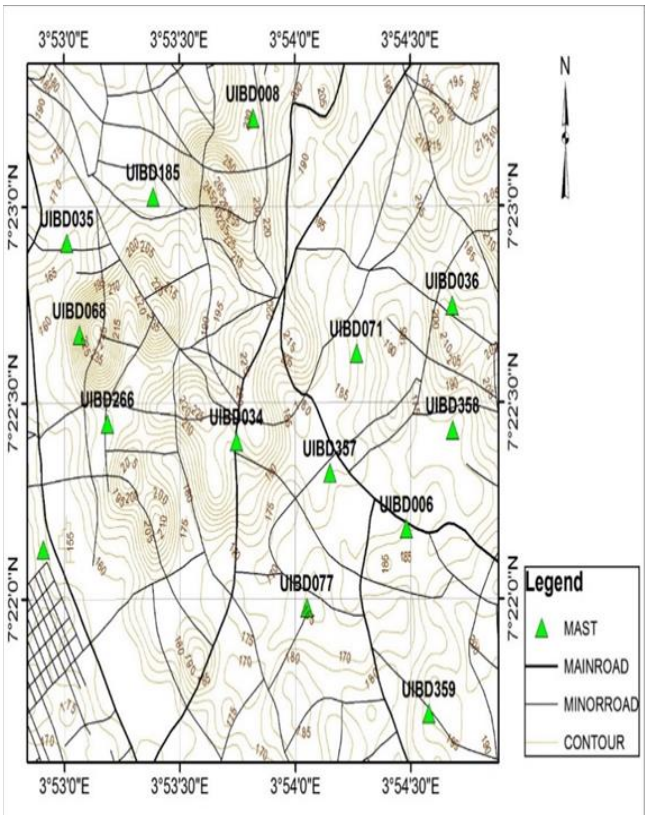

Fig. 2. *Map of drive test site with contours.*

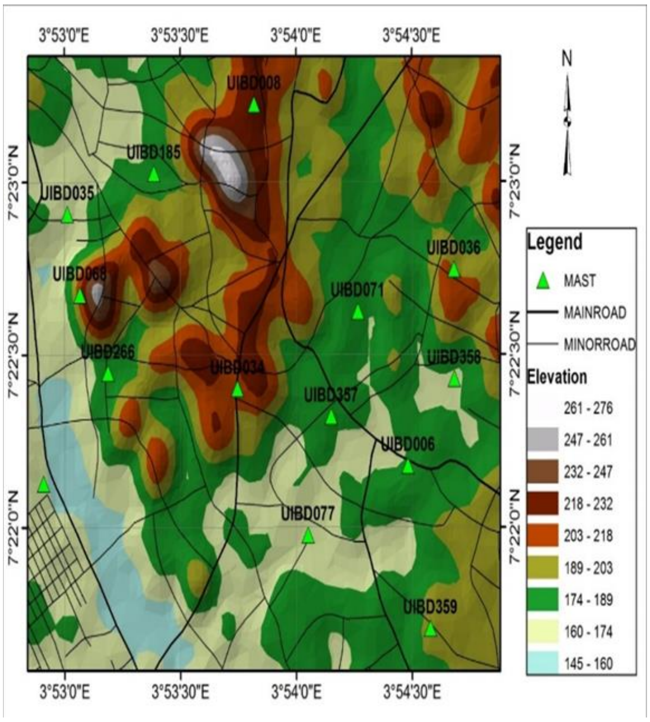

Fig. 3. *Map of drive test terrain.*

The drive test was conducted in five months using TEMS investigation software version 13.1. The first phase of the test was carried out from October 2016 to December 2016 while the second phase was collected in February and August 2017. In order to have access to the base transceiver station information, such as base station identity code (BSIC), mobile country code (MCC), cell identity, mobile network code (MNC), absolute radio frequency channel number (ARFCN), Received signal strength level (RxLev) and the location area code (LAC) of the serving cell over the air interface, TEMS pocket professional phone was used in preparing the cell reference presented in Table 2.

In carrying out the drive test, three subscriber identity module (SIM) cards were used. Two of these three SIM cards were used for voice services test while the third SIM card was used for data services. In addition, RF scanner employed in the test was used to scan the operator frequency band to detect active frequency channels along the test route while the GPS employed was used for gathering information on geographical positioning information along the test route. During the test, a call of about one hundred and twenty seconds duration was made followed by about a twenty seconds idle period. The short call was used to capture the cluster statistics voice of the network. On the other hand, long call duration was used to capture both the mobility and signal strength of the network. The measurement procedure was repeated along the pre-determined test routes. The data gather during the test were stored in form of a log file for further analysis. The results of the analyses are presented in next section under the results and discussions.

TABLE II. *TECHNICAL INFORMATION ON DRIVE TEST SITE*

Site	Cell	Successful Calls	Longitude/ ^{0}N	Latitude /^{0}E	MCC	MNC	LAC	Cell Identity	Antenna Direction	Antenna Height /m
UIBD006	UIBD006_S1	93	3.90802	7.36961	621	50	4000	10191	10	30
UIBD006	UIBD006_S2	116	3.90802	7.36961	621	50	4000	10192	130	30
UIBD006	UIBD006_S3	95	3.90802	7.36961	621	50	4000	10193	250	30
UIBD006	UIBD006_S5	116	3.90802	7.36961	621	50	4000	10195	120	30
UIBD006	UIBD006_S6	95	3.90802	7.36961	621	50	4000	10196	240	30

IV. RESULTS AND DISCUSSIONS

This section focuses on obtained data analysis. The results of the analysis carried out were presented and discussed in this section. The section is divided into two subsections based on the two phases involved in data collection for the study. Thus, in the first subsection, the data collected during the first phase of the study were analyzed. In the second subsection, the data obtained during the drive test were analyzed. In the two subsections, the obtained analysis results were compared with the standard thresholds or benchmarks set by NCC for each KPI indices being used in determining cellular network performances in the nation. Details on the comparative analysis carried out in each subsection are presented and discussed in the next subsections.

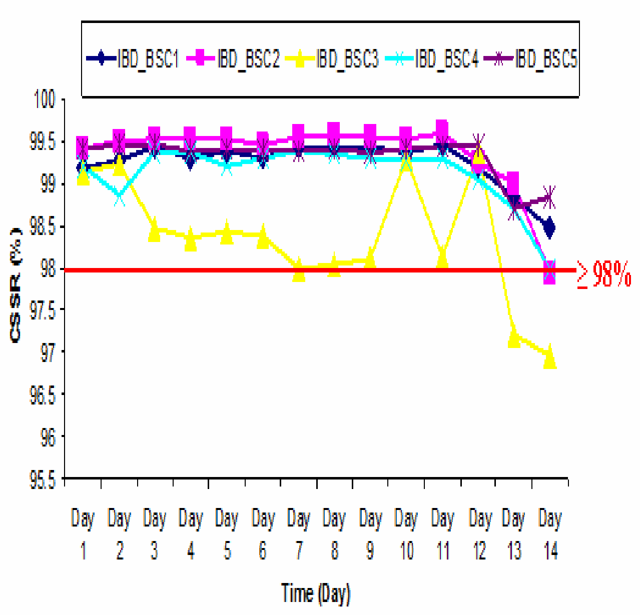

Fig. 4. Percentage quality of CSSR.

A. First Phase Data Analysis Results

In this subsection, the mean daily captured data collected were computed and analyzed using four out of the six KPI indices in Table I. The four KPIs used are CSSR, TCHCon, CDR and HoSR. The graphical representations of the four KPI indices for fourteen days are shown in Fig. 4, Fig. 5, Fig. 6 and Fig. 7. For instance, in Fig. 4, the graphical analysis result of CSSR captured during the study is presented. The graph shows that the considered cellular network performed favorably well in four out of the five base stations considered with CSSR greater or equally to 98%, which is NCC approved benchmark for good network assessment in Nigeria. The considered network performed below the set benchmark in only two days out of the fourteen days considered with an average CSSR value above 97%. The irregularities in the CSSR in the two days for the considered network might be as a result of either influx of more users or some technical issues. With this anomalous in CSSR, the subscribers of the network, according to findings of [21] will still have high call success rate. This implies that the network performance can still be classified satisfactory since high value of CSSR is an indication that a network QoS is good.

Similarly, Fig. 5 shows the TCH congestion, which is a KPI being used to measure the demand for both channels utilization and services in a network. Thus, it value is expected to be low as high value of this KPI is an indication of a poor QoS. According to NCC KPI threshold for cellular system, the TCHCon is expected to be less or equal to two percent. Thus, critical observation of Fig. 5 shows that the average plotted value of the indicator falls perfectly within the benchmark or threshold set by NCC, which shows that the congestion rate of the network considered in this study is considerably small. This indicates that QoS of the cellular network being considered in this study can be judged good.

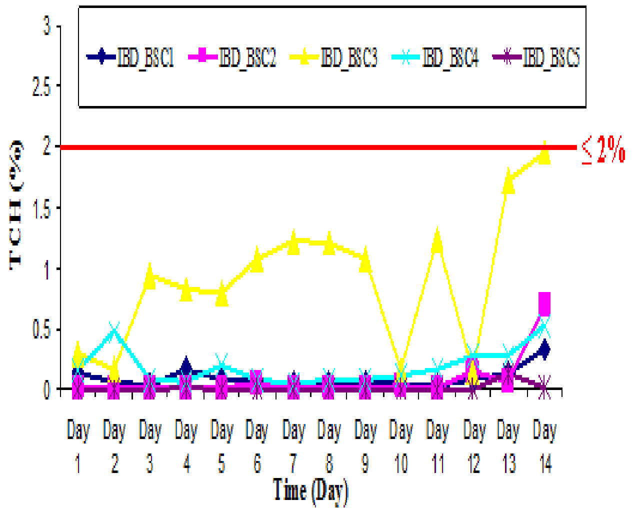

Fig. 5. Percentage quality of TCH.

In addition, the obtained graph of CDR for the considered cellular network is presented in Fig. 6. The KPI value is expected to be marginally low so as to reduce the frequency or number of prematurely terminated calls on the network. As shown in Fig. NCC benchmark or threshold set for CDR is a numerical value less or equal to two percent. Critical observation of Fig. 6 shows that the values of the indicator for four of the five base stations for the network considered are less than one percent. Similarly, in base station 3, where there is deviation from others, the value of the indicator is also less than 2%, which implies that the CDR for the considered network is not only low but also falls within the threshold value set by NCC. This low value of CDR for the considered network is an indication of the network high call retainability potential. This means the network has capacity to retain calls once a call has been established and continue for a desired duration or time.

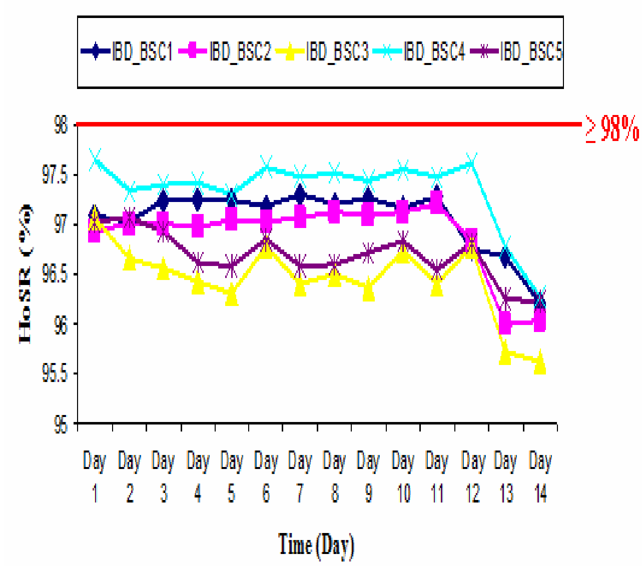

Fig. 6. Percentage quality of CDR.

Furthermore, the performance of network considered was further assessed by plotting its HoSR graphical representation based on collected data. This KPI gives the percentage of successful handover of all handovers attempts over a period. Fig. 7 shows the HoSR for the network considered. Observation of Fig. 7 shows that the network hand over success rate is poor. This implies that impact of congestion at movement during a call in the network considered is high. The possible reasons for this poor HoSR as established in [18] are possibility of incorrect handover relations, bad radio coverage, co-channel interference and adjacent interference. The actual cause(s) of this poor HoSR is x-rayed in the next subsection on drive test data analysis as the test provides information on real time condition on the network.

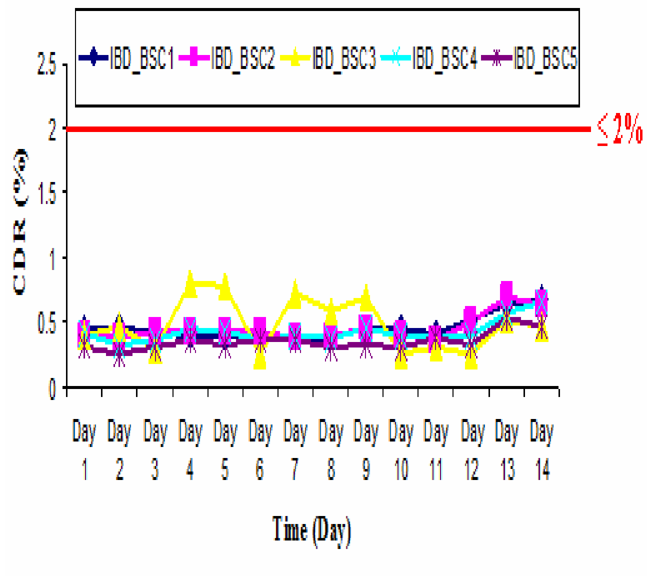

Fig. 7. Percentage quality of HoSR.

B.   Second Phase Data Analysis Results

In this subsection, only the analysis of the drive test data for the month of February 2017 were analyzed, presented and discussed because of limited space. Two of the field measurement results were analyzed. The two field measurement results that were analyzed are signal-to-noise- ratio (E_c/N_o) and received signal code power (RSCP). The colour chart of the two field data were presented in Fig. 8 and Fig. 10 respectively. Higher values of the two data indicate good network coverage or performance. In Fig. 8, the E_c/N_o data obtained during the drive test were analyzed graphically. The result of the graphical analysis as shown in Fig. 8 shows that E_c/N_o strength received during the test varied from one location to another. This variation in E_c/N_o across the routes used accounts for differences in KPI's variations obtained.

Extract performance analysis from Fig. 8, presented in Table 3 shows the percentage performance evaluation of the considered cellular network in the studied areas. From the table, it shows that less than thirty-five percent of the received signals in considered environments meet NCC least acceptable threshold value of -9 dBm for E_c/N_o. This shows that the network coverage in the studied areas is poor, which accounts for the network poor E_c/N_o and its overall poor QoS. Further analysis of each service location per cell indicated with red circles letter A to O provides reason for poor E_c/N_o in service location per cell. For instance, the poor signal quality for location A in PART 1 of Fig. 8, which is shown in Fig. 9, shows that missing neighbor cell between the serving cell UIB029_S1 and UIB035_S3 responsible for poor signal coverage in location A. Similarly, missing neighbor cell between serving base stations equally accounts for some other locations such as locations B and E, which their individual analysis are not shown like that of location A shown in Fig. 9 because of limited space. This missing neighbor cells effect confirms the poor HoSR experienced on the network.

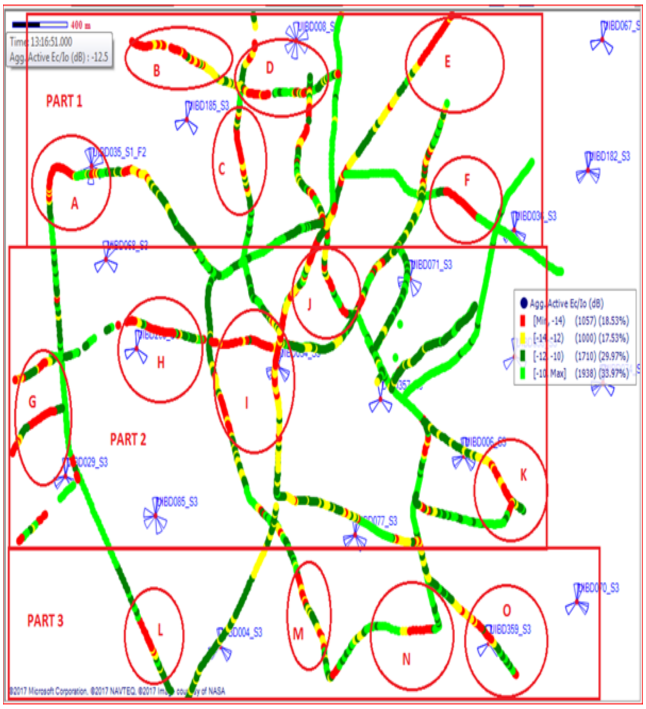

Fig. 8. Colour chart plot for E_c/N_o.

TABLE III. PERCENTAGE DISTRIBUTION OF E_c/N_o

Colour Indicator	E_c/N_o Range	Remark	Value (%)
(red)	Min to -14	Poor	18.53
(yellow)	-14 to -12	Fair	17.53
(blue)	-12 to -10	Good	29.97
(green)	-10 to 0	Excellent	33.97

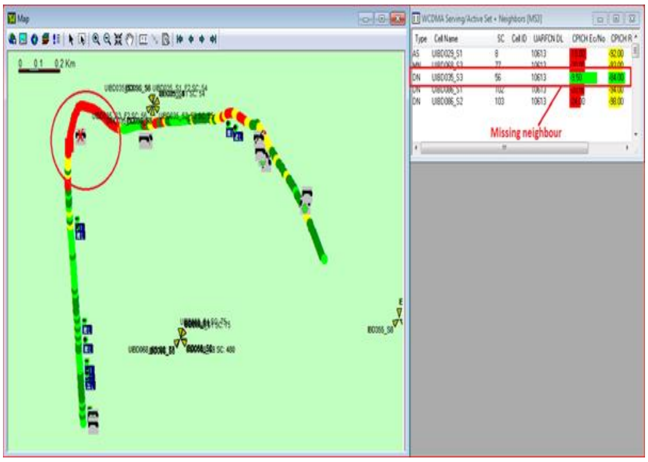

Fig. 9. Signal quality analysis for location A.

Similarly, Fig. 10 shows the colour chart plot of the RSCP in the studied environment. The chart shows that the RSCP varies from 0 to -95 dBm. The higher value of RSCP, as established in [23], indicates very good network coverage. The least acceptance value or threshold set by NCC for RSCP according to [23] is -85 dBm. The RSCP distribution obtained in this study as shown in Fig. 10 and Table 4 shows that it ranges from -95 dBm to 0 dBm. From Table 4 it is obvious that only 2.82% of the studied area had excellent RSCP. This implies that there is high probability of high call drop in the area as a result of poor radio connectivity. A typical example is in location F of PART 2 in Fig. 10, which was extracted as shown in Fig. 11. The dropped call in the location was due to poor RF condition because the dominant server at site UIB071 meant to serve this spot was not active.

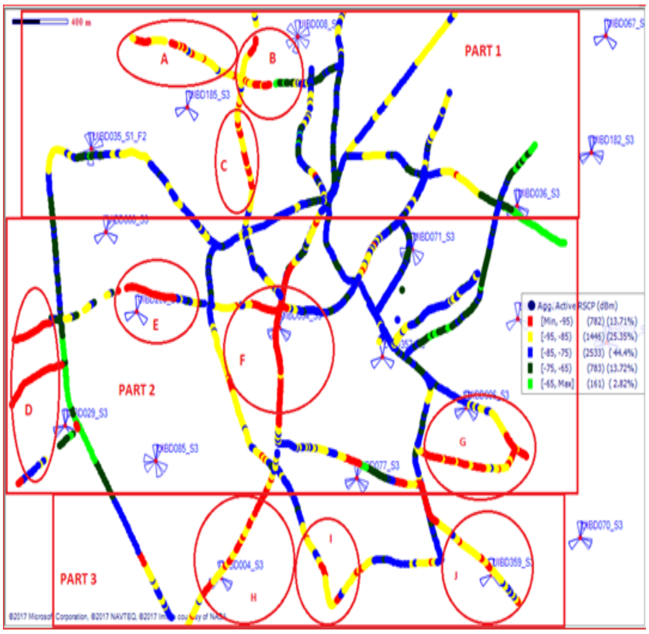

Fig. 10. Colour chart plot for RSCP.

TABLE IV. PERCENTAGE DISTRIBUTION OF RSCP

Colour Indicator	RSCP Range	Remark	Value (%)
	Min to -95	Poor	13.71
	-95 to -85	Fair	25.35
	-85 to -75	Good	44.40
	-75 to -65	Very Good	13.72
	-65 to 0	Excellent	2.82

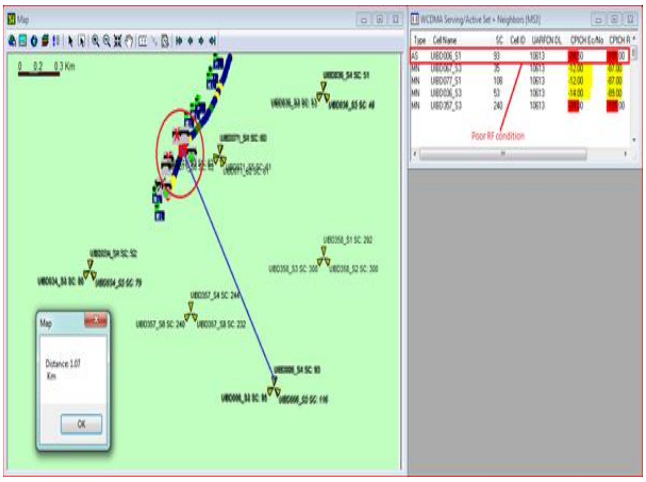

Fig. 11. RSCP quality analysis for location F.

V. CONCLUSION

In this study, the performance of a selected cellular network had been evaluated. The evaluation was conducted using four prominent KPIs normally employ by NCC in evaluating the performance of cellular network in Nigeria. In addition, the selected network was equally evaluated using two parameters in drive test analysis of cellular network. While the results of the KPIs analysis carried out using data collected from the NMS counter of the network show that the network performance excellently well when compared with the threshold or benchmark values set by NCC, results obtained when the network was evaluated using drive test parameters show that the network real time signal-to-noise ratio and received signal code power were low. The result shows that the drive test analysis that gives real time performance of the network is much better in evaluating cellular network performance than using KPI threshold values based on data generated from either the NMS counter of the network or responses from subscribers. The data analysis results equally buttress finding in [4] that QoS of network system centered more on the performance aspects of the network. Generally, the overall performance evaluation of the considered cellular network shows that the network performs moderately well.

Furthermore, based on the result of data analysis carried out, the following recommendations are made to improve the QoS of the considered cellular operator and other similar service providers rendered similar services to subscribers. The recommendations are:

(i) neighbor missing cell between serving base stations need to be configured to enhance both efficient and effective handover between base stations and within base station;

(ii) necessary additional switching centres need to be built in the study area in order to the network capacity and coverage; and

(iii) overall general upgrading and optimization of the network base stations and other equipment need to be done.

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