Independent Quality of Service (QoS) Validation of A Telecommunication Provider in South-West Nigeria

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Abstract—**Nigeria has had over ten years of using the global system of mobile communications (GSM). The user experience in terms of service provisioning has ranged from good to bad and bad to good. The number of providers has varied slightly but the services are the same i.e. voice, text and data. The increasing number of users requesting mobile communication led to a decline in the quality of service provided. There were several complaints by users and the government regulatory agency. The quality of service problem persisted even in the face of sanctions and penalties. In this work, the aim is to determine the quality of service provided and evaluate available data for quality of service problems using key performance indicators such as call setup, drop rate and traffic congestion. Log files from a telecommunication provider were analysed using statistical functions. The results indicated that quality of service problems exist when initiating a call from one party to another.**

Keywords-Quality of Service, mobile communication, validation, Nigeria, key performance indicators

I. INTRODUCTION

Telecommunication is the exchange of information between two or more entities and it involves the use of technology. The exchange of information usually makes use of channels either through signal cables or in the form of electromagnetic waves. One of the major means of telecommunication is with the use of mobile phones. In Nigeria, GSM launched officially in 2001. The use of mobile phones for communication has been on the rise since then. This is majorly because of its ease of use and its portability. Subscribers can move around and take their mobile phones along with them.

Quality of Service (QoS) is an important key performance indicator (KPI) that is used in determining the efficiency of an industry in terms of services rendered. In the telecommunication industry, accessibility, retainability and connection (voice) quality are three major factors used in evaluating quality of service of an operator [1]. For consumers in the industry, it is expected that maximum satisfaction be derived from any services paid for. This maximum satisfaction has now become a difficult task to achieve especially in GSM industry in Nigeria. One of the major reasons attributable to this is as a result of mismatch between expansion in customer base and infrastructural expansion. The work of Adegoke and Babalola in [1] therefore appraised the performance of GSM operators in Nigeria and examined the problems facing the industry. In general, all the networks performed fairly well in dialing few times before getting calls and getting connections to the number dialed. However, they did poorly in cutting off while conversing (dropped call) and worse in connections without voice audio. Although, the situation of each network might have changed subsequently, the present result indicates that the performance of GSM networks in Nigeria is still a far cry from expectations of the consumers. In addition, methods for improvements were suggested such as telecommunication providers should upgrade and optimize all existing base stations; operators should invest heavily in transmission network development and have a proper radio planning and the government should address incessant power failures.

II. LITERATURE REVIEW

According to [2], inadequate information for effective control of GSM Quality-of-Service (QoS) is a problem that needs to be addressed. Total dependence on the information from the providers' end might not give the true state of the problem encountered by the subscribers. Hence, there is need for feedback from the actual users of the services. Their work presented a dynamic ontological model as a necessary tool for effective control of GSM Quality-of-Service (QoS). Questionnaires were distributed to the subscribers of selected network providers. A Chi-Square test was performed on the data and results obtained formed the basis for the model. This model is a three-tier dynamic architecture that used the subscribers' feedback mechanism as the measure for QoS. The work was aimed at serving as a guide to the government during its policymaking. Telecommunication companies can also use the findings as they compete and take management decisions. Subscribers can use the work in their choice of network. The model is expected to assist in ensuring effective quality, affordability of telephone services, as well as the increased geographical spread of communication services in Nigeria.

The work of Mughele and Olatokun in [3] aimed at presenting a report on the quality of services and the evaluation of GSM network performance for various locations. The indicator compares the network's capacity for calls established as against congested calls given the number of call attempts for six different locations. This is demonstrated in the ratio of the

network capacity with respect to the number of call attempts, established, and congested across six distributed locations. The locations were randomly distributed; series of graphs and measurement were taken. A multi-variate analysis of variance (MANOVA), which led to the use of a non-parametric test, Kruskal-wallis H, for ranking the difference in median. It was observed that the network operators need to improve the quality of service offered to their customers. The results showed that the congestion rate for Lagos is the highest followed by Enugu, and Yola had the least congestion experience. Redirection of call can be considered and proper study of the location conducted to determine deployment of network facilities in order to improve customer satisfaction.

[3] concluded that higher quality in a GSM service operation is achievable but only through fast and accurate network optimization. The task of GSM network optimization is highly complex and specialized, but it is also a task with enormous potential rewards, as each incremental improvement in system performance can translate to huge cost savings and increased revenues for the operator.

[4] identified the areas on the GSM network where congestion occurred. The causes of congestion on GSM network and congestion comparative analysis on each of the GSM networks in Nigeria was carried out. The survey method was used for this work. The respondents had handsets with single or multiple network providers and were from different locations within Lagos. The results showed that Lagos experienced heavy congestion problems. The authors did not offer any solutions to the congestion problems.

The authors in [5] stated that, a network service provider offers best-effort service to customers and Quality of Service (QoS) is provided only by network over provisioning. When traffic bursts cause congestion, this default approach does not always provide an acceptable solution. As the trend in networking is convergence of voice, video and data, it is important to differentiate traffic into high and low priority classes through QoS mechanisms. To deliver differentiated QoS, the routers utilize classification and sometimes remarking of the traffic. Based on service agreements with the customer, a certain class of traffic is then given more resources by the router. Evaluation of the results of these methods and approaches on the network performance is very important to device designers, network evaluators, network administrators, network operators and others involved.

To study the effects of QoS solutions/techniques on the traffic, methods for testing need to be developed. The objective of [5] was to propose methods of measuring QoS metrics like throughput, latency, and jitter for different types of traffic through a device. Classification and remarking were observed to put extra load on a device. For some devices, the performance deteriorates when classification and remarking are enabled. Throughput dropped for classification and remarking in some cases. In multiple instances, latency and jitter increased for classification and remarking. There are multiple ways of measuring jitter, which were also discussed in the methodology development. It was also observed that some definitions that might seem better from a research perspective are not always available to measure or widely used in the industry. Based on the study it was concluded that service/network providers would have to take care while providing QoS to the customers in order avoid the scenarios discussed.

The work of [6] investigated and analyzed the Quality of Service (QoS) of cellular mobile networks in Nigeria using some Network Key Performance Indicators (KPI). This study is limited to Visafone Mobile Network that is licensed to provide fixed wireless access telecommunications services on State-by-State basis in Nigeria under the license category classified as Private Network Links (PNL). Visafone mobile Network runs on Code Division Multiple Access (CDMA) technology. In the study the following KPIs: Call Setup Success Ratio (CSSR), Call Drop Ratio (CDR) and Traffic Channel (TCH) Congestion Ratio measurements were sampled and collated from the Network Operating Centres (NOCs) and their values were evaluated against the standard threshold values set by telecommunications regulatory body, the Nigerian Communications Commission (NCC) in Nigeria. The results obtained showed that busy hour TCH Congestion Ratio was 0.0062 which is lower than the NCC stipulated value of $\leqslant$ 2%. Also, the busy hour CDR was 0.7129 and again below the NCC threshold of $\leqslant$ 2%. Finally, the busy hour CSSR was 98.7267, which is within the expected threshold set by NCC.

According to [7] the adoption of the Interconnect Clearing Houses (ICH) in Nigeria is a long awaited development expected in the telecommunication industry. Their work presented an insight into network performance evaluation and quality of service (QoS) improvement of mobile cellular systems in Nigeria using an ICH as a case study. The components of mechanisms of analyzing and evaluating the various networks are discussed. The paper also identifies the important Key Performance Indicators (KPIs) for QoS evaluation which are used in evaluating the Mobile networks. Two assessment parameters such as Call Completion Ratio (CCR) and Answer Seizure Ratio (ASR) for evaluating the traffic analysis of the networks in Nigeria are deployed. The parameters are applied on four mobile network systems in Nigeria using the general models simulated in Matlab for evaluating network performance. The result of the study shows that the QoS of mobile system in the country is not 100% reliable and still needs to be improved upon.

III. METHODOLOGY

After the data used in this work was collected from the network management centre of a national mobile telecommunication company. The telecommunications company provides its services and products using the global system of mobile communication (GSM) technologies for voice, text and data communication. The data was collected between April and June 2012.

The data collected covers six states in the south-western region of Nigeria. The states are Lagos, Oyo, Ogun, Osun, Ondo and Ekiti. The data was statistically analyzed using frequency.

The following parameters were used as a measure of Quality-of-Service for the selected telecommunications provider.

a) Call Set-up Success Rate (CSSR): This measures the ease in which calls are established or set up. The high the value of CSSR, the easier it is to set up a call. For instance if a CSSR of 80% means that out of every 100 calls made 80 are successful while the 20 are unsuccessful. CSSR is defined as the ratio of number of unblocked call attempts to total number of call attempts.

b) Call Drop Rate (CDR): Highlight all author and affiliation lines.

c) Change number of columns: This indicator measures the network ability to retain call conversion when it has been established. What a CDR of 10% means is that out of every 100 calls established, 10 will drop before any of the calling parties voluntarily terminates the call. CDR is defined as the ratio of number of dropped call to total number of call attempts [i.e.(1-call complete probability)*100].

d) Traffic Channel Congestion Rate (TCHC): This is congestion by the users and it measures the relative ease by which the user seizes a traffic channel to set up a call after a signalling seizure has been successful. The higher this value the more difficult it becomes to make a call.

e) Busy Hour traffic Channel Congestion: The Nigerian Communication Commission (NCC) defines it as the percentage congestion of the Traffic channel Congestion measured at the busy hour and it is given by:

$$\frac{Busy\ Hour\ TCH\ Traffic\ (Erlang) - Average\ TCH\ Traffic\ (Erlang)}{Busy\ Hour\ TCH\ Traffic\ (Erlang)} X\ 100 \quad (1)$$

The Busy Hour Traffic Channel Congestion is one of the key performance indicators (KPI) used by the Nigerian Communication Commission to assess the performance of Mobile networks. The NCC recommends a call drop rate of less than 2%. The Busy Hour traffic Channel Congestion has a direct influence on customer satisfaction and quality-of-service.

IV. RESULTS AND DISCUSSION

A. Distribution of Cell sites

The southwest region is comprised of Ekiti, Lagos, Ogun, Ondo, Osun and Oyo states. A cell site refers to the base station that allows data transmission and reception. The region has a total number of 4285 cell sites. The cell sites are distributed as follows:

TABLE I. DISTRIBUTION OF CELL SITES IN SOUTH WESTERN NIGERIA.

STATES	NUMBER OF CELL SITES
EKITI	237
LAGOS	2272
OGUN	508
ONDO	352
OSUN	336
OYO	584
TOTAL	4289

Table I shows that Ekiti state has the least number of cell sites while Lagos state has the highest number of cell sites. This can be correlated with the population in each state. Land size does not seem to be a determinant of number of cell sites.

B. Call Setup Success Ratio (CSSR)

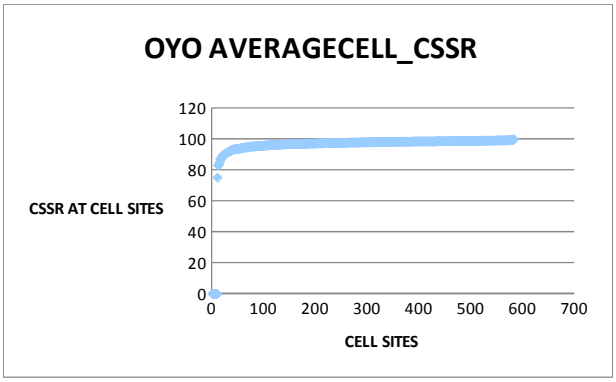

Figure 1: Call Setup Success Ratio for Oyo State

Oyo state has 583 cell sites, and their call setup success rate at different cell sites is shown in Figure 1. Only 12% of the 583 cell sites fall below the recommended NCC guideline. The percentage of people who owned a mobile phone was 32.2 % of the population while those restricted to just access was 49.3% of the population at the time of data collection.

TABLE II. DISTRIBUTION OF MOBILE PHONE ACCESS AND OWNERSHIP IN SOUTH WESTERN NIGERIA

STATES	MOBILE PHONE OWNERSHIP	MOBILE PHONE ACCESS	TOTAL ACCESS
Ekiti	47.7	30.2	77.9
Lagos	76.4	9.2	85.6
Ogun	47.3	39.9	87.1
Ondo	35.7	39.3	75
Osun	58.1	33.8	91.9
Oyo	32.2	49.3	81.5

Table II shows the percentage of mobile phone ownership and access in South-Western Nigeria. There are many mobile owners in Lagos state but the highest percentage is in Osun state with 91.9% .While the lowest value is 75% in Ondo state

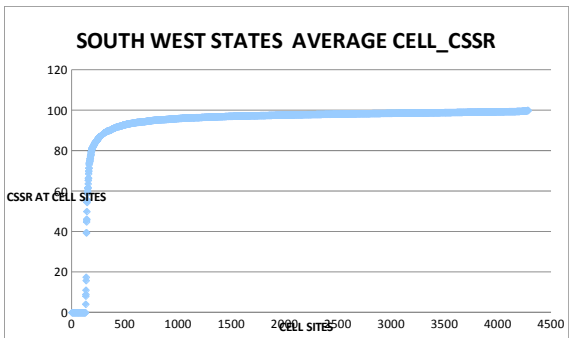

Figure 2: Call Setup Success Ratio for South-Western Region

There are a total number of 130 non-operational sites in the southwest region of Nigeria. This represents approximately 3% of the 4285 cell sites in the south-west. The number of cell sites that fall on average below the NCC guidelines of 95 % CSSR is 751. This represents about 17% of all the sites in the Southwest.

C. Call Drop rate (CDR)

Figure 3 shows the call drop rates at 352 different Cell sites in Ondo State. Of the 352 Cell sites in Ondo state, 75% of them meet the NCC guidelines of less than 2% call drop rate. This implies that 87 cell sites do not meet NCC call drop rate standards .However, 7% of these Cell sites have a perfect call drop rate of 0%.

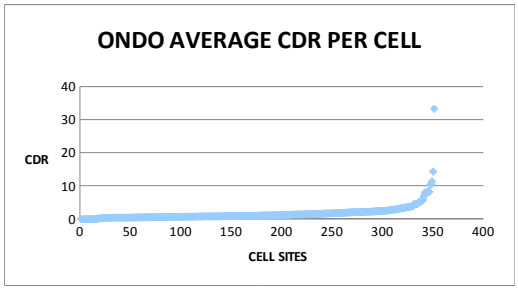

Figure 6: Call Drop Rates at Individual Cell Sites in Ondo State

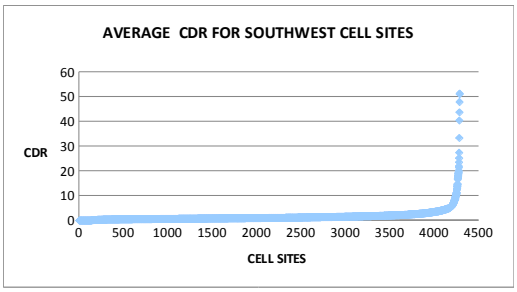

Figure 3: Call Drop Rates at Individual Cell Sites in South-Western region

The south-western region consists of Ekiti, Lagos, Ogun, Ondo, Osun and Oyo states. At the time of data collection, the region had a total number of 4285 cell sites. Figure 4 shows the Call Drop Rates at individual Cell sites in the region. 81% of the Cell sites in the South West or 3472 out of 4285 Cell sites meet the NCC guidelines of less than 2% Call drop rate. This implies that 813 Cell sites do not meet the NCC standards of less than 2% Call drop rate. It is noteworthy that only 3% of the Cell sites in the South West have a 0% call drop rate.

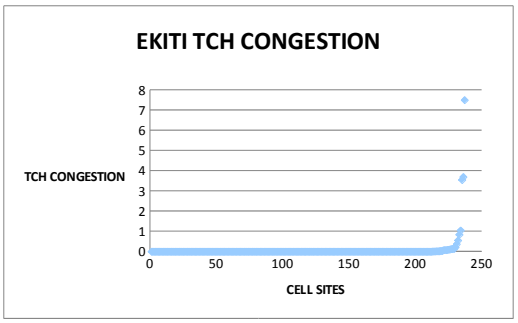

Figure 4: Busy hour traffic Channel Congestion in Ekiti State

As mentioned earlier, the recommendation for the traffic channel congestion by the Nigerian Communication Commission is that it should be less than 2%. 96% of the Cell sites in Ekiti state meet these criteria. In fact, only three cells in the entire state fail to meet this guideline. This implies that the network infrastructure can sufficiently handle the traffic generated in the state. Also, 213 cells out of the 238 Cell sites or 89% of the cell sites have 0% traffic channel congestion.

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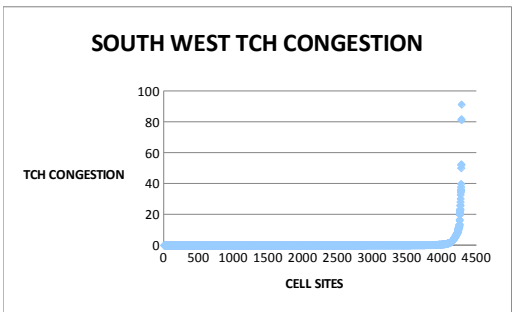

Figure 5: Busy hour traffic Channel Congestion in the South West States

TABLE III. SOUTH WEST STATES AVERAGE CSSR

STATES	Number of CELL SITES	COMPLIANT CELL SITES	NON – COMPLIANT CELL SITES	% NON-COMPLIANCE	% COMPLIANCE	AVERAGE STATE CSSR
EKITI	238	223	15	6	94	97.8
LAGOS	2272	1801	471	20	80	93.92731792
OGUN	508	388	120	24	76	89.10213201
ONDO	352	312	40	11	89	93.65959829
OSUN	336	298	38	11	89	92.7566612
OYO	584	513	71	12	88	95.66270168
SOUTH WEST	**4285**	**4074**	**751**	**18**	**82**	**93.69720584**

TABLE IV. SOUTH WEST STATES AVERAGE CDR

STATES	Number of CELL SITES	COMPLIANT CELL SITES	NON - COMPLIANT CELL SITES	% COMPLIANCE	% ZERO LEVEL CDR	AVERAGE STATE CDR
Ekiti	238	192	46	80	2.5	1.995215567
Lagos	2272	1949	323	85	2	1.286807533
Ogun	508	365	143	71	7	2.083262269
Ondo	352	265	87	75	7	1.677669041
Osun	336	265	71	78	6	1.844706645
Oyo	584	449	135	77	6	1.783905389
SOUTH WEST	**4285**	**3472**	**813**	**81**	**3**	**1.563556342**

TABLE V. SOUTH WEST STATES AVERAGE TCH CONGESTION

STATES	Number of CELL SITES	COMPLIANT CELL SITES	NON - COMPLIANT CELL SITES	% COMPLIANCE	% ZERO TCH CONGESTION	AVERAGE STATE TCH CONGESTION
Ekiti	238	235	3	96	89	0.07971097
Lagos	2272	2152	120	94	32	0.764829866
Ogun	508	492	16	96	57	0.342042078
Ondo	352	345	16	98	80	0.209451567
Osun	336	334	2	99	76	0.098290778
Oyo	584	572	11	98	58	0.189229536
SOUTHWEST	**4285**	**4125**	**159**	**96**	**49**	**0.501006761**

The South West states have 4284 Cell Sites. 96% of all the Cell sites in the South West meet the NCC guidelines of less than 2% busy hour traffic Channel Congestion. 4125 out of the 4284 Cell sites in the South West meet this guideline. Cell sites without any traffic congestion are placed at 49% (2129 of 4284 of all the Cell sites in the Region.

D. Comparison of the Key Performance Indicators with the NCC Guidelines

The Call Setup Success Ratio (CSSR), Call Drop Rate (CDR) and Busy Hour Traffic Congestion (BHTC) key performance indicators for the six southwestern states were compared with those reported nationally by the NCC. The results are presented in Table VI.

TABLE VI. SUMMARY OF KEY PERFORMANCE INDICATORS

KEY PERFORMANCE INDICATOR (KPI)	SOUTHWEST AVERAGE	NATIONAL AVERAGE	NCC RECOMMEND
TRAFFIC CHANNEL CONGESTION	0.501006761	1.07	2
CALL DROP RATE	1.563556342	1.01	2
CALL SETUP SUCESS RATIO	93.69720584	95.95	95

Table VI shows the key performance indicators for the Southwest, National and NCC recommended averages. Firstly, the Traffic Channel Congestion, it was observed that NCC recommends an average of less than 2% traffic congestion at the busy hour. The southwest average is about 0.5%, which is much lower than the National average and the NCC recommendation. Consequently, the southwest meets the NCC guidelines in terms of the Traffic channel congestion. For the call drop rate KPI, the southwest average is 1.5%, this is higher than the National average (1.01%) but much less than the ceiling recommended by NCC (2%). As a result, the south-western region meets the NCC guidelines in terms of the call drop rate KPI. Finally, for the call setup success ratio KPI, the south-western region average is about 94%. This falls below both the National average and NCC recommendation of 95.95% and 95% respectively. Thus, the telecommunication provider has to improve on its call setup processing.

CONCLUSION

This work evaluated the Quality of Service performance of a mobile telecommunications provider using some key performance indicators such as call success setup rate, call drop rate and traffic channel congestion. The results show that for the traffic channel congestion indicator for the southwest average is 0.5% which is much lower than the national average and the recommended 2% NCC upper limit. For the call drop rate indicator, the southwest average is 1.5%, this is higher than the national average (1.01%) but much less than the ceiling recommended by the NCC (2%). For the call setup success ratio indicator, the southwest average is about 94%. This falls below both the national average and the NCC recommendation of 95.95% and 95% respectively. From the findings, it can be concluded that the regional performance meets the NCC guidelines in the call drop rate and traffic channel congestion performance indicators but it does not meet the call setup success rate. It is suggested that collection and analysis of data from the other regions of the country be carried out with the view of comparing each region with the national average. It is also suggested that identification of the factors responsible for the exceptional performance of certain cell sites i.e. those with a zero call drop rate and a zero traffic congestion rate be carried out. Cell sites that perform exceptionally should be studied so that their performance can be reproduced in other cell sites.

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