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Real-Time Accessments of Qos of Mobile Cellular Networks in Nigeria

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Abstract—The main goal of this research is investigate and analyse 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 which 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 this 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 ≤ 2%. Also the busy hour CDR was 0.7129 and again below the NCC threshold of ≤ 2%. Finally the Busy hour CSSR was 98.7267 which is within the expected threshold set by NCC.

Keywords—Quality of Service (QoS), Key Performance Indicators (KPI), Call Setup Success Ratio (CSSR), Call Drop Ratio (CDR) and Traffic Channel (TCH) Congestion Ratio.

I. INTRODUCTION

The term Quality of Service (QoS) in various applications is largely defined in different ways, but most definitions point towards end user satisfaction, expectations or fulfil requirements. The International Organization for Standardization (ISO) gave an initial general definition of quality in ISO 8402 as "the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs" and in the year 2000 it was replaced by ISO 9000 which defines quality as the "degree to which a set of inherent characteristics fulfils requirements" [1].

Monitoring QoS of any telecommunication network requires continuous processes that measure values of the Key Performance Indictor (KPI) parameters in real-time and analyse the measured empirical data of the KPIs that determines quality of service rendered to the subscribers. There are many network parameters that evaluate the quality of delivered network service; this study will be limited to the following Key Performance Indictor (KPI) parameters:

a. Call Success Setup Ratio (CSSR)
b. Call Drop Ratio (CSR), and
c. Traffic Channel (TCH) Congestion Ratio.

The Nigerian telecommunications industry is rapidly growing and many operators and their operations put forth different services, but in the diverse services provided most of the subscribers do not receive satisfaction due to the poor nature of services available on these networks. Competition in the industry is a likely tool that would indirectly improve services rendered, but this is not yet the case in Nigeria since competition in the telecommunications industry is fairly new and may be described as being inefficient. Hence, there has been a persistent out cry in the media and series of complaints from the National Assembly on the poor performance of mobile telecommunication networks in Nigeria.

Since competition in the industry has not yet pushed the operators to improved quality in the service rendered, the telecommunications regulatory body, the Nigerian Communications Commission (NCC) is empowered by law to protect the Nigerian consumers and one of the ways of achieving results in this regards is by specifying the quality of service parameter thresholds for all the different telecommunications services and its ensuring compliance.

The results of this study would assist the regulating body, NCC in determining if the industry best practice QoS Key Performance Indictor (KPI) parameters are met by the mobile network operators. The individual network operators would appreciate an independent network observer, evaluate and analyse their QoS performance.

II. PAST QOS ASSESSMENT EFFORTS IN NIGERIA

In 2007, the NCC held a Public Forum [3] to identify issues affecting QoS in Nigeria, seek solution to the current QoS challenges in the industry and make recommendations on way forward. The forum identified the following issues as factors that require attention in order to improve the unacceptable QoS delivered on the various networks.

- Network Congestion
- Limited Transmission Infrastructure.
- Security of Telecommunications Equipment or Facilities.
- Unreliable Public Power Supply.
- Lack of Information to the Consumer on downtime.

The Nigerian Communications Commission (NCC) conducted QoS audit of the four networks in Nigeria for a period of 21 days from September 21, 2004 to October 11, 2004 [7]. The tests were in two categories namely; voice network performance/quality and Prepaid Performance Test. The Key Performance Indicators (KPI) measured are listed as follows:

- Call Setup Success Rate.
- Call Setup Failure Rate.
- Call Success Rate.
- Call Drop Rate.
- Call Retention Rate.
- System Response Time.
- Handover Statistics.
- Number of Handovers per call.
- Voice Quality as a MOS value.
- Airtime Recharge Performance.

The tests were conducted in three cities of Lagos, Abuja and Port Harcourt. Test within the same cities and test between one of the cities to another were carried out. The summary of the results are shown in Tables 1 and 2:

Table 1: The Result for Network Quality and Performance Test.

Test	Best Results	Worst Results
Call Setup Success Rate	Globacom: 94.1%	Vmobile: 57.3%
Call Success Rate	Globacom: 91.8%	Vmobile: 56.2%
Call Retention Rate	MTN: 98.3%	MTEL: 97.3%
Call Set-up Failure Rate	Globacom: 5.9%	Vmobile:42.7%
Call Drop Rate	Vmobile: 1.1%	MTEL: 2.4%
Call Handovers	MTN: 97.2%	MTEL: 91.3%
Failed Call Handovers	MTN 3.0%	Vmobile: 8.3%
Voice Quality on the Downlink	Globacom: MOS of 3.5	Vmobile: MOS of 1.3
Voice Quality on the Uplink	Globacom: MOS of 3.2	Vmobile: MOS of 1.7

Source: Nigerian Communications Commission [7]

Table 2: The result for the Prepaid Performance Test.

Test	Best Results	Worst Results
Successful Recharge	Vmobile: 91.60%	Globacom: 64.53%
Successful Balance Enquires	MTN: 99.26%	Vmobile: 98.97%
Billing Error Rate	Globacom: 0.07%	MTEL: 2.77%

Source: Nigerian Communications Commission [7]

These results reveal that poor QoS is pervasive across the GSM networks and across the country and none of the GSM is exonerated. The overall performance of the networks is far from being satisfactory. These results only present a comparative study of the networks. Having achieved the best score does not mean the Commission is satisfied with the level of performance of the networks.

III. RESEARCH METHODOLOGY

3.1 Research Design

Three Key Performance Indicators (KPIs) namely; Traffic Channel Congestion Ratio (TCH cong. Ratio), Call Drop Ratio (CDR) and Call Setup Success Ratio (CSSR) were selected for the evaluation of Visafone Mobile network in Abuja and Kaduna Base Station Controller (BSC) areas. These three parameters which have direct impact to subscriber experiences on the network have industrial best practice values which were used as independent variables for the survey. The population of this study consist of the total subscriber base of Visafone Mobile in Abuja network is about 245,284 lines (from data collected from Network Operating Centre (NOC) on March 19, 2009) but the active subscriber lines on the network is about 58,231 lines. The active subscriber lines captured are subscriber customer premise equipment/mobile phones that were switch on at the time of the values were taken from the NOC.

The selected data from Visafone Mobile Network for this study is based on Complex Random (Mixed) Sampling Design, in which Stratified Samples was used. The collected data were grouped into three (3) different strata with each stratum representing a particular key performance indicator such as CSSR, CDR and TCH Cong Ratio. The measurement samples taken show activity on the Base Transceiver Stations (BTS) being supervised by Abuja and Kaduna BSC, and its measurements were taken every thirty (30) minutes time interval.

3.2 Procedure for Data Collection

The sample measurements were generated from the BTSs which also provided the File Transfer Protocol (FTP) services to the Network Management System (NMS) [8]. The NMS which is known as the iManager M2000 was used to pull CSSR, CDR and TCH Congestion Ratio measurements for the period of the study. The NMS is hosted on a central server which is connected to other network elements such as BSC, BTS, MSC, HLR etc. The server with its NMS software was configured to retrieve BTS measurements of remote MSCs and its BSCs.

The collated data from the iManager server were sorted and analyzed by the codes written in Visual Basic programming language for this analysis.

Sample of hourly traffic pattern in respect to CSSR, CDR and TCH Congestion were collated from the iManager Network Monitoring System for July 3, 2010, and the sample for daily pattern was collated between July 1, 2010 to July 10, 2010, while the weekly samples was called from December 19, 2010 to April 4, 2011. The data were basically used to sample the performance of visafone mobile network.

IV. DATA ANALYSIS AND RESULTS

Both descriptive and inferential statistics [9] were used to study the collated data. The data were analyzed using plotted graphs.

4.1 Hourly Data Analysis

The measured data is evaluated against the threshold values set by the NCC [10] which are outlined below as:

a. Target value for Busy Hour (BH) TCH congestion Ratio: ≤ 2%
b. Target value for BH CDR: ≤ 2%
c. Target value for CSSR: ≥ 98%

The analysis of the TCH congestion ratio from collected data is shown in Fig. 1

It was observed in Fig. 1 that between the hours of 1.00am to 5.00am on daily basis, the system does not have congestion on the Traffic Channels, and sometimes the low values of TCH Congestion starts from 6.00am or 7.00am, even on weekends. There is progressive increase in TCH Congestion in the morning hours and it grows to the peak at about 2.00pm and later drops between 5.00pm to 7.00pm before it grows from 8.00pm to 11.00pm. The Nigerian Communications Commission (NCC) is currently developing QoS regulation for the telecommunications industry in Nigeria, the threshold value set for busy hour TCH Congestion level is equals or less than 2%. The average TCH Congestion Ratio found on Visafone Mobile's Network is less that 2%, thus the visafone Network's average TCH Congestion ratio is within the expected limit. Furthermore, the Busy Hour TCH Congestion Ratio value is 0.0062 and is below the NCC threshold value.

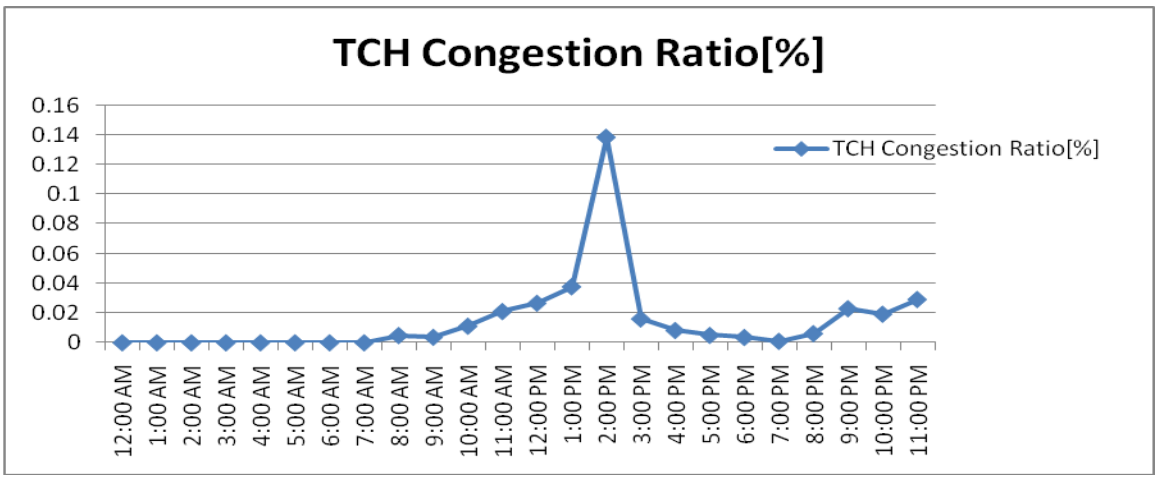

Figure 1: Hourly TCH Congestion Ratio Graph.

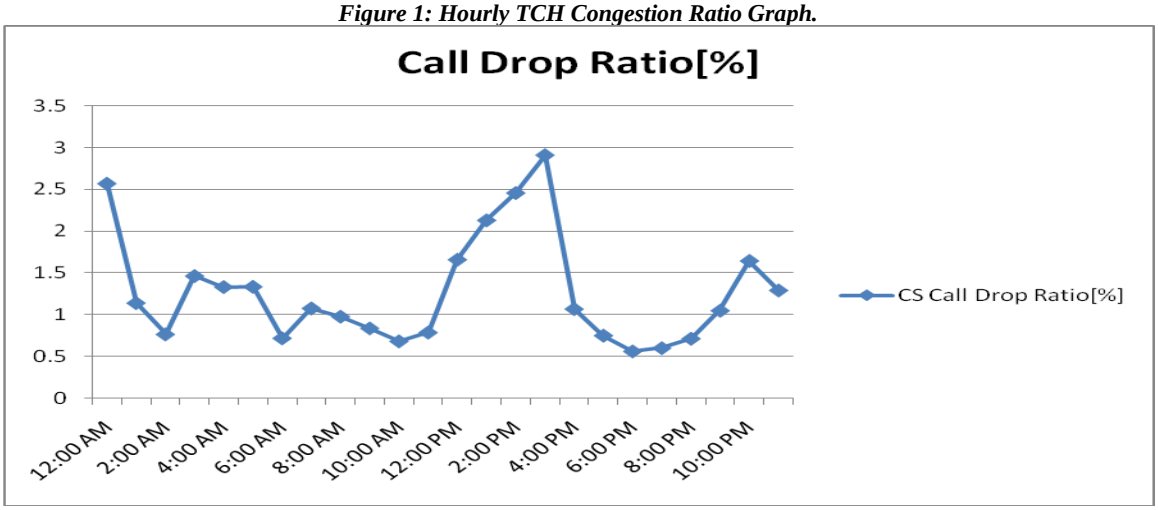

Figure 2: Hourly Call Drop Ratio Graph.

From the values presented in Fig. 2, it is observed that the CDR value of the network was high at about 12.00am but reduced before it fluctuated up and down in value and took the highest value of 2.9074% at about 3.00pm. The CDR value later dropped and increased to a high value of 1.6425% at about 10.00pm before dropping again.

The recommended Busy Hour threshold value set for CDR in the draft QoS regulation of the NCC is equal or less than 2%. The Busy Hour CDR value found on Visafone Mobile Network is 0.7129 and is below the NCC threshold value. If the peak period of 1.00pm to 4.00pm is considered for Visafone Mobile Network, the average value of 2.1395% will be above the expected limits. But the peak period traffic considered for CDR in this research is from 7.00am to 10.00pm, and its average value is 1.2429%. This is below the threshold value of 2%.

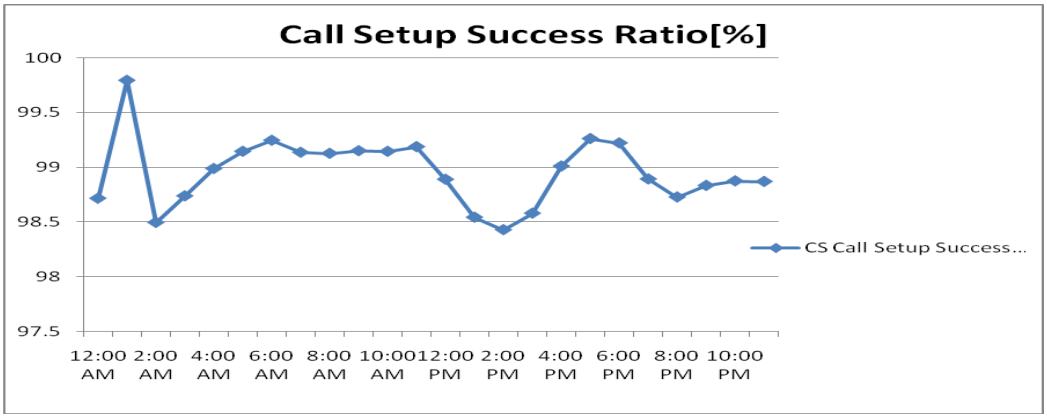

Figure 3: Hourly Call Setup Success Ratio Graph.

Also, from Fig. 3 on CSSR values, lower values of 98.4940% and 98.4275% were recorded at about 2.00am and 2.00pm respectively. It was surprising to observed low value of CSSR at 2.00am but all values are within the threshold value of equal or greater than 98% set by NCC. The Busy Hour CSSR value found on visafone Mobile Network is 98.7267 and is within the expected threshold set by NCC.

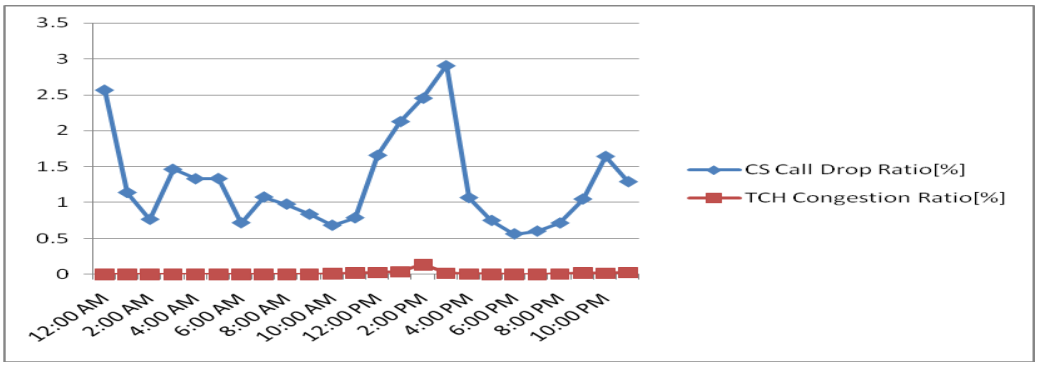

Figure 4: TCH Congestion Ratio and Call Drop Ratio Graphs.

Fig. 4 compares performance of CDR and TCH Congestion ratio and it shows that between 2.00pm and 3.00pm the highest values of CDR and TCH congestion ratio were observed.

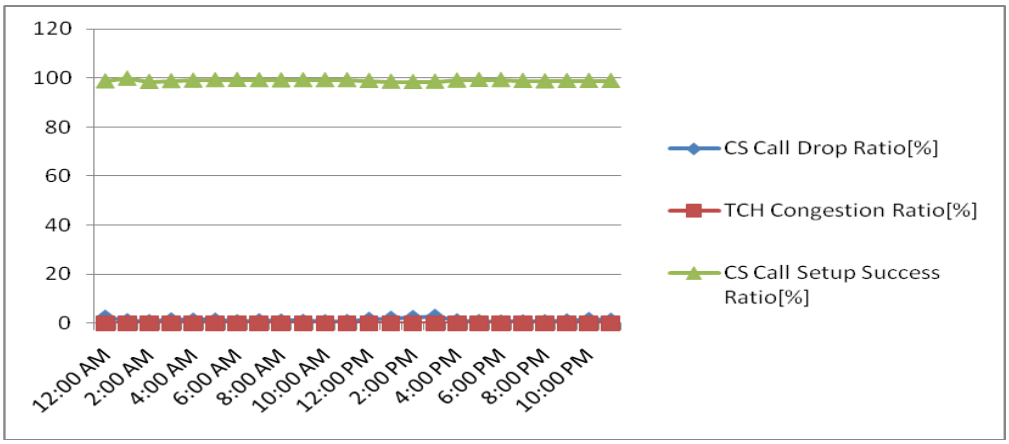

Figure 5: TCH Congestion Ratio, Call Drop Ratio and Call Setup Success Ratio plots.

Fig. 5 compares performance of TCH congestion ratio, CDR and CSSR. It shows that between 2.00pm and 3.00pm the highest values of CDR and TCH congestion ratio were observed while the lowest value of CSSR occurred at 2.00pm.

V. CONCLUSION AND RECOMMENDATIONS

This study evaluated the Quality of Service performance of mobile telecommunications network. Visafone Mobile Network was used as a case study. In order to achieve the aim of the assessment, three key performance indicators where used and matched against the industry best practise values set by the regulator, Nigerian Communications Commission in the draft regulation being development. Descriptive statistics were used to analyze the Traffic Channel Congestion Ratio (TCH Cong. Ratio), Call Drop Ratio (CDR) and Call Setup Success Ratio (CSSR) on hourly and daily basis and it was found that the busy hour TCH Cong. Ratio target of below 2%, the busy hour CDR target of below 2% and the busy hour CSSR target value of above or equal to 98% were obtained.

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