

ANALYSIS OF A GSM NETWORK QUALITY OF SERVICE USING CALL DROP RATE AND CALL SETUP SUCCESS RATE AS PERFORMANCE INDICATORS

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Keywords: –

Key performance indicators, Percentage Call Drop, Call Setup Success Rate, QoS, Network provider, Users

Article History: –

Received: December, 2019.

Reviewed: February, 2020

Accepted: March, 2020

Published: March, 2020

ABSTRACT

Quality of Service (QoS) is an important Key Performance Indicator (KPI) that is used in determining the efficiency of an industry in terms of availability and quality of services rendered. In the telecommunications industry, accessibility, retainability, and connection (voice) qualities are the three major factors used in evaluating QoS of an operator. These affect business and research activities, security, and most importantly, they also affect the daily activities of a common person. For consumers outside the industry, it is expected that the maximum satisfaction should be derived from any services paid for. Over the decades, the increase in the call drop rates and poor network availabilities within the localities, or even while moving from one location to another had become a concern to every network user and researchers. Hence, this paper assesses the QoS of MTN GSM network in four geographical areas of Kaduna State (Kaduna south, Kaduna North, Zaria and Kafanchan), Nigeria. The data collated from the management center of MTN network was used for the evaluation of the measured KPI parameters using the data management tool. The result of this research paper was compared with those specified by the Nigerian Communications Commission (NCC) and were found to be better.

1. INTRODUCTION

Telecommunication is the exchange of information between two or more entities and it involves the use of network technology that 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. GSM has boosted the economic activities in Nigeria and improved the quality of life of Nigerians [1], [5]. They are now able to enjoy services such as mobile television, affordable internet service, cheaper international calls, and even internet banking. As the number of services and subscribers of GSM in Nigeria increase, the demand for good QoS has become an issue. In finding the lasting solution to this problem, the NCC, a body responsible for the regulation of GSM in Nigeria, on 6th July, 2007 issued out the threshold levels on the KPIs to ensure QoS for all the GSM networks in the country. The KPIs on which the GSM networks were tested include:

- i. Call Setup Success Rate (CSSR).
- ii. Percentage Call Drop (PDR) or Call Drop Rate (CDR).

- iii. Call Setup Failure Rate (CSFR).
- iv. Handover Failure Rate (HOFR).
- v. Handover Success Rate (HOSR).

For the purpose of this paper only the first two (CSSR and CDR) were considered in the study. Once a radiotelephone network is designed and operational, its performance should be monitored to improve overall service quality [6], [11].

That is where network performance monitoring for QoS assessment, analysis of faults, and corrective actions come in. In addition to monitoring network faults, the operator needs immediate information on how the network performs, especially from the end user perspective. The end user network performance report can be used as source of information for corrective actions or for evaluating the utilization of resources. The globalization of world economy has further amplified the importance of telecommunications to the economy, not only in Nigeria, but anywhere in the world [3]. Nigeria's GSM industry is one of the fastest growing and the largest Telecommunications industry in Sub-Sahara Africa and

Africa at large. The focus of the GSM operators is gradually shifting from providing coverage to providing quality service [2]. The Euphoria of having a hand set (mobile phone) is gradually giving way to complaints of bad or poor service quality due to the rate of drop calls and congestion. The longer session of rains in Nigeria and its effect on the Signal strength is a critical factor, in addition to the incessant power outages that also contributes to poor service, which must be considered in the planning and ensuring good and better QoS by any of the telecommunications operators. The increase in the call drop rates and poor network availabilities within the localities or even while moving from one location to another have become a great concern to every network user and researchers in the academic profession. These affect businesses, security in the case of military operation, research activities for the academia, etc. The network operators keep expanding their base stations and capacities but the problem of poor call qualities persist. Hence, the need for network optimization for proper handover is important as a means to improve the quality of service. Three fundamental indices are used in monitoring mobile network performance, which include drive test, customer complaints, and network statistics [12]. The quality of network is, therefore, a key index in the race for users. This can be achieved when the network is adequately optimized to meet the expected QoS from its clients [8, 13].

2. MATERIALS AND METHODS

The main tools used in this paper were:

- i. File Transfer Protocol (I Manager M2000) that was used for data collection from the network.
- ii. Microsoft Excel tool box was used to plot the results for easy understanding and interpretation.

The collected data from MTN network management center was then analyzed based on KPIs values gathered. The methodology was a step by step procedure that is itemized as follows:

- i. Analysis of the data set.
- ii. Determination of average KPI (CSSR and CDR) values.
- iii. Evaluation of the performance values

2.1. Analysis of Collected Data

The analysis of the data set for each of the studied locations were investigated base on daily assessment from the Base Station Controllers (BSCs), which were Abuja BSC number 7 (ABHBSC7), Abuja BSC number 13 (ABHBSC13), Kaduna BSC number 8 (KDHBS8), Kaduna BSC number 15 (KDHBS15), Kaduna BSC number 4 (KDHBS4), Kaduna BSC number 1 (KDHBS1), Kaduna BSC number 3 (KDHBS3), and Kaduna BSC number 9 (KDHBS9), respectively. At the Network Management Switching (NMS) center, a File Transfer Protocol (FTP) tool known as the I Manager M2000 was used to pull out the data from the network.

2.2. Determination of Average of CSSR

For each of CSSR and CDR the average variable was already evaluated from the raw data set obtained from the Network Management Center (NMC). The total average of CSSR and CDR on a daily basis for a month was obtained by using MS-Excel average tool box.

In telecommunications, CSSR indicator measures the ease with which calls are established or setup. The higher the value, the easier it is to set up a call. High CSSR is achieved when Standalone Dedicated Control Channel (SDCCH) seizures and Traffic Channel (TCH) allocation are easily achieved to set up a call. It is calculated as number of the unblocked call attempts divided by the total number of call attempts [10]. The amount of traffic flow that would occur if all call set-ups and call attempts were successful is referred to as offered traffic, that is, traffic successfully offered. CSSR is the number of successful attempts to make a call. In an ideal world, a network should be capable of accepting all the calls attempted to be made. The best value of CSSR is 1 i.e. the network should be capable of accepting 100 % of the calls made. CSSR is found out during a short call [10]. The CSSR is also defined as the fraction of the overall total attempts made to make a call that result in a connection to the dialed number. The CSSR is one of the KPIs used by network operators to assess the performance of their networks. It has direct influence on the customers' satisfaction on the services provided by the network and it is expressed in percentage as:

$$CSSR = \alpha/\beta \times 100\% \quad (1)$$

where,

α = Number of Call Setup

β = Number of Call Attempt

2.3. Determination of Average of CDR

In GSM network operation, call drop is a major observed problem frequently complained by subscribers. The call drop rate, however, is an important index that greatly influence the quality of a wireless network. This paper is set to carry out analysis on call drop rates in Kafanchan, Kaduna North, Kaduna South, and Zaria geographical locations in order to establish the frequency of the drop based on the data collected from the operation and maintenance center of NMC. The paper would discuss the cause of call drop and how to locate and resolve the problem that influences call drop in order to improve network quality. CDR, expressed as follows [4]:

It can be expressed as,

$$DCR = \frac{\alpha}{\mu} * 100\% \quad (2)$$

Where,

α = Number of Drop per Calls Number of Call Setup

μ = Number of Call Setup

Equation (2) can be considered as the rate of calls that are not completely successful due to quality deprivation. In mobile network, DCR gives a quick overview of network quality and revenue lost. It is a Key Performance Indicator to determine service retains ability. It has a direct great control on the subscribers' satisfaction and reliability [4]. The average values were sorted daily for each of the three months (January, February and March 2016).

2.4. Evaluation of KPI Values

Evaluation and performance analysis of the quality of service results that were obtained on CSSR and CDR. The performance values for Kaduna South, Kaduna North, Kafanchan, and Zaria computed for the months of January, February and March 2016 were plotted on a graph together with those values the NCC benchmark for comparison.

The NCC is empowered by Government to establish minimum QoS standards in service delivery for the telecommunications industry in Nigeria. These QoS technical standards require operators meet basic

minimum quality levels for all services provided to ensure that consumers continue to have access to high quality telecommunications services [7]. Table 1 is the set NCC KPI benchmarks followed by all operators of mobile services in Nigeria.

Table 1: NCC KPI Benchmarks [7]

S/NO	QUALITY PARAMETER	TARGET VALUE
1	Call Setup Success Rate (CSSR)	≥ 98 (%)
2	Call Drop Rate (CDR)	≤ 2 (%)

From Table1, the QoS was measured base on these NCC standard KPI values for all the key performance parameters influencing the QoS of a network.

1. ANALYSIS, RESULTS, AND DISCUSSION

Performance analysis to evaluate the QoS KPI values of this work against those of NCC was carried out in this Section. Graphical representations of the results for the months of January, February, and March, 2016 on a daily basis, were produced to facilitate comparison and discussion of the results.

3.1. CSSR Results for January, 2016

From Figure 1, Zaria area suffered low performance with CSSR QoS level below the NCC QoS bench mark of $\geq 98\%$ through the month, except on 9th, 12th and 14th when it was almost 98%. Other days (4th, 7th, 28th through 31st) experienced poor call accessibility, particularly the 25th when there was a sharp drop of the ratio of call setups to call attempts. The average value for the CSSR in Zaria for the month of January was 97.27%, which failed to meet the NCC standard benchmark minimum of 98%. On average, Kaduna South suffered an unstable availability of CSSR ratio average value of 97.57% in January, which was below the [7] benchmark for successful SDCCH and TCH, respectively.

Based on the data obtained from the NMC, Kaduna North and Kafanchan were able to meet the stipulated values of $\geq 98\%$ with average values of 98.46% and 98.361%, respectively, although subscribers were unable to establish or set up calls in Kaduna North successfully on 11thJanuary. While Kafanchan

performed below the NCC benchmark on the 6th and 13th through 15th of January as reflected in the graphical plots.

These worst short falls in performances for Zaria and Kafanchan were due to power failures during those days of January. On the other hand, Kaduna South had an average performance of 97.57% and Kaduna North had the best call set up rate with an average value of 98.57% base on set NCC standard bench mark of 98%.

3.2. CSSR Results for February, 2016

From Figure 2 graphical plots of CSSR values for the month of February, Zaria, and Kaduna South performed below the NCC minimum bench mark of 98% during the early stage of the month, specifically on 1st and 2nd of February. The failure to meet [7] benchmark standards was attributed to power failure due to lack of diesel fuel.

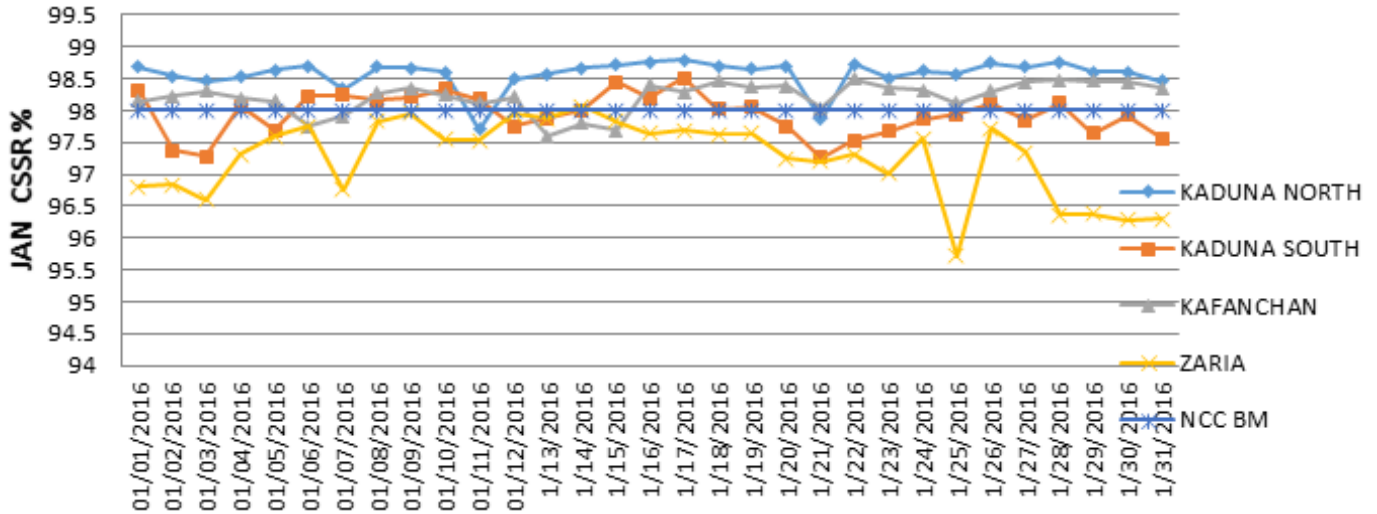


Figure 1: January, 2016 CSSR Results for Kaduna North, Kaduna south, Kafanchan, and Zaria.

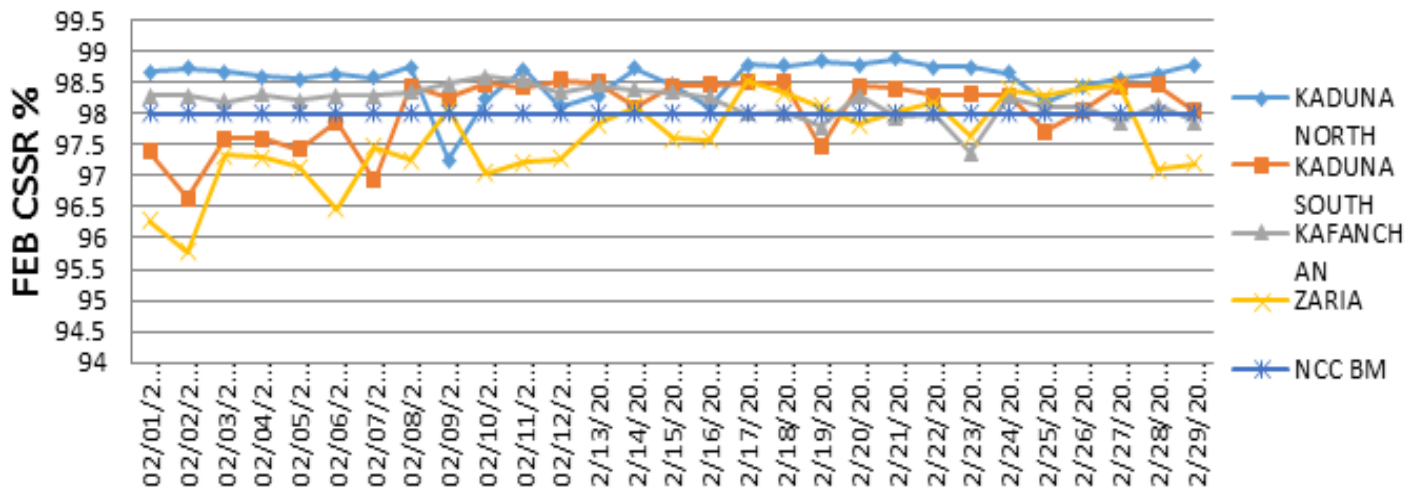


Figure 2: February, 2016 CSSR Results for Kaduna North, Kaduna south, Kafanchan, and Zaria

Failure to meet NCC minimum bench mark standards was again caused by power failure due to lack of diesel fuel. Kafanchan was able to maintain its good performance with an average monthly CSSR value of 98.19%. As for Kaduna North, there was a very good performance of service all through the month except on 9th with a sharp fall in performance as a result of major power outage recorded on the cell site, resulting in zero percentage availability percentage TCH for complete 24hrs. The reasons or causes for not been able to meet the NCC minimum bench mark standard of 98% availability in the four studied locations were majorly due to power failure, as well as other issues such as TCH congestion, interference, poor coverage, and faulty hardware units in those equipment at the base stations or cell sites. It is therefore evident from Figure 2 that Kaduna North had the best CSSR for the month of February, 2016 with an average value of 78.79%.

3.3 CSSR Results for March, 2016

March plots of Figure 3 shows that Kafanchan had a very poor ratio of successful numbers of set up calls against successful numbers of attempted calls and as a result subscribers had an unpleasant experience throughout the month of March compared to the previous months of January and February. Within Kafanchan location, several sites or base stations had zero percent TCH availability on the 1st, 2nd, 4th, 5th,

6th, and 7th with an average CSSR of 95% (less than minimum NCC benchmark [7] of 98%) from a hub base station ID number T1874. This affected four other cell sites due to faulty generator that caused power outage, hence, resulting to subscribers' bitter experience of poor QoS from MTN network during the month of March, 2016. Kaduna North maintained its best performance with an average CSSR value of 98.33% in line with the [7] benchmark of $\geq 98\%$.

The Zaria plot, however, shows that there was slight average performance improvement over Kafanchan with a value of 97.41% against 97.25% for Zaria. Except for days like 1st, 3rd, and 4th when the performance was above 98%, other days it was below the standard QoS level expected by the regulatory body, [7]. In general, these showed that subscribers had a bitter experience throughout the three months considered in this research work.

CDR Results for January, 2016

Figure 4 shows the rate of call drop encountered during the month of January for the areas studied. It could be observed that Kaduna North experienced more call drop beyond the [7] stipulated standard of $\leq 2\%$ on 10th, which means that subscribers in these period had a poor QoS after establishment of calls. It almost hit the standard benchmark of $\leq 2\%$ on 23rd January with good QoS.

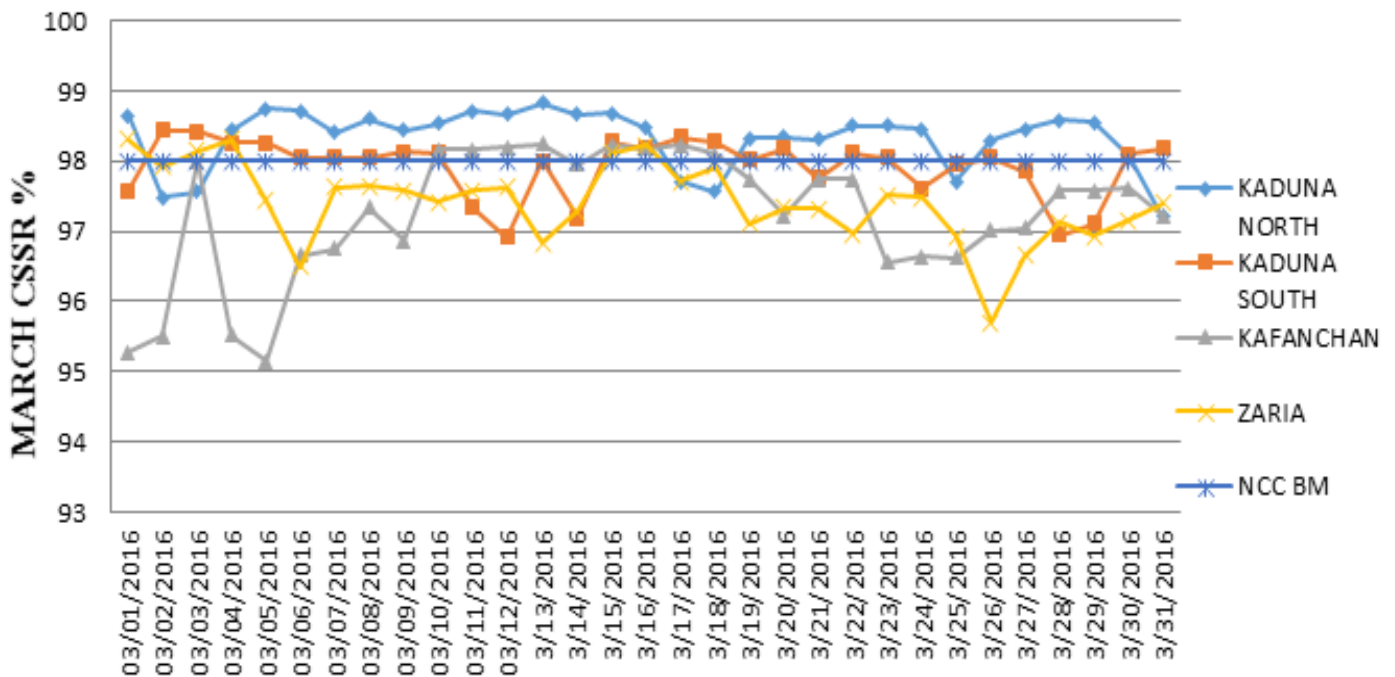


Figure 3: March, 2016 CSSR Results for Kaduna North, Kaduna south, Kafanchan, and Zaria

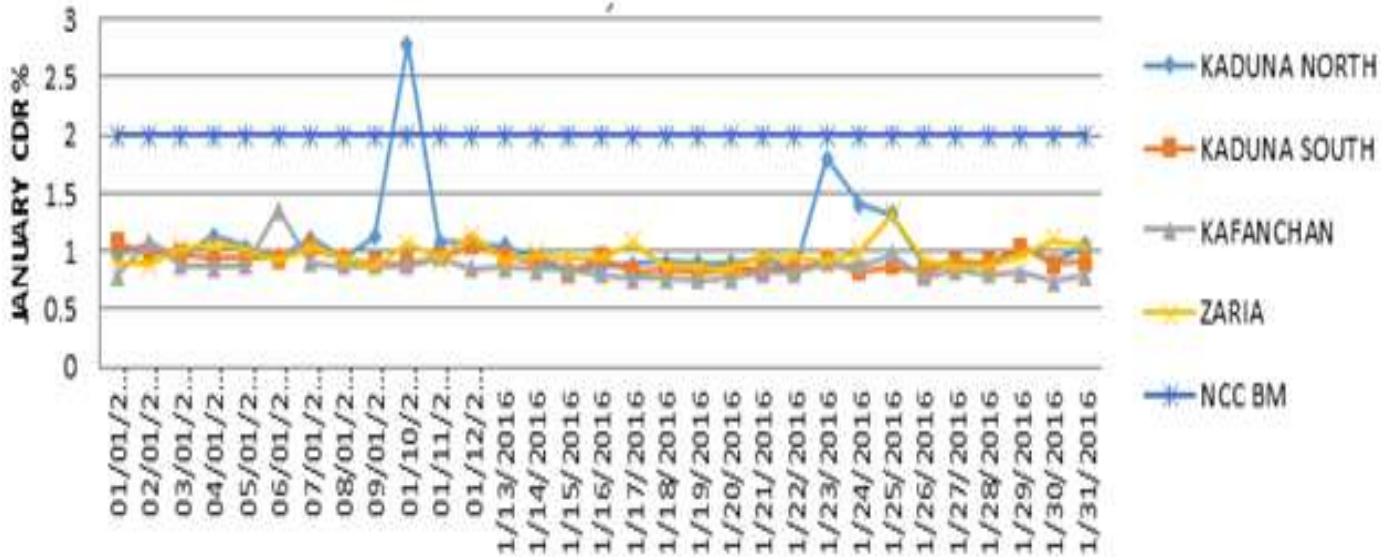


Figure 4: January, 2016 CDR Results for Kaduna North, Kaduna south, Kafanchan, and Zaria

On the average, the percentage call drop in January in Kaduan North was as good as 1.08 %, Kaduna South registered 0.911%, Kafanchan had 0.86 %,and Zaria recorded 0.97 %. These implied that there was a minimal drop of established calls after TCH assignment in most of areas studied and it was a good performance with good QoS for all the locations studied. Considering the KPI CDR, Kafanchan had the best QoS, Kaduna South had the second best, while Zaria; record was not good enough and Kaduna North had the worst performance of the four areas.

3.4. CDR Results for February, 2016

From Figure 5, it could be observed that between 12th and 17th of February, there was an abruptly termination of an established calls almost in all the locations while conversation was ongoing, most especially, in Kaduna North and Kaduna South, where the call drop rates were more than the [7] benchmark of $\leq 2\%$. These resulted in poor QoS in these locations due to major transmission failures between the base station controller and base transceiver station link or the link between the base station controller and mobile switching centre.

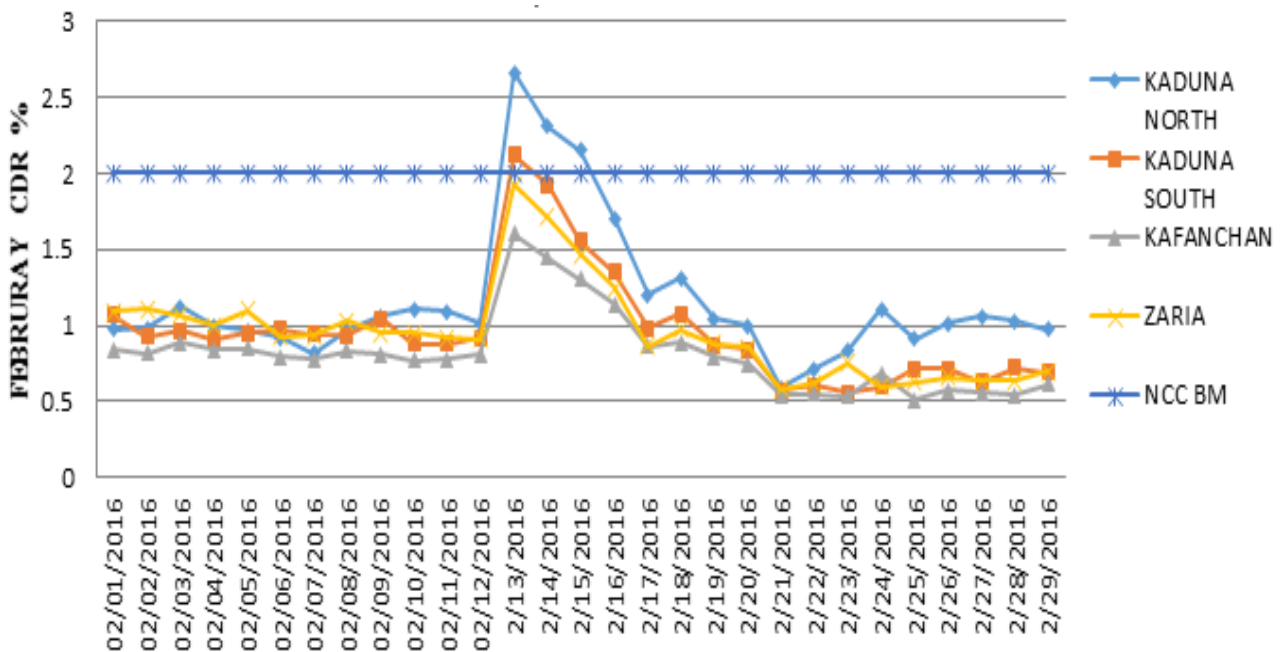


Figure 5: February, 2016 CDR Results for Kaduna North, Kaduna south, Kafanchan, and Zaria

Low signal strength on downlink or uplink, lack of best server, congestion in neighboring cells, battery flaw, poor quality on down or uplink, missing neighboring cells definitions, unsuccessful outgoing handover, unsuccessful incoming handover, low BTS output power are other issues which could have contributed to the poor performance in these areas. The overall performance for the month showed that Kaduna North achieved an average performance of 1.16%, Kaduna South had an average performance of 0.96%, Kafanchan recorded an average performance of 0.82% and Zaria had an average performance of 0.95%. These implied that Kafanchan with the least average value of CDR had good performance and better QoS than any of the three areas of Kaduna North, Kaduna South, and Zaria. Comparing these

values with the NCC standard benchmark values of $\leq 2\%$, the performance of each of the three areas studied was very good due to low CDR values recorded by the four locations researched into.

3.5. CDR Results for March, 2016

Figure 6, it was observed that there was a high rate of call drop beyond the NCC benchmark of $\leq 2\%$ from 24th to 27th March, 2016 for Kaduna North and for Kaduna South, this occurred between 3rd and 7th of March, 2016. These high call drop rates were as a result of poor quality on downlink or uplink, missing neighboring cells definitions, unsuccessful outgoing handover, unsuccessful incoming handover, low BTS output power.

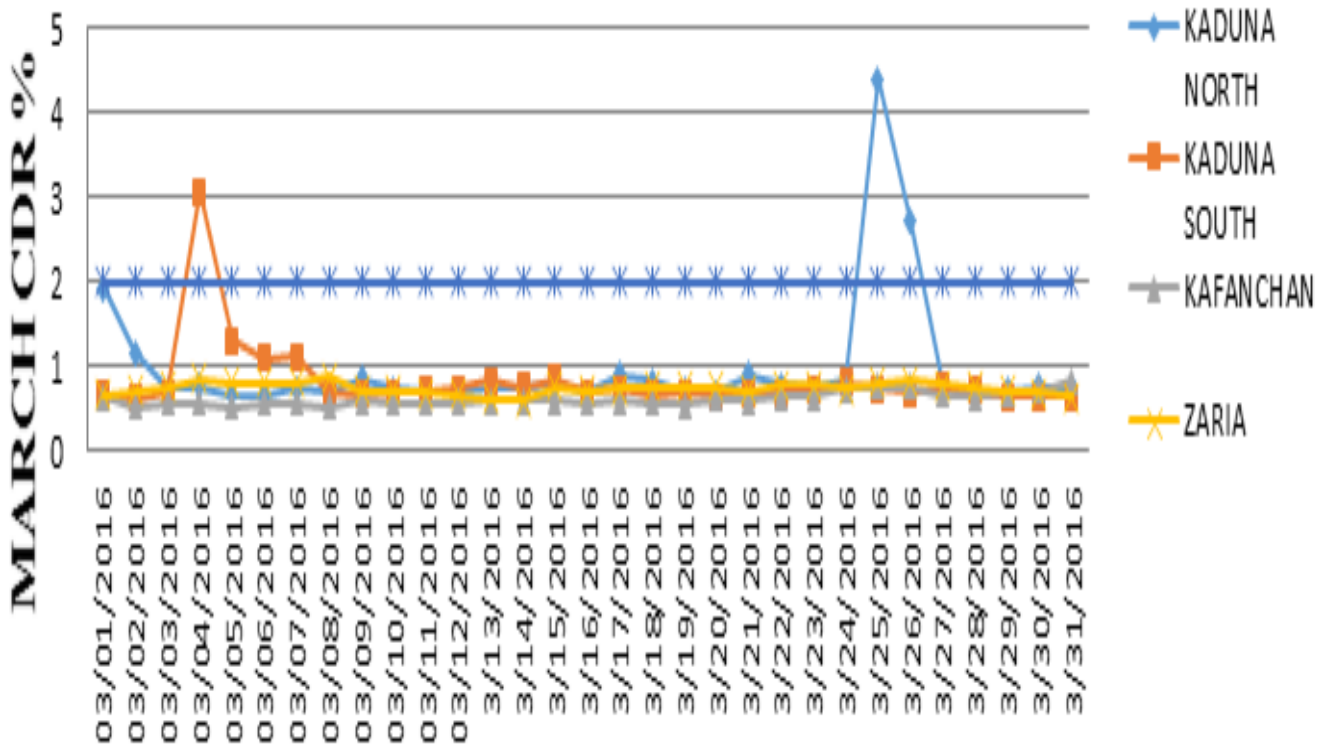


Figure 6: March, 2016 CDR Results for Kaduna North, Kaduna south, Kafanchan, and Zaria

The total average value of call drop rate for Kaduna North was 0.99 %, Kaduna South achieved 0.83 %, Kafanchan recorded as low as 0.62%, and Zaria had 0.75%. These values for the respective areas studied in March, 2016 were also good because each area registered a value less than the standard benchmark value of $\leq 2\%$ recommended by NCC, particularly Kafanchan area with the CDR value as low as 0.62%.

4. RECOMMENDATIONS

In order to improve the network performance and the quality of service, it is recommended that the management of MTN Nigeria and the government regulatory body, NCC should ensure the following:

1. Quality of service for each service rendered to subscribers by network operators such as MTN should be upgraded to 99.50% for successful calls to ensure customers satisfactions.
2. Government should ensure adequate power supply to their site to minimize site downtime due to power failure, also BTS power consumption should be minimized at the design point by manufacturers such as Huawei, Motorola, Ericsson, Alcatel, etc
3. Proper definition of neighbouring BTSs and BSCs should be done for proper and successful handover.
4. MTN should ensure they carry-out constant network upgrade in order to increase the capacities of all existing BTSs in order to be able to handle the subscribers' demand all the time. This will improve the call set up time and also meet up the stipulated KPIs threshold values for good network performance.

5. CONCLUSION

The quality of service of the KPI results for in the four locations (Kaduna North, Kaduna South, Kafanchan, and Zaria) during the three months' period of January, February, and March, 2016 showed considerable good performance by the MTN network in all the locations in terms of call drop rate because they all performed well within the [7] benchmark. Kaduna North experienced good call setup success rate, but other locations require some improvement in order to meet up NCC benchmark. The results also indicated that it was only in Kafanchan that the subscribers enjoyed good quality of handover of calls, but not in Kaduna North, Kaduna South, and Zaria where improvement in needed. In general, the entire MTN network need

to be expanded base on their large number of subscribers in Nigeria (Kafanchan, Kaduna South, and Zaria, in particular). The large traffic caused congestions which in turn result in high call setup failure rate and handover failure rate Therefore, if the large traffic volume problem is addressed it will ensure good quality of service in the MTN network and in turn their subscribers will enjoy unlimited good quality of service

References

- [1] Adegoke A.S. and Babalola I. T. (2011), "Quality of Service Analysis of GSM telephone system in Nigeria," America Journal of Scientific and Industrial Research, Am. J. Sci. Res, 2(5): pp707-712J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
- [2] Adegoke A.S, I. T. Babalola and W. A. Balogun (2008), "Performance Evaluation of GSM Mobile System in System in Nigeria." The pacific Journal of Science and Technology, Vol 9, Number 2, pp 23-26.K. Elissa, "Title of paper if known," unpublished.
- [3] Adekitan, Rasheed Akanfe (2014), "Performance Evaluation of Global System for Mobile Telecommunication Networks in Nigeria".SCSR Journal of Business and Entrepreneurship (SCSR-JBE) Volume 1, Issue 1 (February, 2014), pp 09 – 21
- [4] Gordon Ononiwu¹, Bukola O.H. Akinwale ², Cosmos Agubor¹ and James Onojo (2016) " Performance Evaluation of Major Mobile Network Operators in Owerri Metropolis of Nigeria" ISSN (Print): 2279-0047, ISSN (Online): 2279-0055, pp. 06-13 International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS)
- [5] Idigo V. E., A.C.O. Azubogu, C. O. Ohaneme and K. A. Akpado(2012), "Real-Time Assessments of Quality of service of Mobile Cellular Networks in Nigeria". International Journal of Engineering Inventions. Vol.1, Issue 6, pp 64-68
- [6] Joseph Isabona and Kingsley Obahiagbon (2014), "A practical Optimisation Method to Improve QoS and GoS-Based Key Performance Indicators in GSM Network Cell.
- [7] Nigeria Communication Commission (NCC, 2015) "Quality of service and QoS Metrics Use by

- Nigeria Communication Commission.” pp 93-107, www.ncc.gov.ng
- [8] Nnochiri Ifeoma.U. (2015), “Evaluation of The Quality of Service of Global System for Mobile Telecommunication (GSM) Operators in Nigeria” Journal of Multidisciplinary Engineering Science and Technology (JMEST) I ISSN: 3159-0040, Vol. 2 Issue 7, pp 1686-1693.
- [9] Obota, M.E and Agbo, P.E. (2012), “Strategies for Improving Quality of Service (QoS) of Global System for Mobile Communication (GSM) in Nigeria,” Journal of Research and Development. Vol.4. Number 1, pp123- 127
- [10] Ozoveche A.S and A.U Usman(2015), Performance Analysis Of GSM Networks In Minna Metropolis of Nigeria.Nigerian Journal of Technology (NIJOTECH) Vol. 34 No. 2, pp. 359 – 367 University of Nigeria, Nsukka, ISSN: 1115-8443
www.nijotech.comhttp://dx.doi.org/10.4314/njt.v34i2.21
- [11] Sheik Manzoor A. K. and Shahabudeen F., (2018) “A Study on Key Performance Indicators and their Influence on Customer Satisfaction in Call Centers” International Journal for Engineering Research (IJER). Serials Publications 11(2), ISSN: 0972-9380. Pg 304-313
- [12] Ukhurebor K. E., (2018) “Evaluation of the Quality of Service of a Cellular Network using the Network Statistics” International Journal of Advanced Engineering and Technology ISSN: 2456-7655, pp 1-7, www.newengineeringjournal.com
- [13] Ukhurebor Kingsley E, Andikara John and Azi S.O., (2015) “Effects of Upsurge of Human Traffic on the Quality of Service of GSM Network in Eagle Square Abuja, Nigeria” Journal of Scientific and Engineering Research Volume 6, pp 1-6
- [14] VenkataSai Sireesha B. +, Dr.S.Varadarajan++, Vivek and Naresh+++ (2015) “Increasing Of Call Success Rate in GSM Service Area using RF Optimization” Engineering Research and Applications (IJERA). ISSN: 2248-9622. Vol. 1, Issue 4, pp1-7, www.ijera.com