EVALUATION OF GSM NETWORK QUALITY OF SERVICE USING HANDOVER SUCCESS RATE AS PERFORMANCE MATRICES

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Keywords: –
Handover Success Rate, QoS, Network Provider, Subscribers.

Article History: –
Received: July, 2020.
Reviewed: August, 2020
Accepted: September, 2020
Published: September, 2020

ABSTRACT

Wireless cellular communication systems have experienced a positive transformation over the past decades. Today there is a global change in the use and operations rendered by cellular networks. Cellular phones not only enables receive and call from almost anywhere worldwide, but also facilitates other business services that are very much vital to society. Handover process is considered as the procedure that takes current call from one cell to another as the demand (user) moves through the coverage area of a cellular system. Better-quality Cellular network performance is achieved if an efficient handover prioritizing structures are put in place when a user is moving between the cells. As the number of subscribers of GSM in Nigeria increases, the demand for good QoS has become a matter of concern in the country. In finding a lasting solution to the problem, the Nigerian Communication Commission (NCC), the body responsible for the regulation of Telecommunications sector in Nigeria, issued out the threshold levels on the key performance indicators (KPIs) for ascertaining QoS of all the GSM networks in the country. In this paper we try evaluating, analyzing the QoS of MTN GSM network in four topographical areas of Kaduna State (Kaduna south, Kaduna North, Zaria and Kafanchan), Nigeria using Handover Success Rate (HOSR) as performance matrices. 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.

1. INTRODUCTION

Essentially, the communication between the caller and the called is considered as the service of all cellular networks. To achieve this package, the network must sustained and maintain a call, which involves numerous tasks: recognizing the called, ascertaining the location, routing the call and confirming that the connection continued as long as the call discussion continues. After the operation, the connection is terminated and caller (user) is charged for the service rendered [1].

Generally, the GSM runs a common set of services to its numerous users or customers worldwide. The method of handover within any cellular structure is considered very vital. This process is critical, which if executed incorrectly which can result in call drops [2]. Therefore, to sustain the process and keep existing users, as well as encouraging new ones, the GSM service providers needed to deliver its services unfailingly and reliably to meet the customer's satisfaction. The service rendered is directly dependent on the quality and the performance of the network to which mobile network service providers must be ready to sustain [3]. In GSM network setup, indices have shown that the coverage area is divided into different cells and segments which comprises of a Mobile Station (MS) which linked the Base Transceiver Station (BTS) through air interface. BTS encompasses other features like the Transceiver (TRX), which provides for the transmission and reception of numerous radio frequency (RF) signals to and from the end user. Connection is established between the BTS to the Base Station Controller (BSC) through ABIS connection interface [1], [4], [5].

Four models of layer define QoS parameters, they include: (i) the Network Availability which defines QoS from the perspective of the network and service provider. (ii) The Network Access, which is the prerequisite for all the other QoS features and QoS considerations. The result here is the QoS parameter Network Availability from the perspective of the customer or end user. (iii) Covers the three QoS features: Service Access, Service Reliability and Service sustainability. (iv) The different services to be rendered to the customers or end users. The results represent the QoS parameters for the respective services rendered [6].

Handover process is a very important aspect in GSM business. It represents one of the main key performance indicator (KPI) in all the GSM networks. While the network monitoring process is going on, The KPIs parameters are to be observed closely. Mostly, the term KPI is used for factors related to voice and data channels, but network performance indicators can be generally characterized into coverage, capacity and quality standards also that cover the speech and data aspects and it is considered as a competitive advantage for service providers which each struggles to achieve [7]. Handover initiation can also be considered as method used in deciding when a request to a handover is taken place. Handover is centered on received signal strength (RSS) from the current base station and the next base station [8]. Another important objective for trying a handover, apart from signal strength and quality, is when the Timing Advance (TA) used by mobile station go beyond a threshold value agreed by the operator [9]. This occurs when the mobile station is moving over the cell edge to another cell. The failure of the handover process is regarded as the drop of quality of service which in turn dissatisfies the customers or users [10], [11], [12].

The threshold levels of the KPIs approved by the NCC for ascertaining QoS of all the GSM networks in the country are as follows: I. Call Setup Success Rate (CSSR) II. Call setup failure rate (CSFR) III. Percentage Call Drop (PDROP) IV. Handover failure rate (HOFR) V. Handover success rate (HOSR) [13]. Therefore, once a radio telephone network is designed and operational, its performance should be monitored to improve overall service quality [3].

The following are some of the possible reasons for the poor HOSR: (i) Congestion (ii) Link connection (iii) Bad antenna connection (iv) The MS measures signal strength of another co-or adjacent cell than supposed (v) Incorrect handover relations (vi) Incorrect locating parameter settings (vii) Bad radio coverage (viii) High interference, co-channel or adjacent [7], [14].

Thus, the need for network performance monitoring for QoS assessment, analysis of faults and corrective measures comes in. In addition to monitoring network faults, the operator also needs immediate information on how the network performs, especially from the end user perspective [1].

The quality of network is, therefore, an important index in the competition for users. This can be attained when the network is effectively optimized to meet the predictable QoS from its clients [23, 24].

2. MATERIALS AND METHODS

The tools used in carrying out this research work are as follows:

(i) Data collection from the network was possible by using File Transfer Protocol (I-Manager M2000). ii. Plotting the results of data collected from the network was achieved using Microsoft Excel tool box. Based on KPIs values gathered, the collected data from MTN network management center was investigated. The method adopted in achieving the said goal are as follows: (i)

Analysis of the data set. (ii) Determination of average KPI (HOSR) values. (iii) Results discussion.

2.1. Analysis of Collected Data

Based on daily assessment from the Base Station Controllers (BSCs), the analysis of the data set for each of the studied sites were investigated. These includes: Abuja BSC (ABHBSC7), Abuja BSC (ABHBSC13), Kaduna BSC (KDHBSC8), Kaduna BSC (KDHBSC15), Kaduna BSC (KDHBSC4), Kaduna BSC (KDHBSC1), Kaduna BSC (KDHBSC3), and Kaduna BSC (KDHBSC9), respectively. Transfer Protocol (FTP) which is a file (I-Manager M2000) was used to retrieve the data from the network at the Network Management Switching (NMS) center.

2.2. Determination of Average of HOSR

The average variable was already evaluated from the raw data set obtained from the Network Management Center (NMC) for each of HOSR. MS-Excel tool box was used to acquire the average variable of HOSR on a day-to-day basis for a month. GSM systems require a process known as Handover to withstand the continuity of the users call since a single cell is restricted to a limited service area. Furthermore, a single cell has the highest service area of about 35 km for each antenna. The lesser the size of the cell the faster the movement of the mobile station over the cells and the more handovers of calls are required [15]. HOSR is also considered as the percentage of successful handovers of all handovers. A handover attempt is established when a handover command or instruction is sent to the mobile. Poor HOSR are manifested through congestion, link connection, incorrect handover relations, incorrect locating parameter setting, bad radio coverage, high interference, co-channel or adjacent [16]. Ninety-Nine percent (99%) is the busy hour HOSR by NCC at all hour [22]. The handover process is run when there is a need for a cell change when the mobile station is busy. The network is responsible for making the handover decision and performing the actual handover [1].

The HOSR represent the percentage of positive handovers of all handover attempts. A handover attempt is when a handover command is directed to a mobile [7].

HOSR indicator is defined as the rate of successful handovers (intracell + intracell) (1)

$$\text{HOSR indicator formula} = \frac{\text{No of successful [intercell + intracell] x HA1}}{\text{Total number of handover requests}}$$

$$= \left[\frac{(\alpha+\beta)}{(\gamma+\eta)}\right] \text{ x 100 Condition Applied} \quad (2)$$

where,

α is the number of incoming successful handovers
β is the number of outgoing successful handovers
γ is the number of outgoing Handover requests
η is the number of incoming Handover requests.
HA represents the Handover Attempts
[16], [17], [18], [19], [20]

Note, for simplicity Handover Failure Rate (HOFR) is a vital indicator for checking mobility. Handover failure implies that mobile station tries to make a handover (inter/intra cell) but for some reasons it fails. These values are kept within some defined threshold in order to meet the required QoS standards accepted by the monitoring bodies

like Nigerian Communications Commission (NCC) for customer's satisfaction [25].

HOFR can be expressed in percentages as:

$$HOFR = \alpha/\delta \times 100\% \quad (3)$$

where,

α = Number of Handover Failures

δ = Number of Handover Attempt

[25]

2.4. Evaluation of KPI Values

Quality of Service (QoS) and Quality of end-user Experience (QoE) are considered the two main methods used for assessing the performance of GSM services. While the former is decided by service providers, the latter is determined by feedbacks from end-users. Evaluations of GSM services from service providers' viewpoint is usually based on some Key Performance Indicators (KPIs) [26], [27]. Therefore, in this paper we try basing our findings on HOSR which is one of the key performance indicator.

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 based on evaluation and performance analysis of the quality of service results that were obtained on HOSR. We then compare these results with the NCC benchmark. The operators are mandated to ensure they meet the NCC QoS technical standards. The NCC functions as a monitor, ensuring that minimum QoS standards in service delivery for the telecommunications industry in Nigeria is strictly obeyed [21]. Table 1 is the set NCC KPI benchmarks followed by all operators of mobile services in Nigeria. The table serves as guide adhering to the quality of service measured based on the NCC standard per the key performance indicator. From Table1, the QoS was measured base on this NCC standard KPI value for all the key performance parameters manipulating the QoS of a network [21].

Table 1 NCC KPI Benchmarks [21].

S/NO	QUALITY PARAMETER	TARGET VALUE
1	Handover Success Rate (HOSR)	≥ 98(%)

3.1 ANALYSIS, RESULTS, AND DISCUSSION

To enable easy comparison and discussion of this results, performance study to assess the QoS KPI values of this work against those of NCC was carried out in this Section. Graphical representation of the results for the months of January, February, and March, 2016 on a day-to-day basis. Generally, handover will occur under the following conditions: A busy mobile station which is roaming from a cell into another cell or a mobile station is making a call at overlapping area of two cells one of which is very busy in traffic, BSC notify Mobile station to measure signal intensity and channel quality of adjacent cells. This call will be handed over to the cell which is not busy in traffic Objects to be examined: the neighbor cells with an outgoing handover success rate and the

serving cell with an incoming handover success rate [14].

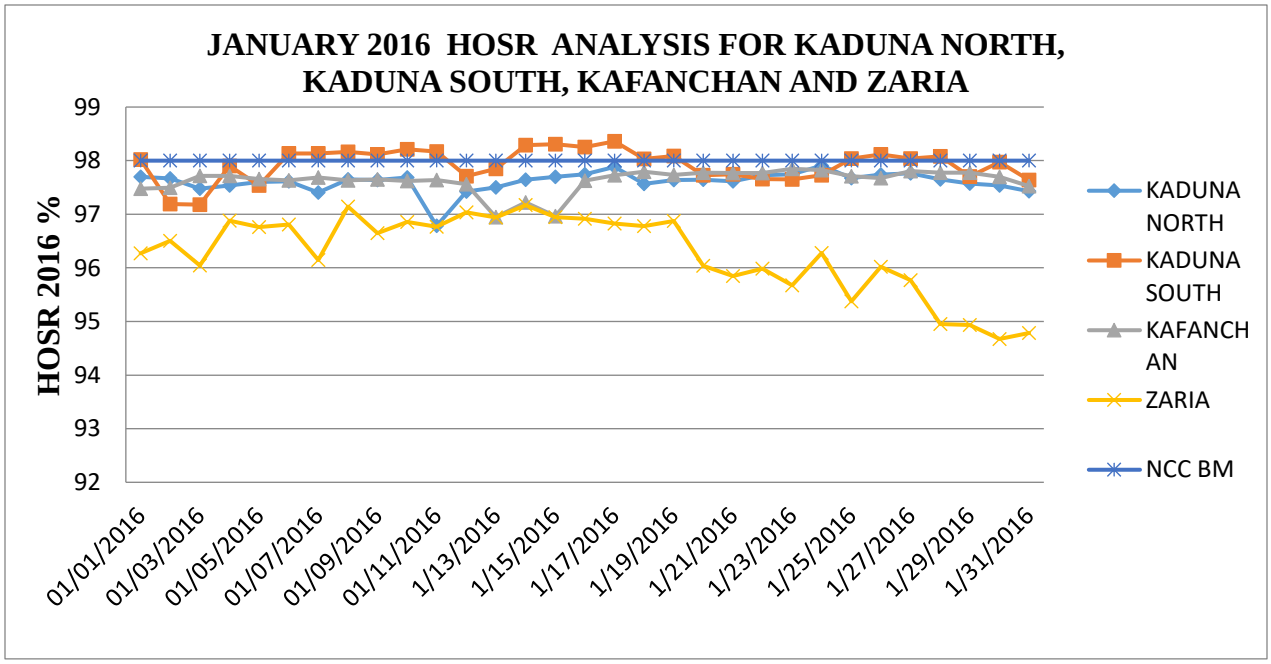

Figure 1. Graph of January 2016 HOSR: Results for Kaduna North, Kaduna south, Kafanchan, and Zaria

3.1.1 HOSR Results for January, 2016

BSC is successfully. The NCC handover success rate (HOSR) benchmark value is set at 98%. This implies that (HOSR) value below 98% indicate poor network quality. Figure 1 shows the analysis of the HOSR for the four topographical areas studied in the month of January, 2016 on the assessment of their QoS performances. It could observe that Zaria had a very poor handover performance of an average values of 96.27887054%, Kaduna North had a monthly average of 97.60858556%, Kaduna South also had an average value of 97.92684211% performance. Kafanchan also couldn't meet up the standard NCC benchmark with performed average values of 97.62713479%. All of these four locations studied performed below the NCC threshold of ≥ 98% throughout the month of January which implies a poor quality of service for the subscribers. These could be as a result of transmission problem i.e. Transmission fluctuations or serious bit error rate (BER) in transmission link, targeted cell congestions, poor coverage (Missing adjacencies of cells) or Hardware faults (such as BTS transceiver) can also being incorporated as a decreasing HOSR, which is a part of BSC failures.

3.1.2 HOSR Results for February, 2016

Figure 2. shows that Zaria performed worst below the standard benchmark of ≥ 98% throughout the month of February 2016 with an average performance of 96.6354601%. Kaduna South had a poor handover between

1st to 7th same month but improved thereafter from 8th to 29th with total average value of 98.09285904 % above the NCC benchmark. The early fall in handover emanated from the last days of January 2016 results which were caused by traffic congestion, link connection failure, Bad radio coverage, incorrect handover ration, high interference, hardware failure etc. While Kaduna North experinced the worst handover throughout the month with an average value of 97.45819859% a little below the NCC benchmark. This implies that subcribers did not enjoy a smooth or good quality of service during this period. Kafanchan, also had a poor handover at early period of the month similar to that of Kaduna South between 1st to 10th of February but later improved from 11th to 29th with a total average value of 98.34565887 % in accordance with the NCC benchamark of ≥ 98% which shows there was a good quality of service in this location compare to other location for the month. Apparently these were caused by traffic congestion, link connection failure, Bad radio coverage, incorrect handover ration, incorrect locating parameter setting, high interference, hardware failure and the MS measures signal strength of another co-or-Adjacent cell than presumed.

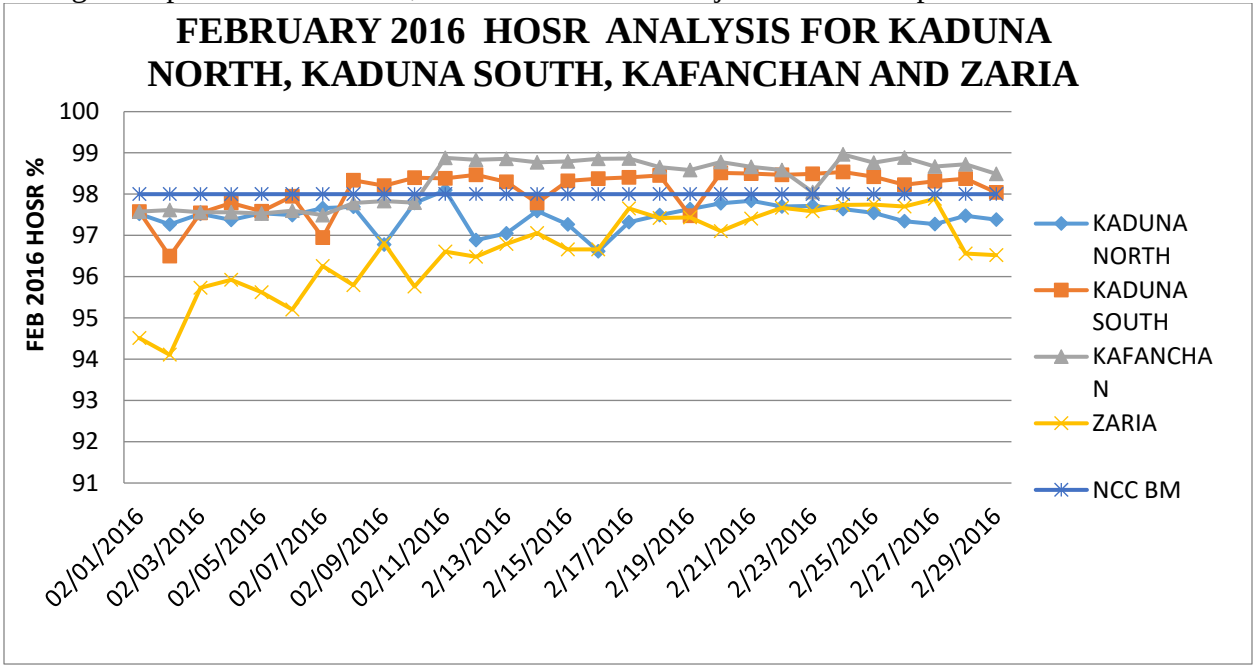

Figure 2. Graph of February 2016 HOSR: Results for Kaduna North, Kaduna south, Kafanchan, and Zaria

3.1.3 HOSR Results for March, 2016

Figure 3 presents March 2016 handover performances for the four locations understudy. This indicates that there was a poor handover rate in all the locations(Kaduna North,Kaduna South and Zaria) except Kafanchan with a little inprovement from 10th to 31st which had an average HOSR of 98.07797177% in accordance with NCC benchmark. Kaduna South had an average montly performance of 97.77267177% a little below the stipulated NCC benchmark of ≥ 98%. Meanwhile the performance struggled to meet up the standard between 2nd ,3rd,4th and 5th days before subscribers began to experienced poor quality of service until 15th, 16th 17th,18th,19th, 20th, 21st to 27th where there was a slight stability of service at the level of NCC benchmark which may be due to poor

coverage and inconsistent handover rate as can be seen on the representation in Figure 3. Kaduan North, had a poor handover rate with 97.28763896% quality below the NCC bemchmark which implies that MTN subscribers had a bad experinece in terms of the network because of instability to hand over calls from one cell to another. Zaria had the worst handover ratio in the month of March with an average values of 96.9% due to poor coverage (Missing adjacencies of cells) or Hardware faults (such as BTS transceiver), RF antenna not properly defined which needs to be optimized for effective handover rate.

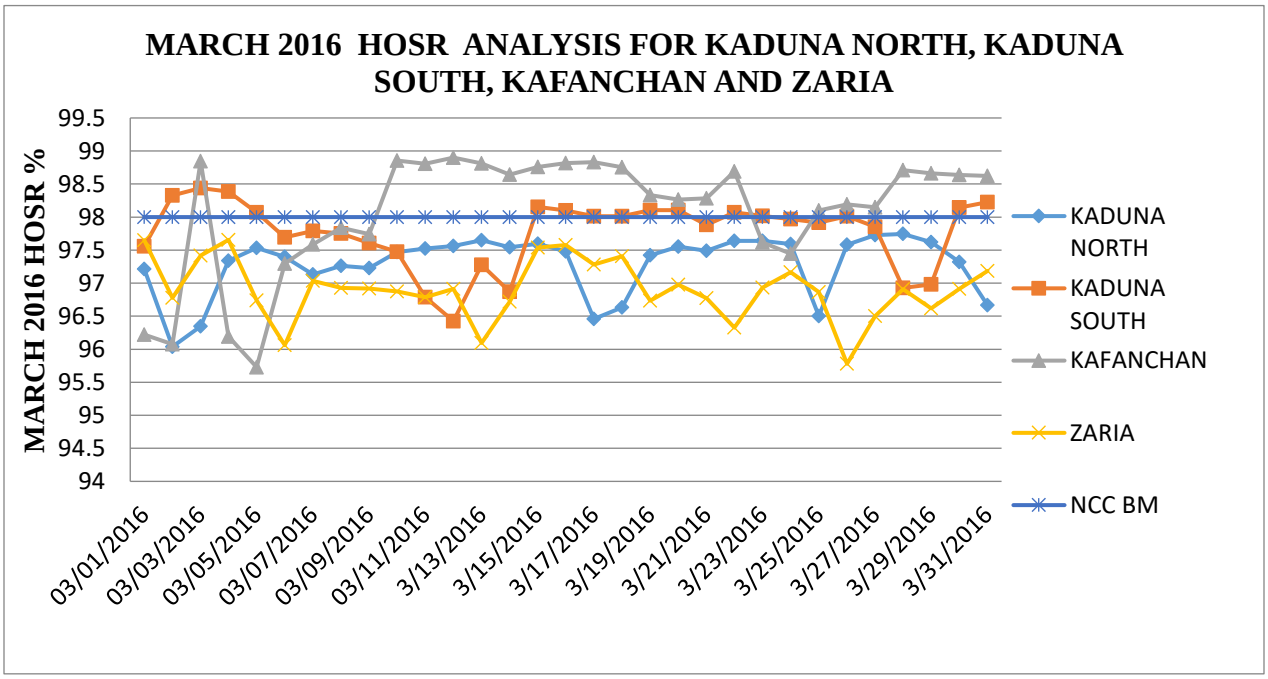

Figure 3. Graph of March 2016 HOSR: for Kaduna North, Kaduna South, Kafanchan, and Zaria

4.0 RECOMMENDATIONS

In order to improve the network performance and the quality of service, we recommend that the management of MTN Nigeria and the government regulatory body (NCC) should ensure the following:

1. Constant network upgrading by the MTN in other to increase the capacities of the existing base stations for the network to be able to handle the demand from their clients. The outcome of this will indeed go a long way in meeting the stipulated KPIs for good performance.
2. Development in terms of research algorithms to serve as means for
3. monitoring,evaluating, and analyzing QoS performance of cellular networks.
4. MTN should ensure that all traffic alarms on the BTS such as voltage standing wave ratio (VSWR), receive signal strength indicators (RSSI) etc. are cleared to enhance successful handovers.

5. The Federal Government, NCC and other regulatory bodies should enforce a regular monitoring of the network operators and submission of reports on their performances at very short intervals so that quality of service (QoS) can be established to meet up with demands of the subscribers.

6. Quality of service comparison with other operators (Etisalat, Glo, Airtel etc) using KPI analysis should also be encouraged in future research works.

5.0 CONCLUSION

Data analysis, results and discussions have shown that longer session of rains had an adverse effect on the signal strength which is a critical factor in any cellular network, also the continuous power outages contributes to poor quality of service which must be considered in planning and ensuring good and better quality of service by any of the Telecommunication operators. The quality of service of the KPI results for the four locations (Kaduna North, Kaduna South, Kafanchan, and Zaria) during the three months period of January, February, and March, 2016 showed Zaria had the worst performance by the MTN network in all the locations in terms of handover success rate and the rest are a little below average of the NCC benchmark [21]. These could be attributed to congestions caused by the large traffic which in turn result in high handover failure rate. A means of decongesting the large traffic volume problem should be addressed to ensure good quality of service for the MTN network and these will go a long way in satisfying their numerous customers with good quality of service.

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