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Assessment of the Key Performance Indices of Cellular Network Providers in Nigeria

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Abstract
This paper focuses on performance improvement of Key Performance Indices (KPI) of cellular networks providers. Aba environment was used as a test-bed for the drive test macromobility. Four Key Performance Indicators (KPIs) namely; Traffic Channel Congestion Ratio (TCH cong. Ratio), Call Drop Ratio (CDR), Standalone Dedicated Control Channel (SDCC) and Call Setup Success Ratio (CSSR) were selected for the evaluation of four GSM networks in Aba metropolis majorly via the existing Base Station Controller (BSC) areas. The selected parameters are perceived to have direct impact to subscriber experiences on the network in the independent survey. The application of drive test and deductive reasoning was exploited to show the non-uniformity of the operators in terms of Quality of Service (QoS) delivery to its end customers. The results obtained shows that in February 2020, Glo SDCC was 0.39, MTN 0.58, Etisalat 1.64 and Airtel 0.58. In March 2020, Glo CSSR was 98.02, Airtel 97.48, Etisalat 96.88 and MTN 96.42. In April 2020, Glo TCH CONG was 0.79, MTN 0.55, Etisalat 0.27 and Airtel 0.79 respectively. It was observed that all the network operators failed to attain the NCC DCR benchmark of 2%. Thus, in February to April 2020, Glo had a better KPI performance with minimal call drops with NCC minimum threshold of 98% and also achieves ≤ 0.2 SDCC minimum threshold. It was also observed that the entire network failed to attain the NCC TCH CONG benchmark of 2.

Keywords: *Key performance indices, Quality of service, GSM operators, Network providers, Subscriber*

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1. Introduction

Mobile telecommunications have become one of the most vibrant service sectors in the country with its growing network coverage. Rapid growth in the mobile industry has brought in a number of foreign operators to start business in Nigeria and the resultant competition in the sector had witnessed steady reduction in call charges. Nigeria today has one of the largest telecom markets in the world, with a combined subscriber base of about 147 million. The subscriber base is continuously increasing and the sector has delivered strong return on investments year on year. The telecom sector is a major sector of the economy contributing greatly to the economic growth of the country, contributing to nearly 8.88% of the Nigerian GDP (NBS, 2017). Poor quality service has become a reoccurring decimal of local mobile telecommunication companies, leading to customer complaints and dissatisfaction with the service. Call dropping, cost to business and call delays are some of the complaints that have been raised by some mobile phone users (Okonedo, 2018). Network Congestion is not left out of the observed challenges. Besides, the mobile node platform lacks an intrinsic decision algorithm for future services integrations as well as poor sensitivity or high Bit Error Rates. These challenges are being experienced via inability to set up calls, call drops, occasional service outages, cross-talks and network congestions among others (Odii and Onuoha, 2018). Responses such as "the number does not exist and the number you are calling is outside coverage area" have become the refrain of some of the mobile operators. More so, mobile network operators in the country have been found to have violated the quality service standards prescribed by the National Communication Commission (NCC) (NCC, 2016).

Again, the designers of cellular networks have not adequately put into consideration design goals for the cellular porting flexibility. Consequently, poor network quality of service results as the number of customer's increases and integration of new web application becomes difficult since they are not originally provisioned for in the design

(Juwah, 2019). Idigo *et al.* (2017) investigated and analyze the Quality of Service (QoS) of cellular mobile networks in Nigeria using some Network Key Performance Indicators (KPIs). Their study was 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). 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 (which is below the NCC threshold of ≤ 2%) and the Busy hour CSSR was 98.7267 which is within the expected threshold set by NCC. However, they carried out its study on CDMA network service. Olatokun and Nwonne (2018) presented a precise analysis of mobile users' behaviour in terms of mobility and traffic that would help to optimize capacity for both circuit and packet switched services. Their research work employed the multiplicity of techniques for the capacity analysis of GSM network in Nigeria. In the work, enhanced stochastic knapsack was evaluated for resource sharing approach in multi-services while using erlang Loss Model for SMS capacity analysis. The work was actualized by the characterization of a typical representation of the Northern part of Nigeria. The work observed that traffic modelling was the critical part of networks modelling.

Kuboye *et al.* (2017) evaluated the significance of price (call rate), service quality, service availability, promotion and brand image and its effect in users' perception in selecting a mobile telecommunication services provider in the Nigerian telecommunication market, using Ibadan, a Nigerian municipality as a case study. The authors observed that the paramount interest of mobile service providers was to achieve optimum consumer's satisfaction so as to retain them, as evaluating the perception of a mobile user in a highly competitive telecommunication market is very a crucial factor leading toward competitiveness and success. In their work, it was gathered that no work has carried an investigation to assess the influence of the attributes of the mobile operators on users' choice of mobile service operators in the life of the Nigerian mobile users. This formed their focal point of study, which was to understand the factors that influence mobile phone users in their choice of a mobile phone service provider in the Nigerian mobile telecom market. The work then examined the influence of call rate, service quality, service availability, promotion, and brand image on mobile phone users' perception in selecting a service provider using Structural Equation Modelling (SEM).

Thus, the problem of this study is that poor quality service has become reoccurring issue that leads to customers compliant and dissatisfaction with the service. Network congestion, call dropping, and call delay are some of the compliant raised by some mobile phone users. The objective of this study is to carry out performance improvement of KPIs of cellular network providers.

2. Materials and methods

2.1. Materials

The materials used for this study include: (a) Ascom equipments, a leading provider of Mission-Critical Communications Network Testing division. (b) Trace mobile: A mobile supporting GSM and GPRS equipped with special software. (c) Global Positioning System (GPS): It is a satellite system that provides users with location of the measurement point. (d) Personal Computer (PC): It is a computer equipped with interface carte RS 232 in order to make the link between the serial output of the MS and the serial port of the PC. (e) General Simulator 3 (GNS3): GNS3 is a Graphical Network Simulator that allows emulation of complex networks. Just like Virtual PC that is used to emulate various operating systems in a virtual environment. These programs were used in virtual environment on the computer. (f) Wireshark: Wireshark analyzer was used to analyze the traffics in the network.

2.2 Method

In this paper, Aba environment was used as a test-bed for the drive test macromobility study. The following are the areas covered from where the drive test scheme was carried out viz: Ukaegbu Road, Umuola Road, Ovom Road, New Umuahia Road, Opobo Road, Ehere Road. These areas are located in Aba, Abia State of Nigeria. The city has an area of about 713km squares with a population of about 776,298 inhabitants. It is an urban area made up of mid-range and few tall buildings. Its day-time temperature fluctuates between 28ºC to 30ºC, while night-time ranges from 22ºC to 23ºC. It has high altitude and undulating terrain. The investigation was conducted form February to April 2020. The GSM networks studied are MTN, Glo, Airtel and Etisalat. The study was conducted using ASCOM infrastructure of NCC. The primary data obtained from this investigation was later compare with secondary data from NCC reference

QoS dataset which gave the same result (NCC, 2017). Consequently, NCC KPI data was leveraged in making the deductions. Four Key Performance Indicators (KPIs) namely; Traffic Channel Congestion Ratio (TCH cong. Ratio), Call Drop Ratio (CDR), Standalone Dedicated Control Channel (SDCC) and Call Setup Success Ratio (CSSR) were selected for the evaluation of four GSM networks in Aba metropolis majorly via the existing Base Station Controller (BSC) areas.

2.3 Key performance indicators (KPI)

The following are the KPI considered in this research (Fakorede, 2016): (a) Call setup success rate (CSSR): This is the rate of call attempts until traffic channel is successfully assigned.

$$CSSR = \frac{No.of\ successful\ seizures\ of\ SDCCH \times 100\%}{Total\ no.of\ request\ for\ seizure\ of\ SDCCH\ channel} \quad (1)$$

(b) Call drop rate (CDR): This is the rate of calls not completed successfully.

$$CSSR = \frac{No.of\ TCH\ drop\ rate\ after\ assignment \times 100\%}{Total\ no.of\ TCH\ assignment} \quad (2)$$

(c) Call Handover Success Rate (CHSR): This is the rate of successful handovers (intracell + intercell).

$$CHSR = \frac{No.of\ successful\ (intracell+intercell) handovers \times 100\%}{Total\ no.of\ handover\ requests} \quad (3)$$

(d) Call Completion Rate: This is the rate of successful completion of both incoming and outgoing calls.

$$CSSR = \frac{No.of\ successful\ completed\ inbound\ or\ outbound\ calls \times 100\%}{Total\ no.of\ placed\ or\ received\ calls} \quad (4)$$

(e) Standalone Dedicated Control Channel (SDCCH). It carries signaling data following the connection of the mobile with base station and just before a TCH assignment is issued by the base station. The SDCCH maintains connection between MS and BS. It is really an intermediate and temporary channel that accepts newly completed call from BSC and holds the traffic while waiting for the Base station to allocate a TCH channel.

$$SDCCH = \frac{No.of\ successful\ TCH\ seizure\ or\ assigned \times 100\%}{Total\ no.of\ TCH\ request} \quad (5)$$

In configuration of calls for the measurement, intra-network call was made between master and slave channels of the QVM. This was done because it is always difficult to identify particular network that is responsible for failures in inter-network calls.

2.4 Analysis process framework

After collecting information using ASCOM infrastructure of NCC, different indicators were combined and analysed in order to detect problems. Figure 1 shows the flowchart test Procedures for Ascom Drive test. The structured approach for QoS involves site survey, using Q-Voice viz-a-vis drive test macromobility. Data transfer for post processing was carried out but if transfer success is satisfied, evaluation is then carried out else the QVoice continues the data acquisition process.

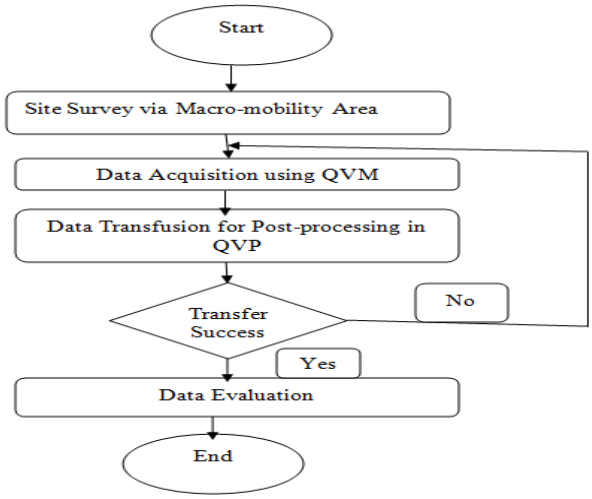

Fig. 1: Structured methodology for QoS data gathering

2.5. Data analysis

Sample of hourly traffic pattern in respect to CSSR, CDR and TCH Congestion were collated from the QVP Network Monitoring System and the data were basically used to sample the performance of all the mobile GSM network operators which was consistent with the NCC (NCC, 2017). An analysis of the collated data was analyzed but the measured data was evaluated against the threshold values set by the NCC which are outlined 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 data samples for the hours of this survey were used to determine the QoS judgment of the KPI values based on the busy hour. The Busy Hour Call attempt (BCHA) Traffic occurred at morning rush hour by 8.00am. The peak period duration (7.00am to 10.00pm) which concedes with the average peak periods used by most networks was also considered in this analysis.

3. Results and discussion

3.1. Results

3.1.1 February

The approach to the analysis is to first look at the performance of the each KPI at a particular month, then carry out a comparative analysis of the various Network performances. Fig. 2 to 5 show the behaviors of the Four (4) networks, MTN, ETISALAT, GLO and AIRTEL in the month of February, 2020.

3.1.2 March

Fig. 6 to 9 shows the behaviors of the Four (4) networks, MTN, ETISALAT, GLO and AIRTEL in the month of March, 2020.

3.1.3 April

Fig. 10 to 13 shows the behaviors of the Four (4) networks, MTN, ETISALAT, GLO and AIRTEL in the month of April, 2020.

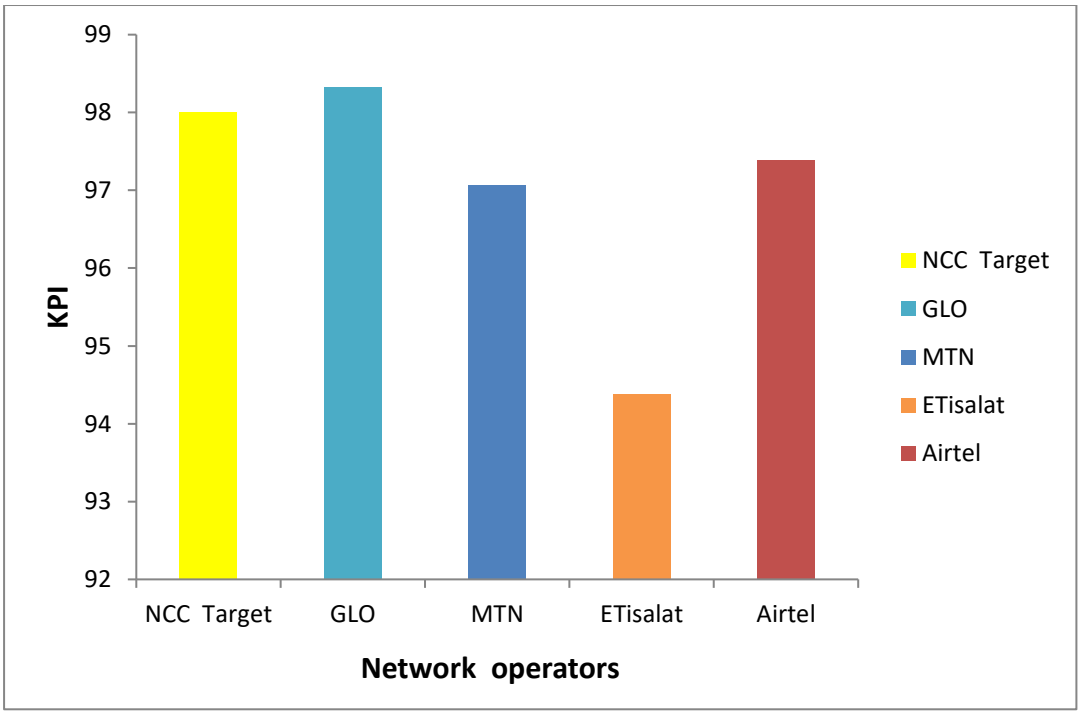

Fig. 2: CSSR KPI against network operators (February, 2020)

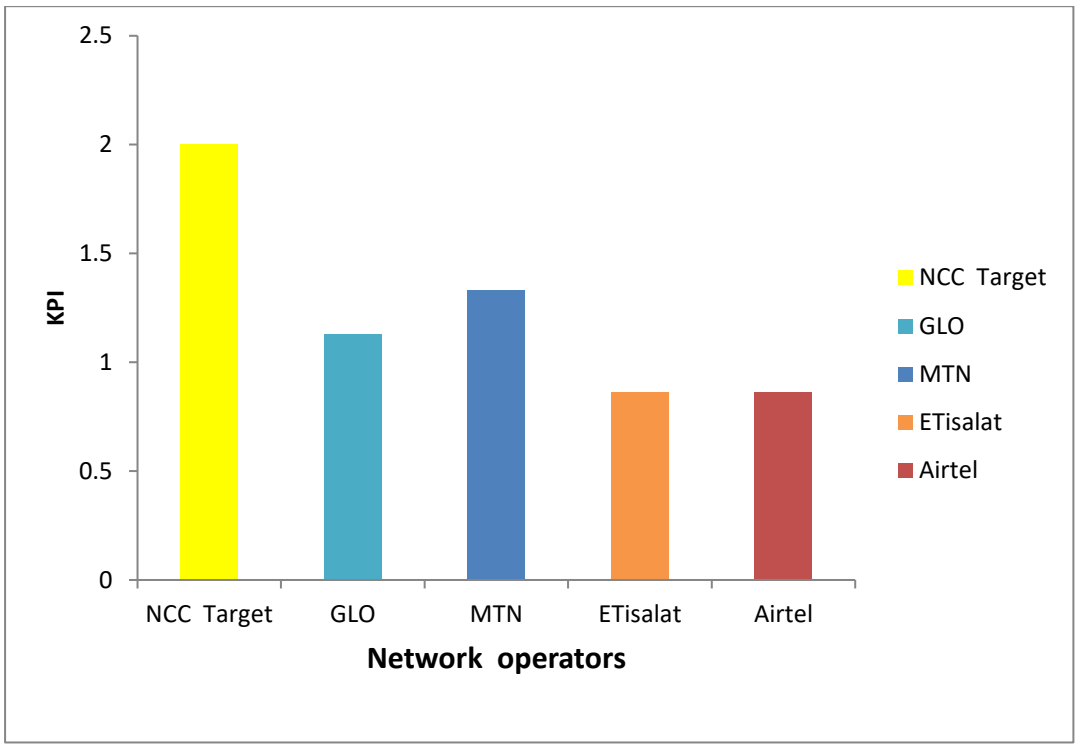

Fig. 3: CDR KPI against network operators (February, 2020)

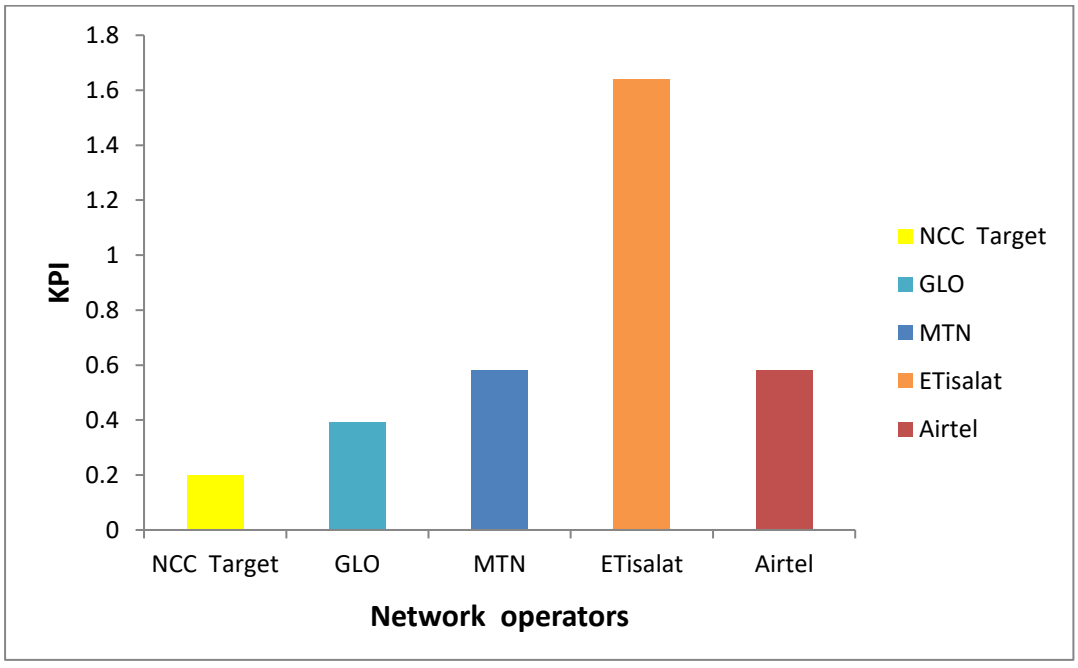

Fig. 4: SDCCH KPI against network operators (February, 2020)

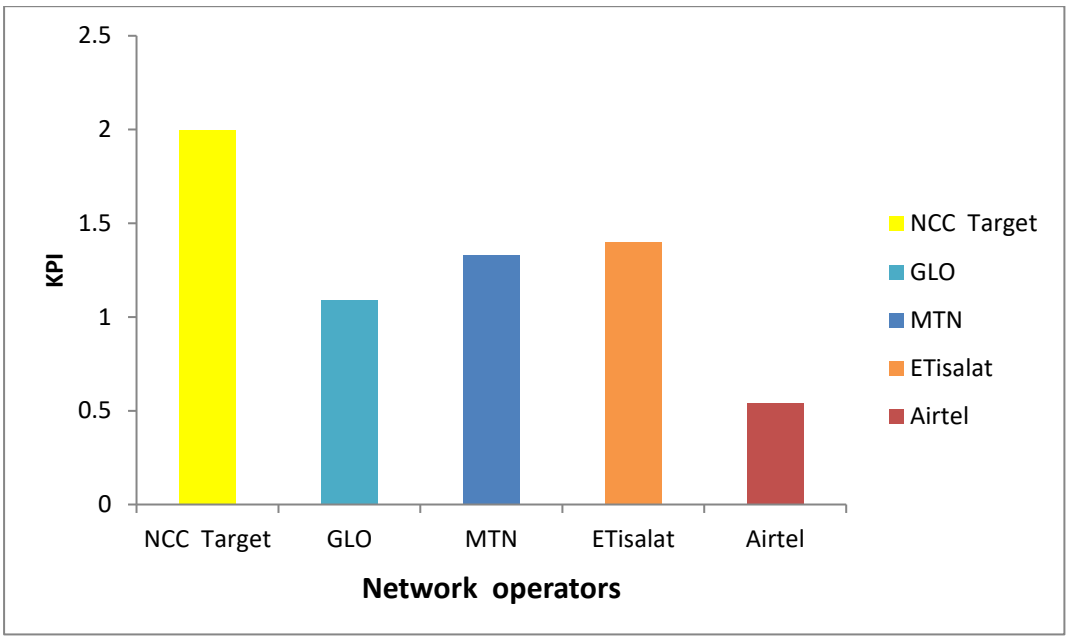

Fig. 5: TCH_CONG KPI against network operators (February, 2020)

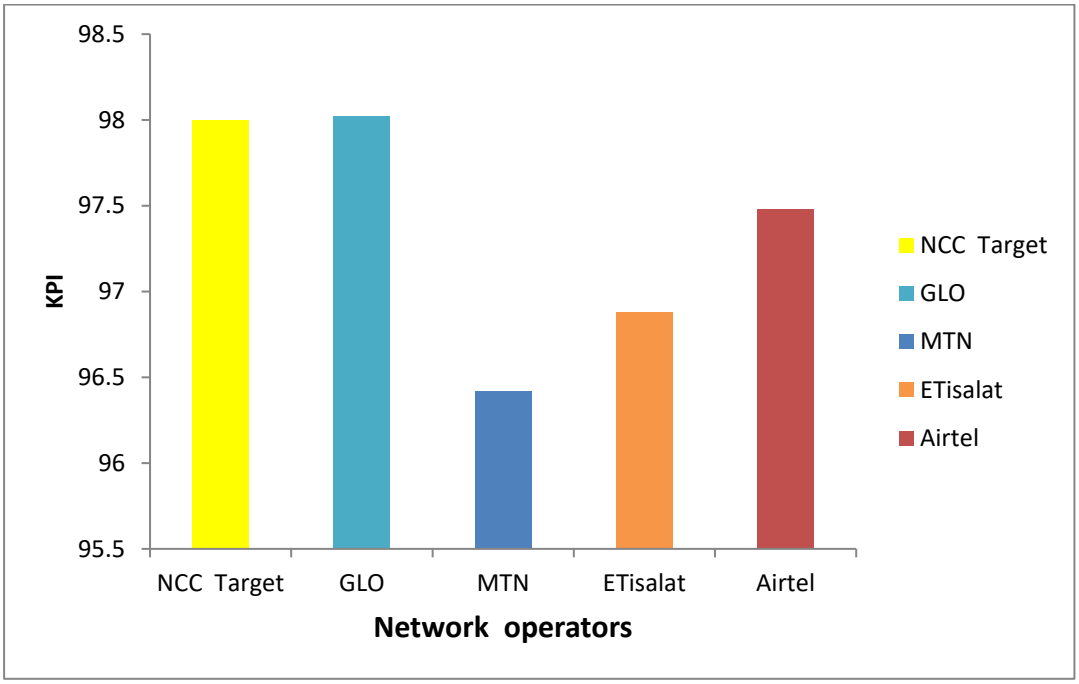

Fig. 6: CSSR KPI against network operators (March, 2020)

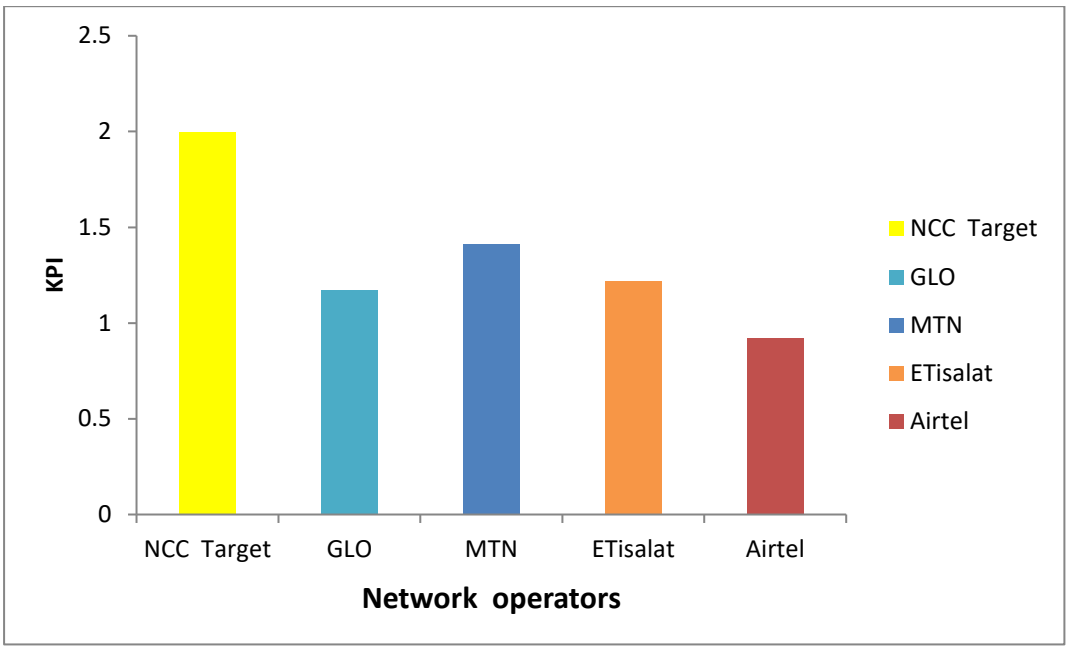

Fig. 7: CDR KPI against network operators (March, 2020)

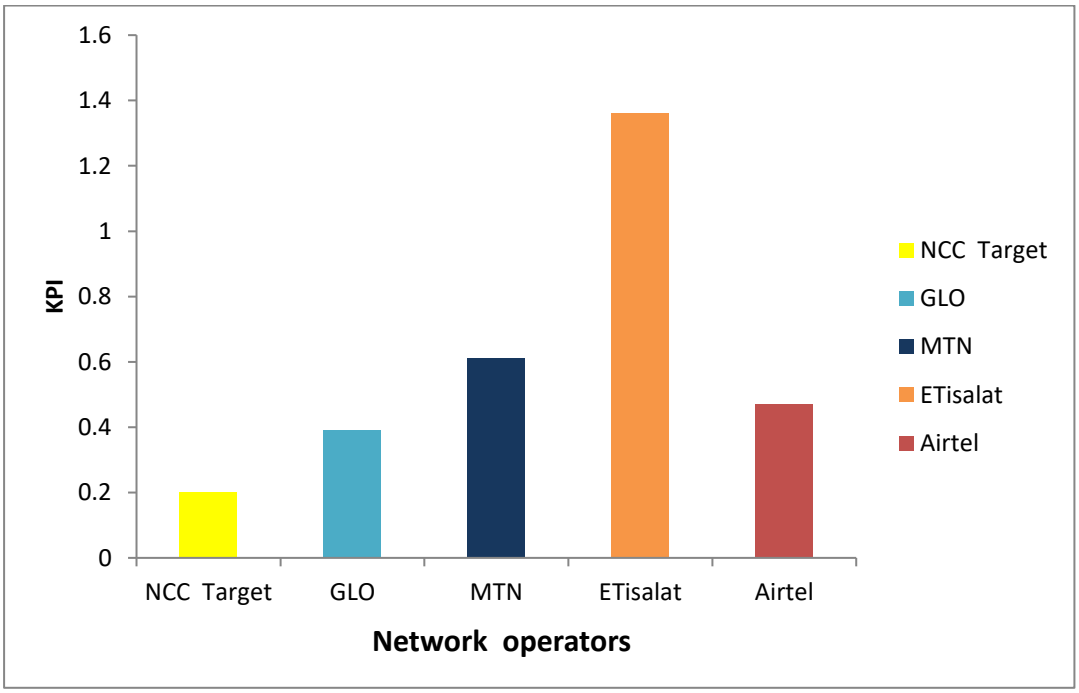

Fig. 8: SDCCH KPI against network operators (March, 2020)

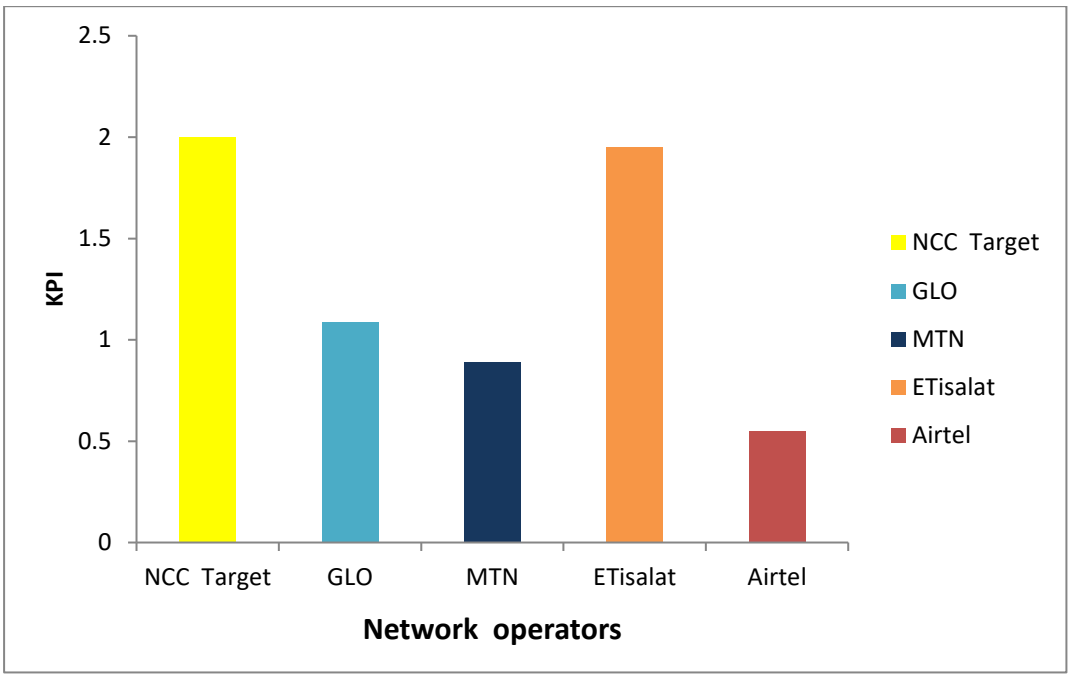

Fig. 9: TCH_CONG KPI against network operators (March, 2020)

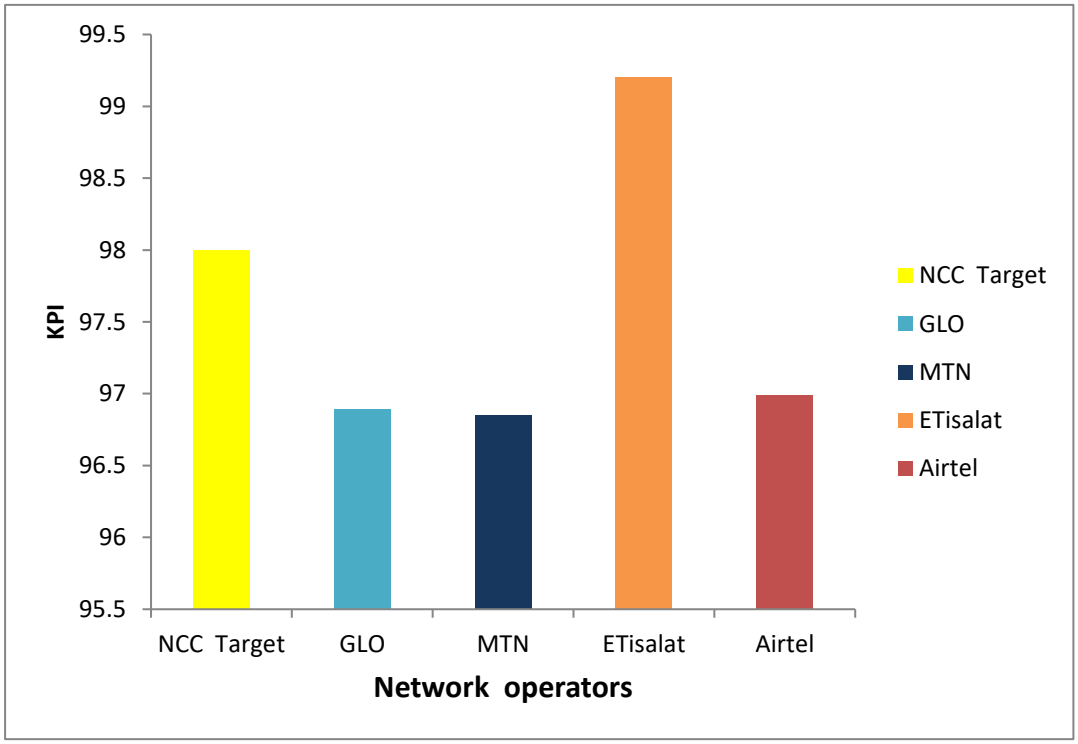

Fig. 10: CSSR KPI against network operators (April, 2020)

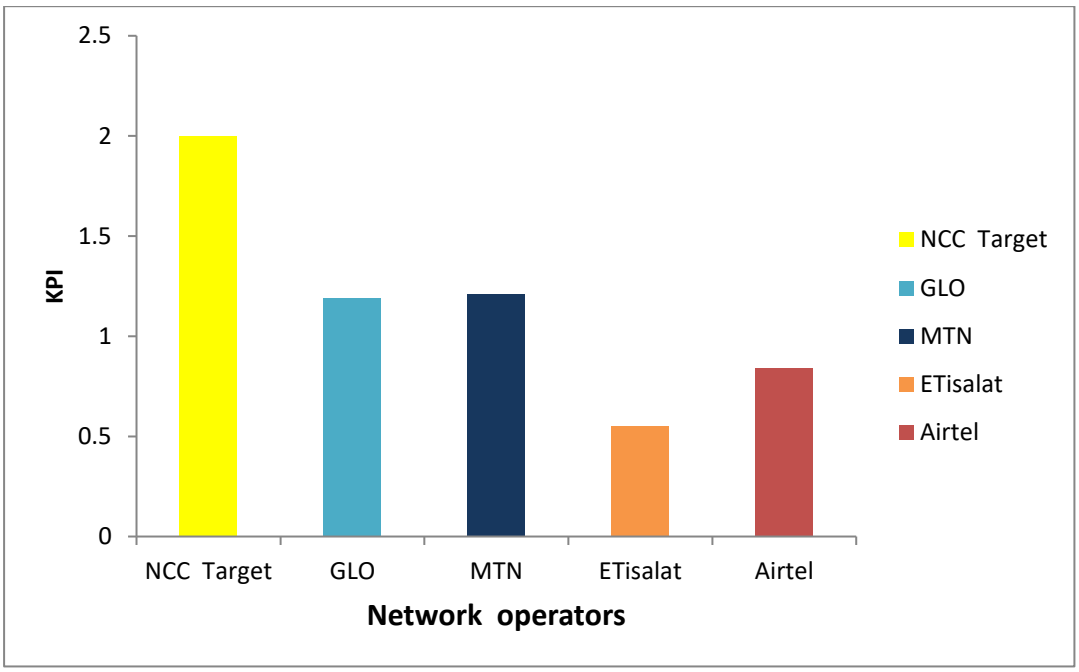

Fig. 11: DCR KPI against network operators (April, 2020)

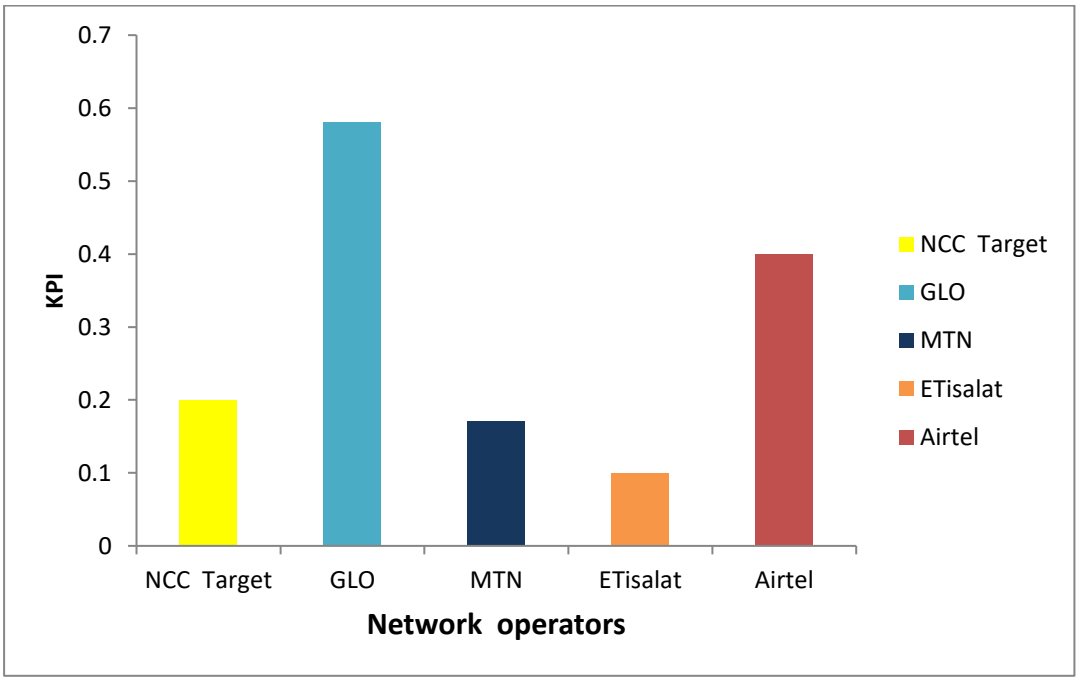

Fig. 12: SDCCH KPI against network operators (April, 2020)

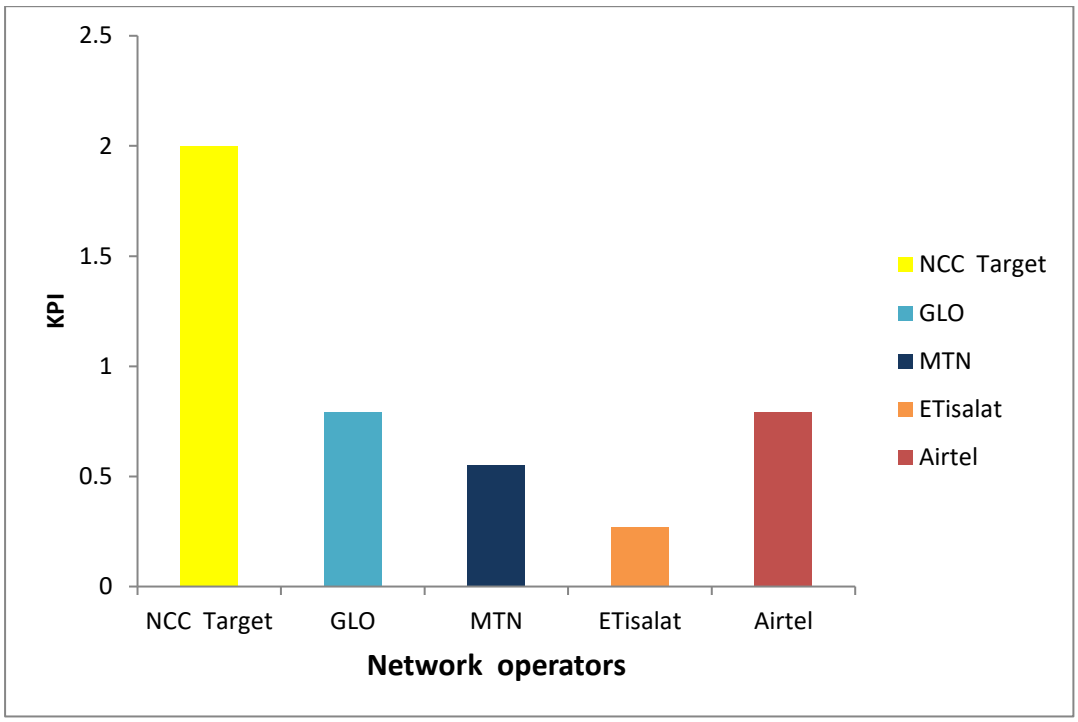

Fig. 13: TCH_CONG KPI against network operators (April, 2020)

4. Discussion

From Fig. 2, it can be seen that Glo (98.33) met and superseded the NCC CSSR minimum threshold of 98**%** in the period under review. Airtel, was 97.39, MTN was 97.07, while Etisalat, was 94.38. From Fig. 3, it was observed that all the network operators failed to attain the NCC CDR benchmark of ≤ 2%. Glo CDR was 1.13, MTN CDR was 1.33, Etisalat CDR was 0.86, While Airtel CDR was also 0.86. The DCR was significantly higher than the reviewers' in the literature (Idigo, *et al.,* 2017). From Fig. 4, it was observed that the entire network met and superseded the Commission ≤0.2 SDCC minimum threshold in the period under review. Glo SDCC was 0.39, MTN SDCC was 0.58, Etisalat SDCC was 1.64, while Airtel SDCC was 0.58. Etisalat had the best SDCC under the month of February. From Fig. 5, it was observed that all the network operators failed to attain the NCC TCHCON benchmark of 2. Glo TCHCON was 1.09, MTN TCHCON was 1.33, Etisalat TCHCON was 1.40, while Airtel TCHCON was also 0.54. From Fig. 6, given that the NCC CSSR target of 98**%**, it was observed that Glo (98.02) met and superseded the Commission minimum threshold in the period under review. Airtel, was 97.48, Etisalat was 96.88 while MTN was 96.42. From Fig. 7, given that the NCC CDR target of 2**%**, it was observed that all the network operators failed to attain the NCC CDR benchmark of 2**%**. Glo CDR was 1.17, MTN CDR was 1.41, Etisalat CDR was 1.22, while Airtel CDR was 0.92. From Fig. 8, given that the NCC SDCC target of ≤0.2**%**, it was observed that all the network met and superseded the Commission minimum threshold in the period under review. Glo SDCC was 0.39, MTN SDCC was 0.61, Etisalat SDCC was 1.36, while Airtel SDCC was 0.47. Etisalat had the best SDCC under the month of February. From Fig. 9, given that the NCC TCHCON target of 2, it was observed that all the network operators failed to attain the NCC TCHCON benchmark of 2. Glo TCHCON was 1.09, MTN TCHCON was 0.89, Etisalat TCHCON was 1.95, while Airtel TCHCON was 0.55. From Fig. 10, given that the NCC CSSR target of 98**%**, it was observed that Etisalat (99.20) met and superseded the Commission minimum threshold in the period under review and higher than reviewers' in the literature (Idigo, *et al.,* 2017). Airtel was 96.99, Glo (96.89) while MTN was 96.85. From Fig. 11, given that the NCC DCR target of 2, it was observed that all the network operators failed to attain the NCC CDR benchmark of 2. Glo CDR was 1.19, MTN CDR was 1.21, Etisalat CDR was 0.55, while Airtel CDR was 0.84. From Fig. 12, given that the NCC SDCC target of ≤0.2, it was observed that Glo and Airtel networks met and superseded the Commission minimum threshold in the period under review. Glo SDCC was 0.58, MTN SDCC was 0.17, Etisalat SDCC was 0.10, while Airtel SDCC was 0.40. Glo had the best SDCC under the month of April, while Etisalat had

the worst SDCC under the same month. From Fig. 13, given that the NCC TCHCON target of 2, it was observed that all the network operators failed to attain the NCC TCHCON benchmark of 2. Glo TCHCON was 0.79, MTN TCHCON was 0.55, Etisalat TCHCON was 0.27, while Airtel TCHCON was 0.79.

4. Conclusion

In this paper, Key Performance Indices (KPI) of network providers which causes poor service quality in Nigeria was examined. The four network operators in Nigeria were analyzed in the context of their KPI data which NCC regulates. The application of drive test and deductive reasoning was exploited to show the non-uniformity of the operators in terms of QoS delivery to its end customers. From the results, it was deduced that there are factors that contributes to GSM operators not meeting the exact expectation of the QoS specified by NCC even though some networks showed improvement over others with respect to some KPIs.

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