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Performance Analysis of Mobile Network Services: A Case Study of Shiroro Power Station, Nigeria.

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***Abstract*-- In this work, performance of four mobile network operators (MNOs) was measured, analyzed, and evaluated in Shiroro Power Station environs and recommendation were made to improve the quality of their voice and data services. Drive test was performed using transmission environment monitoring software's (TEMs) and statistical analysis was done for performance evaluation. The results show that the receive signal strength level was between the ranges of -50dBm to -110dBm as against the standard range values of -30dBm to -70dBm, recommended by the Nigerian Communication Commission (NCC) and the receive quality for Mobile Network A, B and C were observed to be Excellent. This imply that MNO A, B and C met the NCC recommendation in term of receive quality level. However Mobile Network D receive quality level was observed to be poor. MNO C offered the best quality of service in term of call setup time(CST), Call setup success rate (CSSR), Call completion success rate(CCSR) whereas in term of dropped call rate (DCR) MNOA and MNO B were the best. MNO D receive quality signal was observed to be poor in the studied area. Mobile internet service of MNO B was observed to be the best in term of Latency and Throughput follow by MNO C but in term of data rate MNO A was observed to be the best followed by MNO C. Certain technical issues were observed to be responsible for identified poor performances.**

Keywords: Quality of service, mobile network operators, key performance indicators (KPIs), drive test, Mobile Internet Service.

I. INTRODUCTION

Telecommunications remains a fundamental engine for development of any economy. It is a vital infrastructural element that increases the growth and expansion of other sectors such as: Industry, Tourism, Mining, Agriculture, Security, Sport, Defense, Education, Banking, Health, and Transportation [3]. The higher subscription, relative importance of voice and data, client's complaints, impact of qualitative information and need for more revenue by mobile network operator (MNOs) is the main trust of this work.

This paper is divided into six sections. Section I is introduction which provide an insight into what is contain in each section. Section II is review of related work and section III talked about parameters such CST, CDR, CSSR, CCSR, CSFR, Data Rate, Throughput and Latency for the evaluation of quality of service, Quality of service in the drive test area and materials and procedure. In section IV results and discussion were presented under the following; Network Accessibility, Network Retain ability and mobile Internet service. Section V and VI are conclusion and recommendation respectively. The evaluation was undertaken using eight (8) KPIs parameters of Mobile Network Services namely; Call Setup Time(CST), Call Setup Failure Rate(CSFR), Call Setup Success Rate (CSSR), Call Dropped Rate(CDR), Call Completion Success Rate (CCSR), Data Rate, Throughput and Latency.

II. RELATED WORKS

Many research works had been carried out on quality of service (QoS) measurement, evaluation and performance on various KPI parameters of Mobile Network Operators, causes and how to improve on such QoS. The papers reviewed includes[2] , [6], [7], [8], [9],[10], [13],[15],[16], [17] and [18]. The authors adopted different approach to collect data from the Mobile Network Operators for QoS, Network performance evaluation namely; Statistical Network data collection from Network Operation Centers (NOCs) and Drive Test models.

The authors of [3] carried out a study on the quality of service of mobile network operators within the Federal Polytechnic Bida campus. This evaluation was undertaken using some KPIs of mobile network services. These KPIs are: Call Setup Time (CST), Call Setup Failure Rate (CSFR), Call Dropped Rate (CDR) and Call Completion Rate (CCSR). Drive test method was used in this study. The work shows

that the QoS rendered in the area of study for Mobile Users is not sufficient, unreliable and unsatisfactory. Recommendation was made in the paper on how to improve the QoS of Mobile Network Providers in this area. In [1] a study on the GSM quality of service performance in Abuja Nigeria was carried out. The study investigates network transmission impairment and offers some useful remedies. Sony Ericson phone and transmission environment monitoring system are used to gather data on physical network impairments in selected densely populated areas of Abuja. The results obtained indicate that the quality of service performance of Airtel is slightly better than the other three GSM service providers tested within Nyanya, Gwagwalada and Wuse areas in Abuja. [4] evaluated the performance of mobile network operators in Akure metropolis, Nigeria. The result show that the quality of voice service offered by MNOs is not optimal and there is room for improved quality of service. Drive test approach and statistical method are used. The tools used includes; post processing software, transmission environment monitoring software(TEMs), laptop, USB cables, car inverter, GPS. In [5],a study was conducted on four mobile network operators (MTN,Vodafone,Tigo and Airtel) in some selected cities of Accra,Tema and Kumasi in Ghana.It was observed that some of the measured KPIs values were fairly close to the standard set by local (NCA) and the international regulator (ITU) indicating customer should experience fairly good service in those locations, while other values (Traffic channel congestion and call set up time were outside the standard set NCA and ITU which mean customer should experience poor Qos in these area. Measurements are collected over network peak time in each area in order to best capture the effects of congestion on call blocking,CSSR and CDR.

III QUALITY OF SERVICE KEY PERFORMANCE INDICATOR (KPI)

In this work, the following KPI parameters for evaluation were employed; Call Setup Time (CST), Call Setup Success Rate (CSSR), Call Setup Failure Rate (CSFR), Call Drop Rate (CDR), and Call Completion Success Rate (CCSR), Data Rate, Throughput and Latency. The KPI parameters on each network were calculated from the data obtained from the drive test

A. Quality of Service in the Drive Test Area

Area where mobile services are mostly needed and high in demand for social, industrial, educational, economic and businesses purposes was selected. For the purpose of this research the Shiroro Power Station was chosen. The Shiroro power station is an hydroelectric power plant of the Kaduna River in Niger state. Its coordinates is $9^0$58’30”N, $6^0$50’04”E.The population is approximate 1000 people. The Shiroro Power Station currently has all the four major mobile network operators operating in Nigeria. Figure 1 shows the four Base Stations (BS) installed in this area.

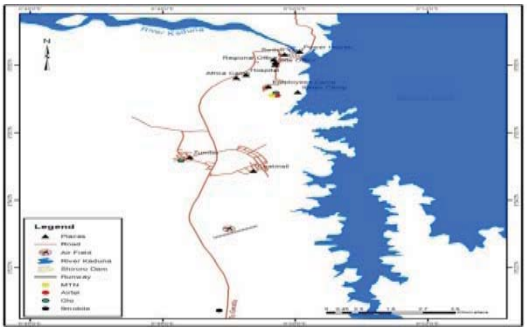

Figure 1: Map of Shiroro power station showing base stations

B. Materials and Procedure

This research measurement was conducted within a period of 5 months (July 2019 - November 2019) during second semester of 2018/2019. The Mobile Networks studied were named Network A, Network B, Network C and Network D. The study was conducted using Transmission Environment Monitoring Software (TEMs) to perform the drive test under the following metrics; Call Setup Time (CST), Call Setup Success Rate (CSSR), Call Setup Failure Rate (CSFR), Call Drop Rate (CDR), and Call Completion Success Rate (CCSR), Data Rate, Throughput and Latency. The KPI parameters were compared with the NCC benchmark [11] and acceptable standard for data communication [19] to see the compliances and also determine MNO with best quality of service. For the purpose of this Research, the following materials and tools were used. Sony Ericson phone and Samsung phone not all phone can be used for this purpose due to phone and SIM configuration, Subscribers Identification Modules (SIMs) Card for all the networks under consideration, inverter car battery, stopwatch, car, Laptop, GPS, and Transmission Environment Monitoring Software(TEMs).

To perform the drive test, TEMs investigation was installed on the Laptop for data collection. Two mobile stations were connected to the laptop one for voice and the other for mobile internet service. Each Mobile Station has a SIM card installed depending on the Mobile Network Operator (MNO). Figure 2 shows the experimental setup. Calls and downloading were then made on the numbers to carry out the drive tests. The quality test performed was restricted to outdoor atmosphere. The drive test route was along the main roads; it started at the Shiroro Power Station second gate and ended at the Shiroro Power Station work center.

Figure 2: Experimental setup during drive test

IV. RESULTS AND DISCUSSION

The drive test was performed in the morning, afternoon and evening. A total of 78 calls were made, the KPI values were calculated. Data rate and Throughput were obtained directly during drive test . Results for various KPIs is presented on figure 3 to 10

A Network accessibility (NA)

Network accessibility is the ability of mobile station to verify, establish and maintain calls. The KPIs connected to network accessibility are: CST, CSFR and CSSR. The responses on NA from the study are shown in figures 3, 4 and 5

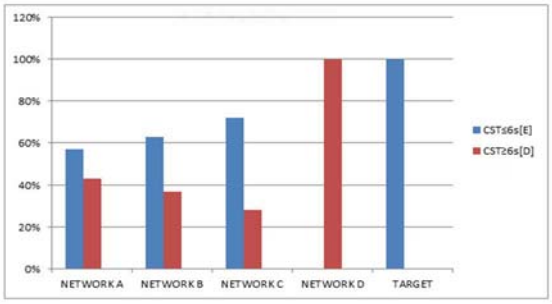

Figure 3: Call Setup Time

Fig 3 shows the Call Setup Time or Call Accessibility to each of the Mobile network provider. CST measures the length or overall length of time required to establish a circuit switched call between users of mobile phone. CST (≤ 6s/E) means easy call setup time while CST (≥ 6s/D) means difficult call setup time. Figure 5, shows that among all the Mobile Networks studied, Mobile Network C is with the highest easy Call Setup Time, which is CST (E/≤ 6s) of 72% with calls difficult CST (D/≥ 6s) of 28%. However, from figure 3, it shows that all the Mobile Network Operators under study performed below the minimum standard (which represent Target in this study) of either less than or equal to six seconds (≤ 6s) CST benchmark set by the NCC for all telecom operators [11]

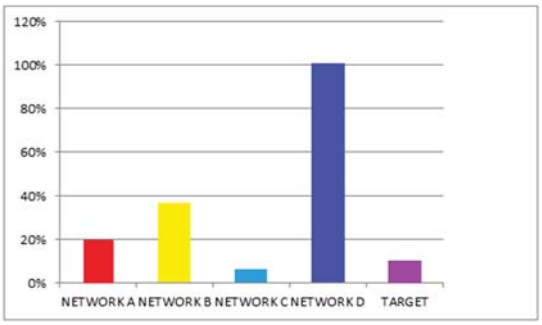

Figure 4: Call Setup Failure Rate

Call Setup Failure Rate (CSFR) measure the rate at which call set-up fails by the mobile service provider. Figure 4 shows the rate at which call setup failed for each of the Mobile Networks. Figure 4 shows that for the entire Mobile Networks studied, Mobile Network C has the best call setup failure rate of 6%. This implies that for every 100 calls made to Mobile Network C ,94 calls are likely to be successful without interruption or termination with only 6 calls unsuccessful. From the study, It is only mobile Network C that meet up with regulatory body (NCC) minimum standard whereas Network A,B and D do not meet up with the NCC CSFR minimum standard (≤ 10%) as benchmark set by the telecom regulatory

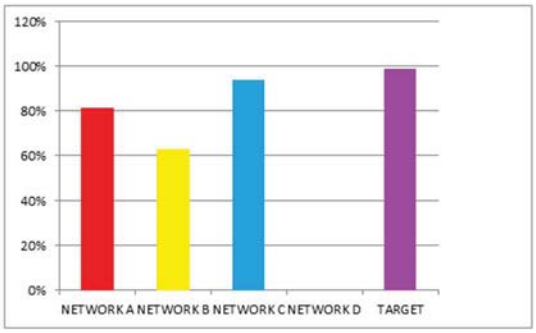

Figure 5: Call Setup Success Rate

The degree of accessibility into each network is better shown in figure 7 which indicates the rate at which calls setup were successful. From figure 5 Network C is the best mobile network with 94% CSSR while Network D has poor connection quality in the studied area. However, all the mobile networks studied performed below the minimum standard (Target) of (≥ 98%) set by the NCC.

B Network Retainability

Network retain-ability refers to how long a mobile subscriber stays on a network after the call has been connected or established. The KPIs connected to network retain-ability are Call Dropped rate and Call Completion Success Rate. The responses of network retain-ability from the study are shown in figure 6 and 7 respectively.

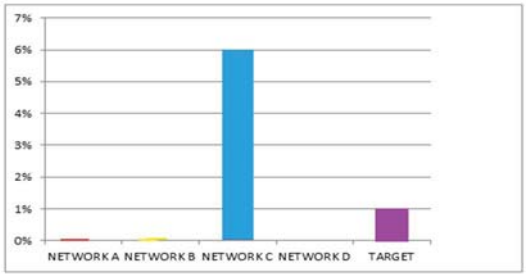

Figure 6: Call Dropped Rate

Call dropped rate is said to be among the worst and highest performing metric that affect QoS in Nigeria. The results from figure 6 shows that Network A and B has the lowest call dropped rate (CDR) of 0% which is not against the NCC minimum standard. Followed by Network C with (CDR) of 6%. While Network D has poor connection quality. From figure 6, Mobile networks C and D performed below the minimum standard (Target) of (≤ 1%) benchmark set by the NCC.

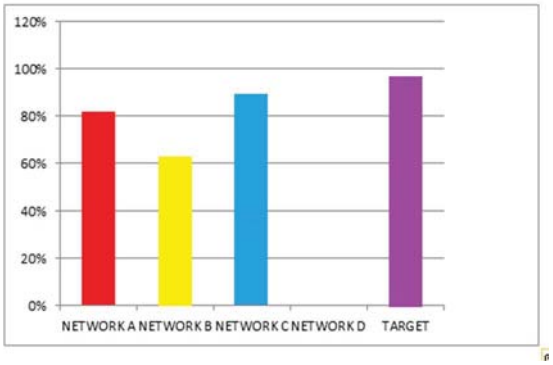

Figure 7: Call Completion Success Rate

From figure 7, with Mobile Network C has highest Call Completion Success Rate value of 89%.This indicates that mobile subscribers on Mobile Network C will cover higher probability of finishing their discussion before call terminate as compare with mobile users on Mobile Network A, B and D followed by Mobile Network A and Mobile Network B. Moreover, all the mobile networks studied performed below and violated the minimum standard (which is Target) of either less than or equal to 97% of attempted calls, CCSR (≥ 97%) benchmark set by the telecom regulatory organ, the NCC for all mobile network operators to complied with.

C Mobile Internet Service

Mobile data service is the internet access through an internet-enabled mobile phone. Mobile broadband is the marketing term for wireless Internet access delivered through cellular towers to computers, tablets, smartphone and other digital devices using portable modems. The KPIs connected for evaluating the mobile internet service on a Mobile Network for the purpose of this study are the data rate, Throughput and Latency. The responses on mobile internet service from the study are shown in Figures 8, 9 and 10. The data rate is a term to denote the transmission speed, or the number of bits per second transferred. The result from figure 8 shows that Mobile Network A has best data rate with value of 35.85 kbps. Followed by mobile Network C with the data rate of 10. 54kbps.Mobile Network B has data rate of 3.39kbp. From figure 8, it shows that all the Mobile Network studied performed below the data communication minimum standard (which is Target) 200kbps for 3G network [19]

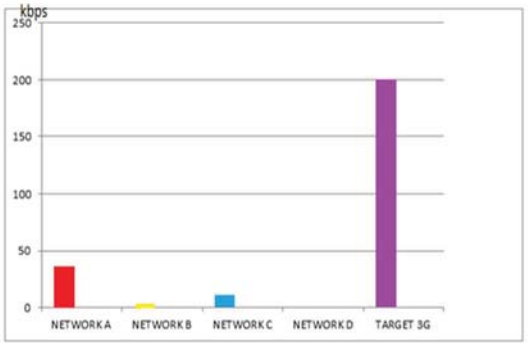

Figure 8:Networks Data rate

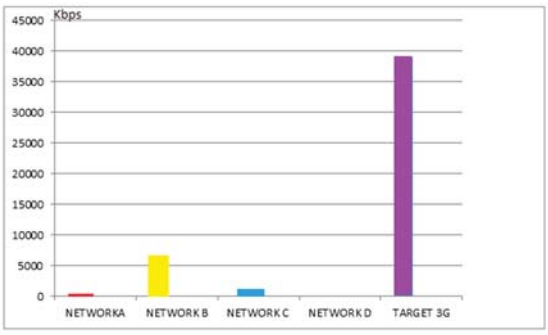

Figure 9: Networks Throughput

The result from figure 11 shows that Mobile Network B has throughput of 6731.8kbps which is the best among all the Networks studied. Follow by MNO C and follow by A. Mobile internet service is not available on the Network D. Mobile Network C has throughput of 153kbps. Mobile Network C is 3G network. Figure 11,-shows that mobile Network A, B and C performed below the data communication minimum standard (which is Target) of 39Mbps for 3G network while mobile network D has poor connection quality.

Figure 10 shows that mobile network D has to latency. Mobile network B has latency of 2.75ms which is not against the minimum standard of 100ms for 3G network. Mobile network C has latency of

121ms as against minimum standard of 100ms for 3G network. Distance is one of the primary reasons for latency delays. Though number of hops it makes, routers in between also affect latency.

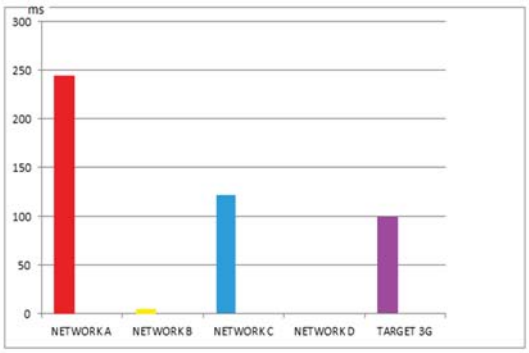

Figure 10: Networks Latency

Table 1: Result for Performance Test and Network Quality

S/N	KPIs	Target	Best Results	Worst Results
1	Call Setup Time (CST)	≤ 6s for local & international calls	NetworkC; 72%	Network D; 0%
2	Call Setup Failure Rate (CSFR)	≤ 10% of attempted calls	NetworkC; 6%	Network D; 100%
3	Call setup Success Rate (CSSR)	≥ 98% of attempted calls	Network C; 94%	Network D; 0%
4	Dropped Call Rate (DCR)	≤ 1%	Network A and B; 0%	Network D; Nil
5	Call Completion Success Rate (CCSR)	≥ 97% of attempted calls	Network C; 89%	Network D; 0%
6	Data Rate(kbps)	200 for 3G	Network A; 35.85kbps	Network D; Nil
7	Throughput(kbps)	39Mbps for 3G	Network B; 6731.8kbps	Network D; Nil
8	Latency(ms)	100 for 3G	Network B; 2.75ms	Network D; Nil

D The Result for Performance Test and Network Quality

The performance analysis for each of the KPI parameters was done as shown from figure 3 to figure 10. Generally, these results reveal that poor Quality of voice and data Service (QoS) is persistent across all the mobile networks. However, these results only present a comparative study of the networks with the telecom regulatory body NCC benchmarked. Table 1 shows the result for performance test and network quality.

From Table 1, it shows that the overall performance of the mobile network operators is not satisfactory. The network accessibility of network C; 72% (CST) was better than the rest mobile networks studied. Network C performed better with a minimum 0f 6% Call Setup Failure rate and a maximum of 94% in Call Setup Success Rate. However, Network A and B performed wonderfully in network retain-ability with a minimum Call Dropped rate of 0% .Network A has the best result in term of data rate whereas in term of throughput and Latency network B is the best.It further reveals that the entire mobile networks studied Network D has the worst quality of voice and data service

V. CONCLUSION

This research was undertaken to evaluate the Quality of voice and data Service of various KPI parameters of mobile network services available within the Shiroro Power station. From the results of the research, it clearly shows that the Network Accessibility, Network Retain-ability aNd mobile internet service in the area being considered were below Nigerian Communication Commission (NCC) KPIs Standard for the considered metrics. Technical issues that were identified to be responsible for poor performance include; geographical problem (landscape), Signal fluctuation or fading due to various factors such as obstructions from (buildings and trees), refraction, signal path loss and proximity to a BTS, discontinuous coverage (blind areas), insufficient coverage, Installation of antenna on transmission company of Nigeria (TCN) infrastructure that is originally design to provide intercommunication services, Increase in subscribers base and introduction of new services, Insufficient base transceiver station and absent of latest wireless technology.

This work revealed the degree of deviations of the key performance indicators from the acceptable standard and technical issues that are responsible for it.

VI. RECOMMENDATIONS

Since no system is designed to continue to function forever and since there are so called environmental factors always affecting its behaviors, plan and efforts should always be put in place to improve the performance. From the results obtained, poor receive voice quality, low call setup success rate, high call setup time and high call setup failure rate, low data rate, throughput and latency etc, which affects the Quality of Service of a Wireless Mobile

Networks indicates urgent need for mobile network operations optimization in Shiroro Power Station. It is also on this basis of this findings that the following recommendations are made in order to improve the observed failures.

- A geographical survey of the area should be carried out before the installation of any new BS/BTS. Three of the mobile networks in the studied area mounted their antenna on the Transmission Company of Nigeria (TCN) mast which was installed to convey Nitel service from Kuta to Shiroro Power station and to provide intercommunication within shiroro power station and the staff quarters.
- The Mobile Network Providers/Mobile Users should install Signal booster to boost the strength of the signal in case of high cost of installing BS/BTS.
- Mobile Network operators should launch 4G technology in Shiroro power station to improve mobile internet service in this area. None of the four mobile Network operators covered in this work has 4G technology in Shiroro power station.

  If the recommendations listed above are rigorously observe and adhered to, then the quality of both voice and mobile internet service of mobile network operations in the study area and Nigeria at large shall certainly improve.

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