Performance Analysis of Mobile Network Services: A Case Study on the Federal Polytechnic Bida, Nigeria

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Abstract

In recent years in Nigeria, satisfactory degree of Quality of Service has not been attained by the telecom service providers. The requisite for an assurance of telecommunication services is imperative as it establishes the relationship between perceptions and expectations of service delivered by a service provider. Mobile networks need to be under continues monitoring and control in order to maintain and improve the performance of services. In this paper, we examine and evaluate 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). For the purpose of this study Drive test was performed using the Mobile Station (MS) software package called MyMobile Coverage Pro (MMC Pro). The results of the study show that Network Accessibility and Network Retain-ability in the area being considered were below Nigerian Communication Commission (NCC) KPIs Standard for the considered metrics. It therefore, shows that the QoS rendered in the area of study for Mobile Users is not sufficient, unreliable and unsatisfactory. The paper recommended a robust optimization of its networks and constant signaling traffic evaluation among others on how to improve the QoS of Mobile Network Providers in the campus.

Keywords: Quality of service, mobile network operators, telecommunication system, key performance indicators (KPIs), drive test.

1 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, Agriculture, Security, Sport, Defense, Education, Banking, Health, and Transportation. It is necessary in day to day activities and essential in times of national crisis or natural disasters; it also minimizes the hazard and rigors of travel. Therefore, the availability of functional and efficient telecommunications facilities is an end result for any country that wants to compete in today's global economy as most economy becomes handicapped in the absence of sound communication system [3, 13 and 18].

Before the liberalization of Telecommunication system in Nigeria, the Telecom regulatory body, the NCC has disclosed that Nigeria had a very few telephone lines for several years which made communication difficult and inaccessible. Over ten (10) million subscribers applied to be connected to the Nigeria Telecommunication system, (NITEL), for services. Today, the story has changed dramatically with the

lunched of Wireless Mobile Communication (WMC) in Nigeria in 2001 [8]. During its launching in 2001, the main objectives was to offer efficient and valuable telecommunication services that will maintain good speech quality, minimize interference, roaming, minimum drop call, maximum handoff, spectral efficiency, and good interconnectivity [1]. Since then, the number of Mobile subscribers continues to grow in Nigeria; it grew from 400 lines in 2001 to 231.525 million lines of subscribers with the current active lines stand at 154.12 millions represent 66.57% and inactive subscribers at 77.41 million subscribers or 33.43% [11, 9, and 15]. Currently, there are four major wireless Mobile operators in Nigeria competing for mobile subscribers for Telecom services namely; Airtel, 9mobile, Globalcom and MTN. However, the unprecedented number of subscribers witnessed by the telecommunication industries has not help the situation as the subscribers are faced with one problem or the others among which is poor quality of service been provided by the mobile service providers. Telecommunication Subscribers in Nigeria have been complaining and suffering from bad quality of service (QoS), ranging from problem of network congestion, incessant dropped calls, failed calls, poor voice clarity, and failed handover, among others [2,3]. Meanwhile, how can we sustain a good, secure, uninterruptible Mobile Services for tragedy responses, public health, military control, safety, and law enforcement command in the face of poor QoS such as: Call Setup Failure, dropped call and poor voice clarity? How can the failed or dropped calls be minimized for everyone to enjoy the use of mobile communication effectively? Thus the need to tackle the problem of failed call and dropped call on the mobile network is important, as this will both be of advantage to operators and users [5].

The definition of Quality of Service may vary from situation to situation and from person to person but only vary in wording, although in general involves determining whether perceived service delivery meets, exceeds or fail to meet Subscriber expectation. On the other hand, the International Telecommunication Union (ITU) defined QoS as a set of quality requirement on the collective behavior of one or more objectives. It is basically the level of guaranteed service to a user. Meanwhile, Parasuraman (1988) define Quality of Service (QoS) from the perspective of users as the level and trend of difference among the Mobile Users perceptions and prospect, or the scope to which a service meets or exceeds opportunity. Therefore, Quality of Service is the differences between Subscriber's expectations and perceptions of service delivered by a service provider [4, 12].

In telecommunication system, Network coverage, Network Accessibility, Network retain-Ability and Connection Quality are the four major factors considered in evaluating quality of service (QoS) of a Mobile Network Provider. Therefore, Mobile network requires being underneath constant monitoring and manage in order to sustain and get better performance of services. In finding remedy and possible solution to the problem of poor QoS, the NCC, an organization responsible for the regulation of Mobile services in Nigeria, on 6th July 2007 issued out the threshold levels on the key performance indicators (KPIs) for ascertaining QoS of Mobile Network Providers in Nigeria [10]. For the purpose of this research focus is on Network accessibility and Network retainability.

2 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. However, most papers focus on statistical network data collected from Network Operating Centre (NOC), administering of questionnaires on subscribers for analysis with few researches works on Drive Test models. [13] Worked and obtained data from the Network Operating Centre (NOC) for three GSM services operators, providing mobile services in Epe town, for a period of twenty three weeks. A model of service quality and a set of dimensions for comparative evaluation, which could provide useful directions to regulators and service providers, were developed. [14] Worked and utilizes the use of Mobile Station application called MyMobileCoverage to conduct drive test which enables the mobile user to view current network coverage with the signal strength mapping with drop and fail calls information. It was concluded

from the research that the QoS in the area was poor and need an improvement and recommendations were made by the researchers.

Globally, and in Nigeria for the past years, the problem of poor quality of service (QoS) has been a main concerned to both mobile Service Providers and Mobile Users. Besiege with the problem of poor QoS been faced by the subscribers gave rise to this study.

3 Quality of Service Key Performance Indicator (KPI)

The QoS of any mobile network is been access, monitor and measure by the KPI. Therefore, KPI are parameters used to determine telecom operators' progress in achieving its planned and outfitted goals and to also evaluate a company performance against others rendering the same or similar services. This research considered the following KPI parameters for evaluation; Call Setup Time (CST), Call Setup Success Rate (CSSR), Call Setup Failure Rate (CSFR), Call Drop Rate (CDR), and Call Completion Success Rate (CCSR). The KPI parameters on each network were calculated from the data obtained from the drive test using the following KPI equations defined by NCC. These are:

a. Call Setup Time (CST)

CST can be calculated from the data obtained from drive test using equations 1 and 2

Percentage of CST (≤ 6s/E) = (∑ calls ≤ 6s/ Attempted calls) × 100 (1)

Where CST (≤ 6s/E) mean call setup time completed within six (6) second, E mean easy call

Percentage of CST (≥ 6s/D) = (∑ calls ≥ 6s/ Attempted calls) × 100 (2)

CST (≥ 6s/D) mean call setup time completed after six (6) second, D mean difficult call.

b. Call Setup Success Rate (CSSR)

CSSR was also calculated using equation 3.

$$CSSR = \frac{Number\ of\ unblockedcall\ attempts}{Total\ number\ of\ attempted\ calls} \times 100 \quad (3)$$

c. Call Setup Failure Rate (CSFR)

CSFR was calculated using the expression below

$$CSFR = \frac{Number\ of\ failed\ call\ attempts}{Total\ number\ of\ attempted\ calls} \times 100 \quad (4)$$

d. Call Drop Rate (CDR)

CDR was obtained using the equation 5

$$\boldsymbol{CDR} = \frac{\text{Number of dropped call}}{\text{total number of call attempts}} \times 100 \quad (5)$$

e. Call Completion Success Rate (CCSR)

Finally, CCSR was calculated using the equation below.

$$CSSR = \frac{Number\ of\ unblockedcall\ attempts}{Total\ number\ of\ attempted\ calls} \times 100 \quad (6)$$

f. The NCC Benchmarked on the KPI Parameters

The NCC, organization responsible for the regulation of Mobile services in Nigeria, on 6th July 2007 issued out the threshold levels on the key performance indicators (KPIs) for ascertaining QoS of all the Mobile Networks in the country. The KPIs considered are: BH Call Setup Time, BH Call Setup Failure Rate, BH Call Setup Success Rate, BH Call Drop Rate and BH Call Completion Success Rate [6, 7].

g. Contravention, Penalties and Enforcement

In an effort to find possible solutions and to satisfy consumers of mobile networks in Nigeria, the NCC issued regulations, 2005, and Enforcement Processes, Etc. for the telecom operators to comply with.

Table 2: KPI parameters considered by NCC Benchmark, contravention and Penalty

S/NO	KPI	Target	Penalty
1	BH Call Setup Time	≤ 6s for local/international calls	₦500,000:00 per month
2	BH Call Setup Failure Rate	≤ 10% of attempted calls	₦500,000:00 per month
3	BH Call Setup Success Rate	≥98% of attempted calls	₦500,000:00 per month
4	BH Call Drop Rate	≤ 1% of attempted calls	₦500,000:00 per month
5	BH Call Completion Success Rate	≥97% of attempted calls	₦500,000:00 per month

By section 104(a) of the NCA Act, any mobile service provider that failed to meet a minimum standard of QoS specified by the commission shall be sanctioned and liable to pay ₦500, 000:00 per month for each month that flouting persists and calculated from the time limit specified by the Commission for the licensee to congregate the least standard of Quality of Service. In part of implementing and enforcing the regulations for good services and customer satisfaction in Nigeria, former President of the Association of Telecommunications Companies of Nigeria (ATCON) and a telecommunication expert, Engr. Titi Omo-Ettu, has called for the revocation of the licenses of mobile network operators who continuously offer poor services to the consumers. He advised the commission to continue to monitor and take measurement of the performances of the telecommunication operators and apply sanctions where necessary. He also urged the NCC body to always give timely warning to the mobile operators, if they were not meeting the require standard in the communication industry. In the same way, for instance, in December 2013 NCC authorized the sanctioned of the four major telecom providers in Nigeria for floating the standard set on QoS with a total fine of $7.5 million (N1.17billion). It therefore, behooves all the providers of Telecom services to ensure that subscribers enjoy the best of service [6, 7, 17 and 19].

3.1 Quality of Service in the Drive Test Area

Area where mobile services are mostly needed and high in demand for academic, economic and businesses purposes was selected. For the purpose of this research the Federal Polytechnic Bida, was chosen. The Federal Polytechnic Bida is located along Bida- Doko Road in Bida Local Government Area of Niger State, Nigeria and covers a land area of about 2 kilometer square.

The institution currently has all the four major mobile network operators operating in Nigeria. Figure 1:0 shows that there are four Base Stations (BS) installed outside the school main gate serving the

polytechnic and its environs; one for each Mobile Service Provider. A Base Station from one Network provider was installed for Data efficiency used for internet facilities in the institution.

Figure 1.0: The Map of Federal Polytechnic, Bida showing Base Stations.

However, the distance of all the Base Stations with the drive test areas is within 2 km but land slope is a major factor here. Critical surveyed and analysis of the available network facilities in the Institution with over twenty five thousand estimated students showed that during the Busy Hour period the probability that over three to four thousands mobile users may compete for limited services which usually results to congestions and queuing which leads to poor quality of service.

3.2 Materials and Procedure

This research measurement was conducted within a period of 4 months (August 2017 - November 2017) during second semester of 2016/2017 session with busy activities within the school as both staff and students of the polytechnic were fully on-ground. The Mobile Networks studied were Network A, Network B, Network C and Network D and operational in the area being considered. The study was conducted using a Mobile Station (cell phone) software application called MyMobileCoverage Pro (MMC PRO) 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).The KPI parameters were compared with the NCC benchmarked to see the compliances and also to determine MNO with best quality of service. For the purpose of this Research, the following materials, tools were used. These materials and tools are: Mobile Stations (MSs), Subscribers Identification Modules (SIMs) Card for all the networks under consideration (Network A, Network B, Network C and Network D), Electronic Stop Watches (4) and a Motor Vehicle.

To perform the drive test, MyMobileCoverage Pro was installed in a Mobile Station(s) (MSs) to take the measurement of the Mobile Network Operators. Each Mobile Station has a SIM card installed depending on the Mobile Network Operator (MNO). Calls 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 and ended at the Polytechnic's small gate which is along Bida–Doko road in Bida. The pictorial view of the MMC PRO platform is shown in figure 2.0.

Figure 2.0: MMC PRO Platforms for KPI parameters & their factors.

4.0 Results and Discussion

The MMC PRO was able to capture data from each of the Mobile station (MS) on different MNO parameters (either in idle mode or in dedicated mode).The drive test was performed at 8:00pm each day. 8:00pm was selected based on the preliminary investigation of the study area and it was observed to be the busy hour for students when mobile traffic was at its peak in the institution. A total of 4,000 calls were made during the weeks (Monday to Friday) from the Networks under study that is 1000 calls to each network. The KPI values were calculated using the expression earlier defined from equations 1 to 6 on all mobile network providers and results for various KPIs is presented on figure 1 to 5.

4.1 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 3.0, 4.0 and 5.0.

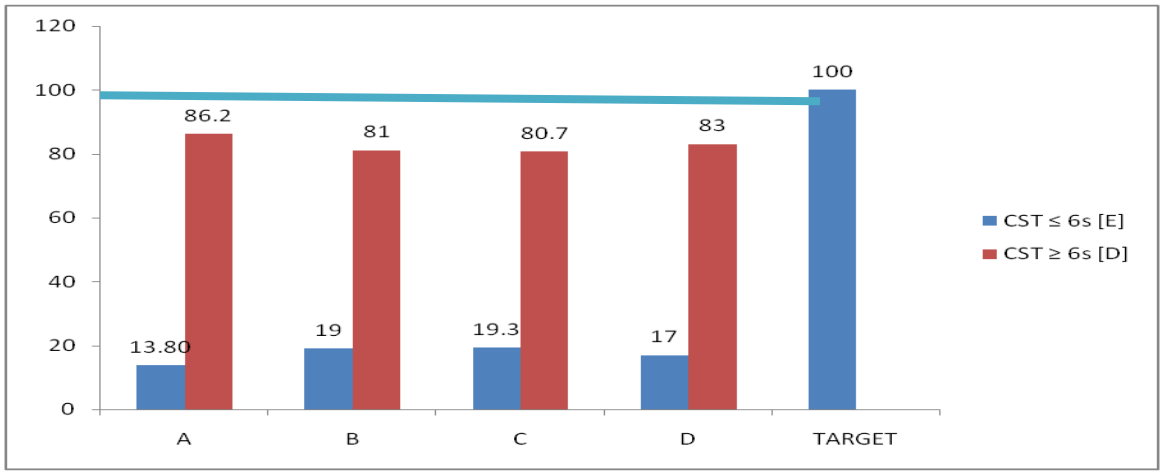

Figure 3.0: Call Setup Time

Fig 3.0 shows the call setup time or call accessibility to each of the Mobile network provider. CST (≤ 6s/E) means easy call setup time while CST (≥ 6s/D) means difficult call setup time.

Network C has the highest easy call setup time, CST (E/≤ 6s) of 19.3% with call difficult CST (D/≥ 6s) of 80.7% while Network A has the lowest easy call setup time. This simply implies that the accessibility into Network C in terms of call setup time is the easiest. Comparing the KPIs from the graph with NCC benchmarked, all the networks performed below the minimum standard set by NCC of CST≤ 6s.

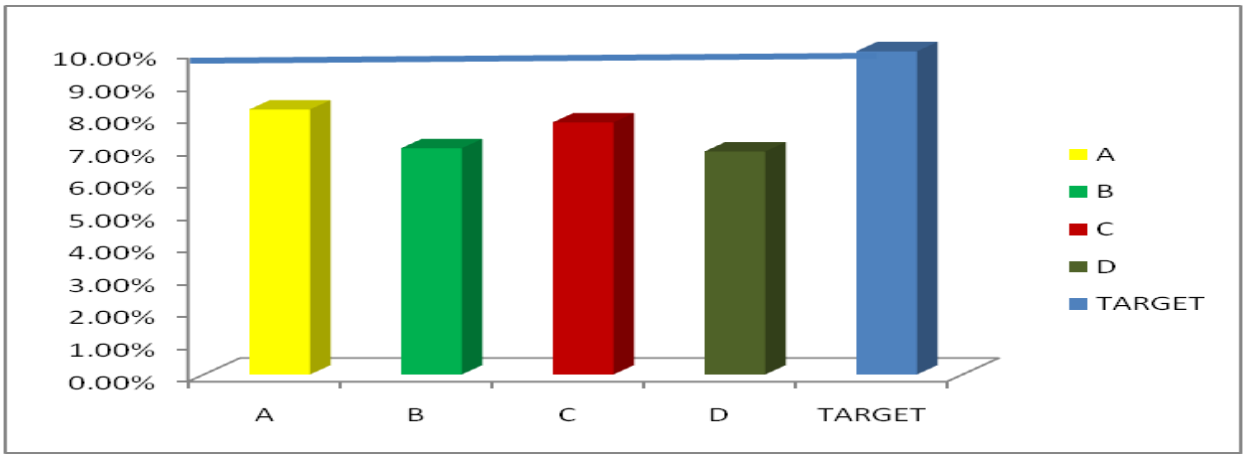

Figure 4.0: Call Setup Failure Rate

Figure 4.0 shows the rate at which call setup failed to each of the mobile networks. The figure shows that the entire mobile networks studied Network D has the best call setup failure rate of 6.9% while Network A has the highest network calls failure. This implies that for every 100 calls made to Network D, 94 calls are likely to be successful without interruption or termination with only 6 calls unsuccessful or blocked (CSFR).Nevertheless, all the mobile networks studied performed magnificently as the minimum standard (which is Target) of (≤ 10%) benchmark set by the telecom regulatory body the NCC, was not violated.

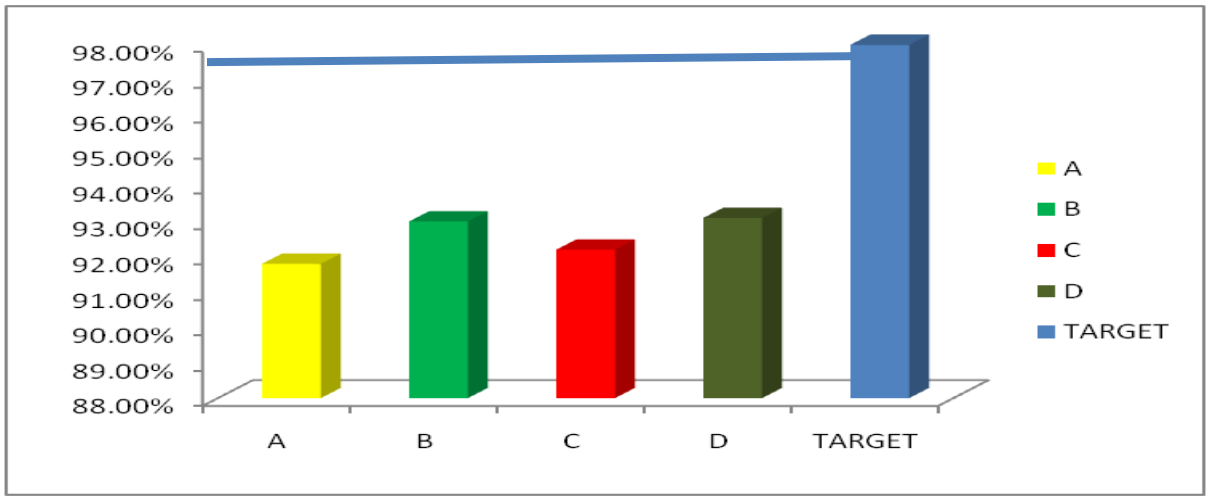

Figure 5.0: Call Setup Success Rate

The degree of accessibility into each network is better shown in figure 3, which indicates the rate at which calls setup were successful. From figure 3 Network D has the best mobile network in establishing calls of 93.1% CSSR while Network A has the poor mobile network of 91.8%. However, all the mobile networks studied slightly performed below the minimum standard (Target) of (≥ 98%) set by the telecom regulatory body the NCC.

4.2 Network Retainability (NR)

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 if figure 6.0 and 7.0 respectively.

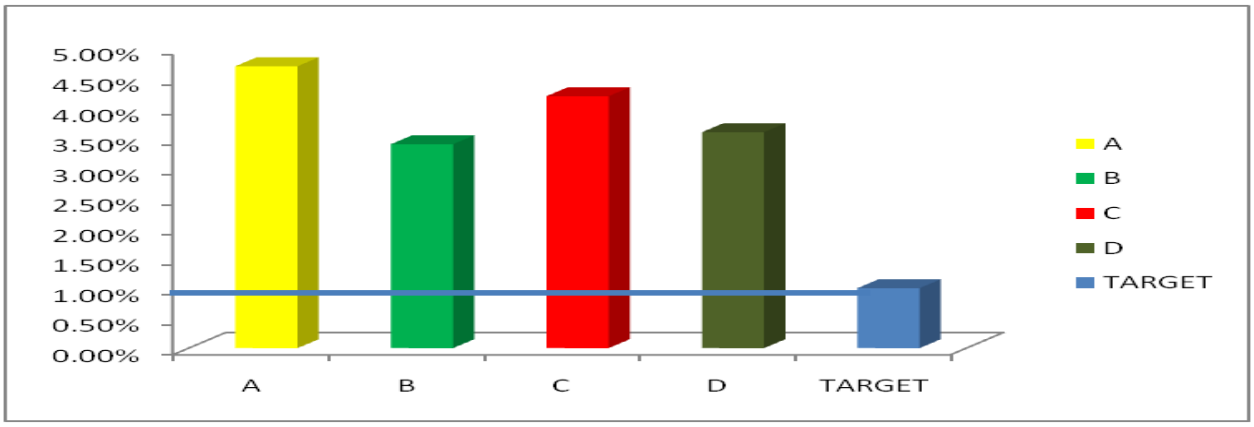

Figure 6.0: Call Dropped Rate

Call dropped rate is said to be among the worst and highest performing metric that affect QoS in Nigeria. The results from figure 6.0 shows that Network A has the highest call dropped rate (CDR) of 4.7% followed by Network C with (CDR) of 4.2%. While Network B has the lowest call drop rate (CDR) of 3.4%, and closely followed by Network D with (CDR) of 3.6%. From figure 4, it shows that majority of the mobile subscribers' experiences call dropped to all the networks while a serious conversation is still ongoing in the institution. On the other hand, all the mobile networks studied performed very poorly as the minimum standard (Target) of (≤ 1%) benchmark set by the telecom regulatory body the NCC, was grossly violated.

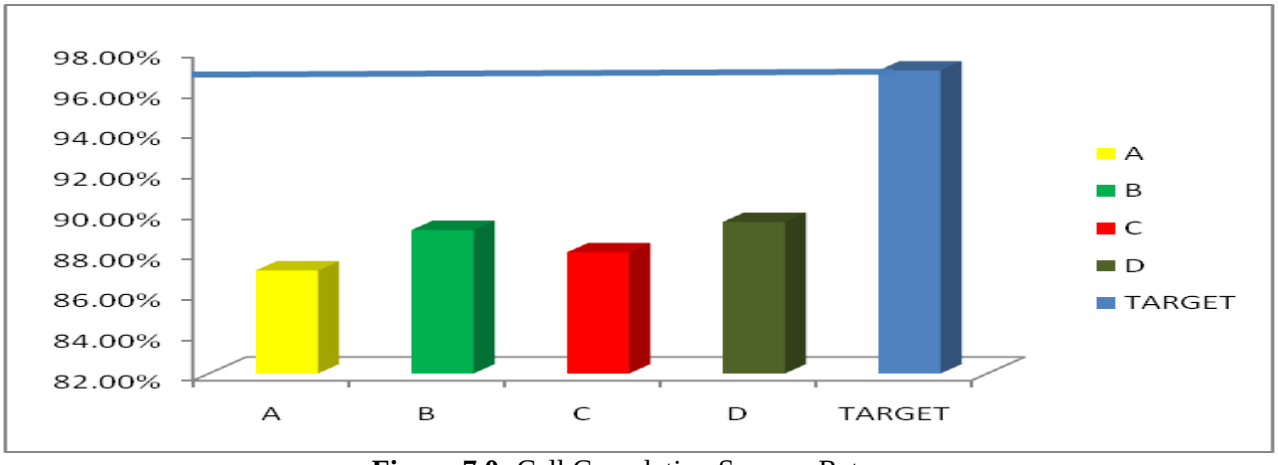

Figure 7.0: Call Completion Success Rate

Meanwhile, the call completion success rate (CCSR) and Call drop rate (CDR) are inversely related. From figure 7.0, with Network A higher in CDR of 4.7% value, it means the CCSR value of (87%) will be lowest. However, Network B that has lowest CDR will have its CCSR highest of 89.6% and follow by Network D with CCSR of 89.4%. This indicates that all mobile subscribers on Network B and Network D have higher probability of finishing their conversation before call terminate when compare with mobile

users on Network A and Network C. Nevertheless, all the mobile networks studied performed very poorly and violated the minimum standard (Target) of CCSR (≥ 97%) benchmark set by the telecom regulatory body the NCC for all mobile network operators to complied with.

4.3 The Result for Performance Test and Network Quality

The performance analysis for each of the KPI parameters was done as shown from figure 1 to 5. Generally, these results reveal that poor Quality of 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 2.0 shows the result for performance test and network quality.

Table 2.0. Result for Performance Test and Network Quality.

S/NO	KPIs	Target	Best Result	Worst Results
1	BH Call Setup Time (CST)	≤ 6s	Network C; 19.3%	Network A; 13.8%
2	BH Call Setup Failure Rate (CSFR)	≤ 10%	Network D; 6.9%	Network A; 8.2%
3	BH Call setup Success Rate (CSSR)	≥ 98%	Network D; 93.1%	Network A; 91.8%
4	BH Call Dropped Rate (CDR)	≤ 1%	Network B; 3.4%	Network A; 4.7%
5	BH Call Completion Success Rate (CCSR)	≥ 97%	Network B; 89.6%	Network A; 87.1%

From table 2.0, it shows that the overall performance of the mobile network operators is far from being satisfactory. The network accessibility of network C; 19.3% (CST) was better than the rest mobile networks studied. Network D performed better with a minimum 0f 6.9% Call Setup Failure rate and a maximum of 93.1% in Call Setup Success Rate respectively. However, Network B performed wonderfully in network retain-ability with a minimum Call Dropped rate of 3.4% and Call Completion Success Rate of 89.6%. It further reveals that the entire mobile networks studied Network A has the worst quality of service (QoS) in both network accessibility and network retain-ability.

5 Conclusion

This research was undertaken to evaluate the Quality of Service (QoS) of various KPI parameters of mobile network services available within the Federal Polytechnic, Bida. From the results of the research, it clearly shows that the Network Accessibility and Network Retain-ability in the area being considered were below Nigerian Communication Commission (NCC) KPIs Standard for the considered metrics. With these findings, it can be concluded that the QoS evaluation over all the KPIs performance of the mobile network operators in the institution campus and probably in Nigeria at large was poor, unreliable and unsatisfactory and may not be safe for disaster responses, military control, public health, safety, and law enforcement command.

6 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 are put in place to improve the performance. From the results of the research, frequent call drops, low call setup success rate, high call setup time and high call setup failure rate etc, which affects the quality of service of a mobile networks are indicator of an optimization skull area. The networks need optimization. In order to correct the problem of poor QoS in the country and any other areas with similar situation, suggestions on how to improve the QoS of the Mobile network operators need to be made. It is on this base that the following recommendations are made in order to improve the observed defects:

- All the mobile network operators should ensure a robust optimization of its networks in order to ensure good service delivery to the subscribers.

- Telecom providers should spend heavily in transmission of network expansion and have a good radio planning. This would guarantee increased network resilience, improved bandwidth utilization and mitigation of capacity bottleneck.
- GIS (geographical information system) based tools and Automated Test Calls (ATC) is recommended for use. The use of GIS- based tools becomes imperative as it assists to create and informed technical decision in resolving network problems. It shows areas experiencing low quality of service. However, ATC take care of all the limitations of manual Test calls in monitoring quality of service.
- Wireless Mobile Operators should constantly carry out proper signaling traffic evaluation to know the capacities of their network equipment so as to meet the expected number of subscribers within the network.
- 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.
- A geographical survey of the area should be carried out before the installation of BS/BTS as presently land slope account for network coverage problem in the Institution.
- The NCC body is advised to always access, monitor, measure, regulate and give timely warning to the mobile operators, and where necessary sanctioned for any contravention if they were not meeting the require standard in the telecommunication industry in order to ensure good quality of service.

It is assumed that if the recommendations listed above are rigorously observe and adhered to, then the QoS and taken as a whole performance of the Mobile network operation in the study area and Nigeria at large shall certainly improve.

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