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Performance Comparison for Voice Services of 3G networks in Kano metropolis.

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ABSTRACT: *The telecommunication carriers in Nigeria continues to build on the momentum of second-generation network, now deployed third generation, 3G wireless technology to solve for the inherent limitations of the 2G. But still the voice and data calls being transmitted within 3G mobile networks are composed by different information flows with various constraints on the quality of service, QoS. Optimization of radio network resources will maximize the usage. This paper provided an in-depth knowledge of 3G voice network parameters and compared the performances in A, B, C and D networks in Kano metropolis. The comparison was made using the Nigerian Communication Commission, NCC targets. Drive test was employed with the aid of W995 Sony Ericson phone with built-in transmission environmental monitoring systems which extracted and recorded the data over some selected eNodeBs. The A network achieved: 95.06%, 4.94%, 95.92%, B network achieved: 94. 88%, 5.12%, 91.89%, C network achieved 92.27%, 7.73%, 94.44% and D network achieved 95.27%, 4.73%, 92.50%, on CSSR, CBR and SHOSR respectively. The performance traces of these parameters are much worse than the NCC's targets. These were due to poor Received Signal Code Power, low Ec/No and pathloss. However, mobile operator D and A were observed to performed better and closely to the NCC's targets followed by B while C appears to be the least in most of the evaluated KPIs considered in this study. In order to achieve the best performance, these mobile carriers have to monitor and optimize their network continuously.*

Keywords: *3G, Drive Test, KPIs, Performance, RSCP*

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I. INTRODUCTION

Telecommunication has been in existence for ages and has undergone many changes in the recent years, especially in the development of mobile communication systems which is seen as one of the most advanced form of human communications ever(Jiso, 2017). In the last couple decades Global System for Mobile Communication (GSM) technology is part of second (2^{nd}) Generation mobile communication and is a leading generation of wireless system but due to limited frequency spectrum resources, low frequency spectrum utilization, poor support for multimedia services (providing only text, speech and low speed data services), and low system capacity which hardly meet any demand for high-speed bandwidth services, these necessitated the need for third generation (3G) mobile communication (Jiso, 2017). The entire systems and services of 3G mobile network is based on the standard of International Telecommunication Union (ITU) under International Mobile Telecommunication 2000 (IMT-2000) developed by 3G Partnership Project (3GPP) (Anwar & Li, 2008). Universal Mobile Telecommunication System (UMTS) is part of the IMT-2000 family. In a communication system based on multiple access, amount of users need to access the channel simultaneously, to implement this, there are several techniques that allow users to share the channel. Here UMTS employed Wideband Code Division Multiple Access (WCDMA) and includes the High Speed Packet Access (HSPA) specifications(Acharya & Gaba, 2014) as well as novel packet switched (PS) domain. The PS supports a completely different usage environment (user populations, terminal types, applications, services etc.) unlike the legacy circuit-switched (CS) domain, this makes it infinitely more heterogeneous and complex than the CS domain. WCDMA is a spread spectrum technology, which expands the signals over a bandwidth of 5MHz and is capable of carrying voice and data at the same time (Chevallier, Brunner, Garavaglia, Murray, & Baker, 2006). The WCDMA system uses several codes, when the signal is transmitted from the base station (eNodeB) carries a unique code called scrambling code, SC, used in the downlink direction for cell separation. It is also employed in the uplink direction to separate every user from each other (Chevallier et al., 2006). This is the type of technology employed in Nigerian 3G mobile networks. 3G is generally characterized to have high frequency spectrum utilization to support high quality voice services, multimedia and internet services such as e-mail, web browsing, video streaming, interactive games, mobile e-commerce etc, it also allows its users to know more on their surrounding such as weather forecast, location of schools, hotels, markets, airports etc thus it become of good assistant to the people's life and their works(Jiso, 2017). These were due to the transition ability of the network from CS to PS (Jiso, 2017:)Anwar & Li, 2008). The voice and data calls being transmitted within 3G mobile networks are composed by different information flows with multiple constraints on the demanded quality of service (QoS). These problems raised several research questions. The optimization of radio network resources has now become unceasing solution to the QoS constraints. Optimization of the radio resources will distribute the network resources in such a way that it will maximize the usage (Rani & Ahuja, 2011). Moreover, these optimization techniques could only be effective and improved if the optimization engineer has an in-depth knowledge of the network parameters, performances of individual parameters and the environment of deployment.

Diagnosing 3G mobile networks performance in the case study area is quite challenging and laborious, due to various degrading factors. The available research and knowledge of 3G mobile networks in Kano and the entire country is scanty. Kano Metropolis is chosen as the case study area with the active cellular subscriber lines put at more than twenty million. The population of the people in this area continue to grow substantially due to education, long flourished marketing and trading activities which has been the dominant economic activity of the populace of the Kano metropolitan, which is why it is referred as the Centre of Commerce in the country(Galadanci & Abdullahi, 2018). With the full deployment of 3G mobile networks in Nigeria as well as the case study area, it is crucial to understand the performance of the network and also to provide the in-depth knowledge to the optimization engineers.

Evaluation and analysis of 3G network was carried out in Lagos metropolis by (Akinyemi, Makanjuola, Shoewu, & Edeko, 2014), the research revealed that quality of service (QoS) of the Ikeja-Ojota-Oregun area is very bad as a result of low transmitted power by many base stations and inefficient line of sites resulting in very low percentage of the RSCP in the range of -60 to 0dB which lead to difficulties in the process of establishment of calls resulting in blocked calls. (Yuwono & Ferdiyanto, 2015) conducted a drive test to analyses the performance of 3G WCDMA network of Yogyakarta city in Indonesia, the research measured RSCP, Ec/No of Rural, sub-urban and urban areas in the city, there by evaluating five 3G KPIs (CSSR, CCSR, SHOSR, DCR and BCR), the services was recommended to be improved in Urban areas as a result of architecture of the buildings and the number of subscribers. Trend analysis of the performance metric of key cellular network quality was conducted by (Olabisi, 2014), the performance of base station over a period of 30 days was studied by analyzing eight KPIs, the highest total traffic was observed to be on fourth day which greatly affect all other indicators (affecting the service quality experienced by the users in same day). (Acharya & Gaba, 2014) reviewed different types of handovers in 3G/UMTS network and compared them. (Sriwastava, Singh, & Verma, 2014) proposed four different optimization techniques to increase the handover success so that the probability of call drop and blocking could be reduced while in (Hasdah & Kumar, 2013) conducted a simulations to study soft handover in 3G cellular network and compare between the soft handover and hard handover base on threshold value of the handover, the research shows that soft handovers in the system increases the traffic load and also network with soft handovers initiated with low threshold value have minimal amount of interference in the system. Effort was made in (Joseph, Konyeha, Bright, & Peter, 2016) to calculate radio field strength propagation data and path loss in 3G base UTMS network by using a local telecom service provider in Benin city of Nigeria at a frequency of 2100MHz , upon all the models in the study, Okumura-Hata model was found to best fitted the prediction of the path attenuation loss in UTMS networks of the area.

This work critically analyzed the performances of 3G mobile networks' voice call parameters. The following parameters were analyzed and compared among A, B, C, and D networks: RSCP, SHOR, pathloss and Transmitted power. Different open issues remain from the previous works. Most of the available literatures were focused on the data call, while voice call analysis remains silent. For some authors, combined the performance analysis of both voice and data calls. In comparison, most of the literatures did not capture the factors accounting for the voice call performance constraints. But due to the significant importance of voice calls in our daily life and it economic impacts on both the government and the mobile network carriers, the paper considered performance analysis of voice calls within 3G mobile networks only.

1.1. Important Parameters' Definitions measured in the Study

a) **Handover:** is a process of transferring an ongoing call or data session from one cell site to another without interruption(Acharya & Gaba, 2014)(Hasdah & Kumar, 2013). Soft and HandOver Success Rate (SHOSR) can be calculated by using equation(Yuwono & Ferdiyanto, 2015):SHOSR = $\frac{\text{Number of successful handover}}{\text{Total number of handover attempts}} X\,100$ (1)

b) Call setup success rate (CSSR): is the probability of establishing a call(Galadanci & Abdullahi, 2018). It is the ease with which calls are established or setup(Usman & Ozovehe, 2015). and it is given by equation (Yuwono & Ferdiyanto, 2015):

$$\text{CSSR}\,[\%] = \frac{\text{Number of unblocked calls attempt}}{\text{Total number of attempts}} X\,100\% \quad (2)$$

c) CBR (Block Call Rate): This is the probability of calls blocked due to congestion in the service provider's network (International Telecommunication Union-T E.811. Recommendation, 2017). It is given by equation (Yuwono & Ferdiyanto, 2015):

$$\text{CBR}\,[\%] = \frac{\text{Number of blocked calls}}{\text{Total number of call attempts}} X\,100\% \quad (3)$$

d) Call Drop Rate (CDR): is also called Drop Call Rate (DCR) which is probability of a call terminating without the will of either parties(International Telecommunication Union-T E.807. Recommendation, 2014);

$$\text{CDR}\,[\%] = \frac{\text{Number of dropped calls}}{\text{Total number of calls attempted}} X\,100\% \quad (4)$$

e) Call Completion Rate (CCR): is the probability that a call has, after being successfully set up, to be maintained during a period of time, ending normally, i.e., according to the user's will.it is given by equation (Yuwono & Ferdiyanto, 2015):

$$\text{CCR}\,[\%] = \frac{\text{Number of normally ended calls}}{\text{Total number of calls attempted}} X\,100\% \quad (5)$$

f) RSCP (Received Signal Code Power): this is the signal strength in 3G which denotes the power measured by a receiver. It is used as an indication of signal strength, as a handover criterion, in downlink power control, and to calculate the path loss(Akinyemi et al., 2014).

g) Ec/No or Ec/Io: This is the ratio of the received energy per chip (= Ec) and the interference level (Io), usually given in decibel dB, it is usually used to measure equipment capability(Akinyemi et al., 2014)

h) Transmitting Power (Tx power): This is the performance metric used to measure the transmitting ability of enodeB. It is measured in dBm(Akinyemi et al., 2014).

i) Path Loss: The path loss is the difference (dB) between the transmitted power and the received power. It represents signal level attenuation caused by free space propagation, reflection, diffraction and scattering (Anyanwu Chinedu, Chukwuchekwa Nkwachukwu, 2017: Galadanci, Abdullahi &Bature, 2018)

II. MATERIALS AND METHODS

The materials used during the collection of data in this research was shown in figure 1 which include: Laptop, TEMS mobile Phone (Sony Ericsson W995), built-in GPS of the TEMS phone, and Subscriber Identity Modules for A, B, C and D mobile networks respectively. TEMS Pocket 7.2 is a Sony Ericsson based release with built-in scanner phones which support both GSM and WCDMA. (Ascom, 2009). It is an advanced cellular network diagnostics tool suitable for day-to-day verification, maintenance and troubleshooting of cellular networks, it is also handy for many cell planning tasks(Galadanci& Abdullahi, 2018).

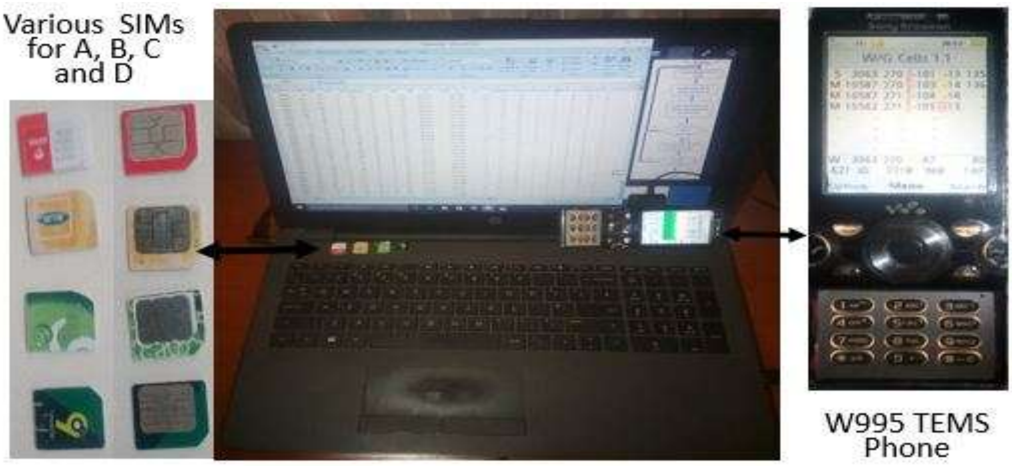

Figure 1: The experimental set-up of W995 Ericson with built-in TEMS software.

2.1 METHOD/PROCEDURE

This research adopted field tests (typically known as drive test) measurement from the users' standpoint. The tests were exclusively based on automatic connection of hardware with software (W995 phone + TEMS Software + Computer), to eliminate the subjectivity inherent to the human user. Automatic measurements were carried out with the aid of W995 TEMS phone over thirty-five locations in Kano metropolis. Measurements were carried out indoor and outdoor, on equal terms for the four mobile carriers, in the same locations as depicted in figure 3 below and with the same parameters (that is, SHOR, CDR, CSSR, CCR and CBR), thus made it possible to perform comparative analysis of the perceived performances. The measurements reflect various features affecting the QoS. Figure 1 illustrates the experimental set-up for the research. The drive test routes were defined using google earth software.

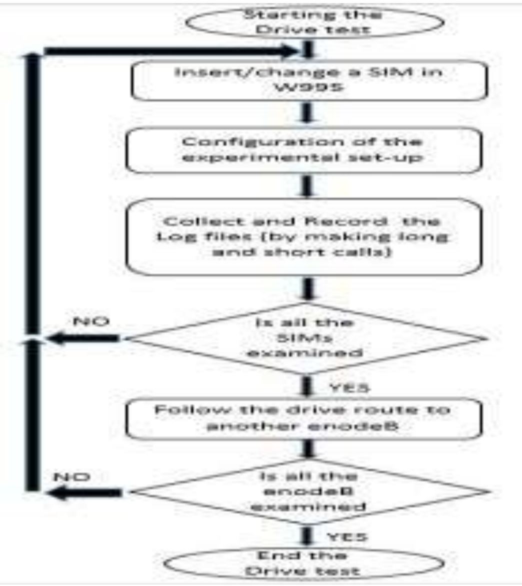

Figure 2: Flow Chart **Figure 3:** Some of the 35 locations of the study (Galadanci, Abdullahi &Bature, 2018)

The data was collected for a period of 16 weeks (4 months), various times a day at an interval time of different hours. All the values were obtained for both intra and inter test calls were extracted and recorded from W995 phone to computer. The test phone provided the information of performance problems, while the in-built software provided the reasons of the performance problems. Therefore, the various parameter information such as RSCP level, Ec/No, path loss, transmitted power etc. were presented in plots. The computations of key parameters were adopted using equations 1, 2, 3, 4 and 5 to calculate the SHOSR, CSSR, CBR, CDR and CCR respectively. The measurements were organized as in step below using flow chart:

STEP I: here two types of drive test were conducted on A, B, C and D networks. First is the static drive test, in which 3G to 3G voice calls, and 3G to 2G voice calls were critically analyzed to determine the best RSCP and Ec/No. Secondly, is the dynamic drive test, in which the coverage of all the sectors were examined using long and short calls respectively. The long calls lasted for 120 seconds, while the short calls lasted for 50 seconds before termination.

STEP II: Subscriber Identity Module (SIM) is inserted for the particular network in consideration, which was later change to another network(s).

STEP III: the voice call tests were made with automatic selection of the 3G network technology from the phone menu. WCDMA coverage indicator is also chosen, and the number of simultaneous users and type of bearer services were not considered. Global Positioning System (GPS) and it features is automatically configured. Active and idle calls duration were automatically setup. Finally, Stick memory and internal recorder were configured.

STEP IV: at this step the files generated during tests/measurements are automatically exported into PC.

STEP V: when all the four networks' SIMs are tested, the measurement setup would be moved to the next route/point, otherwise it will go back to the previous steps to check for error.

STEP VI: at this step, when all the predefined eNodeBs or base stations are considered, therefore the measurement will stop here, otherwise should re-visit the previous step for error correction. The results of this measurements have reflected the behavior of the networks in the locations and at the time the measurements were accounted.

III. RESULT AND DISCUSSION

Figure 4, 5, 6 and 7 depict the graphical presentation of the RSCP, Tx power, Ec/No and pathloss for the mobile operators under the study from the Drive Test. The tables gives the NCC's target for voice KPIs, the ranges of the signals and calculated KPIs while the Interpretation of the results obtained from the graphs and tables followed in the discussion.

3.1 Results

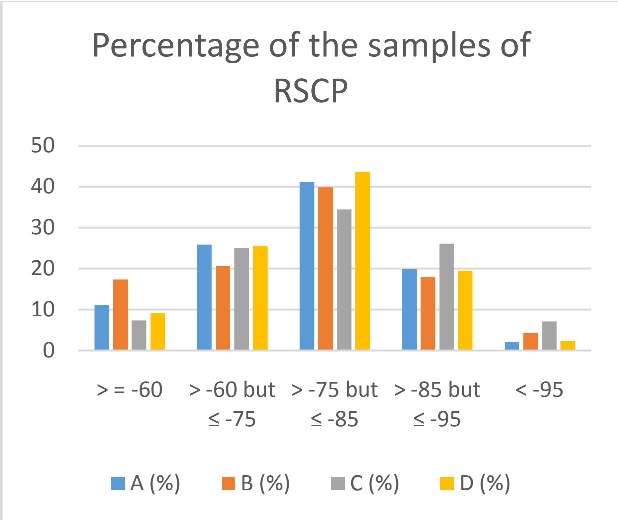

Figure 4: Received Signal Code Power (dBm)

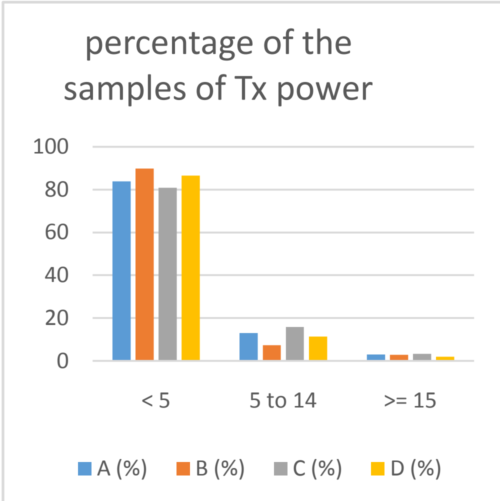

Figure 5: Transmitting Power

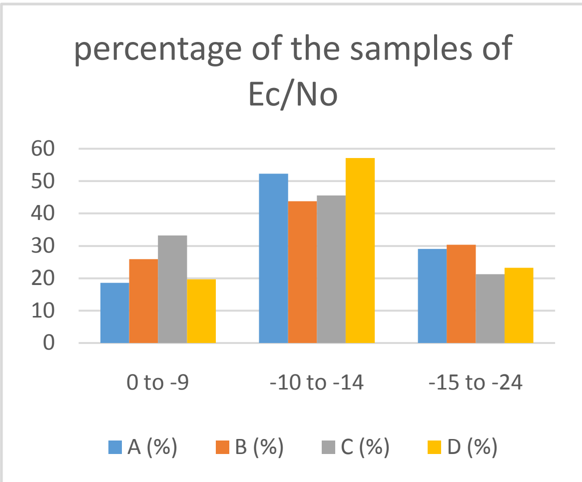

Figure 6: Ec/No (dB) distribution

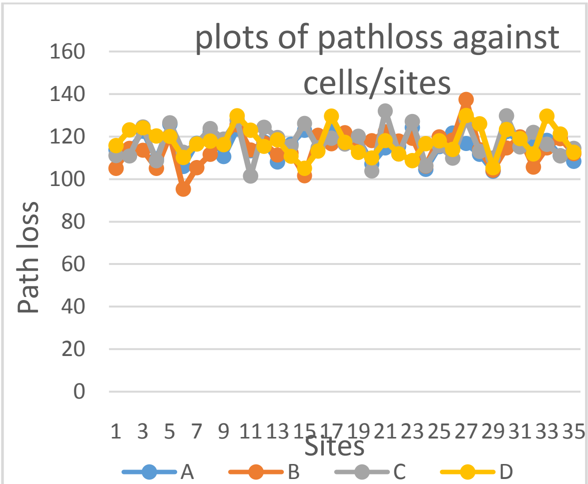

Figure 7: pathloss distribution of the carries

Table 1: Evaluated KPIs parameters and ranking

Parameters (%)	A	B	C	D	Ranking					
					A	B	C	D	Best	Worst
CSSR	95.06	94.88	92.27	95.27	2nd	3rd	4th	1st	D	C
CDR	1.39	1.89	2.70	0.89	2nd	3rd	4th	1st	D	C
CBR	4.94	5.12	7.73	4.73	2nd	3rd	4th	1st	D	C
CCR	98.53	98.11	97.07	99.06	2nd	3rd	4th	1st	D	C
SHOSR	95.92	91.89	94.44	92.50	1st	4th	2nd	3rd	A	B

3.2 Discussion

Table 2: RSCP, Tx power and Ec/No signal strength indication[13].

RSCP (dBm)			Tx Power (dBm)			Ec/No (dB)	
Range	Indicator		Range	Indicator		Range	Indicator
-60 to 0	Excellent		Below 5	Good		0 to -9	Good
-75 to -60	Good						

-85 to -75	Fair		5 to 14	Fair		-10 to -14	Fair
-95 to -85	Poor						
-124 to -95	Very poor		Above 15	Poor		-15 to -24	Poor

Table 3: NCC KPIs Target(Usman & Ozovehe, 2015)(Galadanci & Abdullahi, 2018).

KPI	CSSR	CDR	HSOSR	CCR	CBR
Targets %	≥ 98	≤ 1	≥ 98	> 96	< 2

Correlating the evaluated KPIs in table 1 with their respective NCC's target in table 3, only mobile network D met the targets on both CDR and CCR, mobile network A and B met the target only on CCR while mobile network C couldn't hit a target in any of those five KPIs.Base on the sample performance analysis, poor call establishment(CSSR) were due to poor RSCP in most of the areas.Blocked calls were due to low Ec, high Io, pilot pollution, timing/delay issues, and missing neighbor. CDR and CCR were mostly affected due to low Ec and high No (Io), (degraded signal quality around the vicinity of a mobile phone), pilot pollution, interference, unsuccessful handover attempt to neighbor cells, and coverage issues. It is recommended here that improving the cell handover can also give a significant improvement in the CDR and the retainability of the networks in general.

IV. CONCLUSION

This work revealed that, the performance of the voice services of these mobile operators is far beyond expectation by the users within the study area, thus, none of these mobile operators were providing their services up to the standard of NCC. However, mobile operator D and A was observed to performed closely to the NCC's targets followed by B while C appears to be the least in most of the evaluated KPIs considered in this study. In order to achieve the best performance, carriers have to monitor and optimize their network continuously.

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