

# Guagingof key performance indicators for 2G mobile networks in Calabar, Nigeria

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## Abstract

The increase in the number of mobile subscribers, coupled with the increase in mobile services is enough reason to monitor the QoS of mobile network operators frequently. This work looks into the QoS of network operators in Calabar, Nigeria, taking into consideration some KPIs ((CSSR, DCR, CST, HOSR, and network quality and network coverage). Analysis of data obtained after a benchmarking drive test shows that Globacom network was within NCC performance threshold for all network KPIs monitored. Also, MTN network performed poorly in HOSR but met the minimum benchmark in other network KPIs. Airtel network failed in the required DCR benchmark but was within the minimum benchmark for other KPIs while 9mobile failed in CSSR and DCR performance threshold but met the performance threshold for other KPIs. This result will be useful to the regulatory body, NCC, those in academic, RF engineers, network subscribers and especially, the network operators which we expect, will optimize their networks immediately.

**Keywords:** Call Setup Success Rate; Drop Call Rate; Call Setup Time; Handover Success Rate; Key Performance Indicators

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## 1. Introduction

Mobile network has raised the economic activities in Nigeria and has upgraded the standard of life of Nigerians [1-2]. As the number of services and subscribers increase, the demand for good Quality of Service (QoS) increases [3-4]. In finding a lasting solution to this problem, the Nigerian Communication Commission (NCC), the body in charge of the regulation of mobile networks in Nigeria, on 6<sup>th</sup> July, 2007 issued out the performance threshold on Key Performance Indicators (KPIs).

It became necessary for mobile network providers to monitor the quality of service of their networks accurately, with a view to improving them in the most effective and cost-efficient way, so as to achieve customers' loyalty and maintain competitive edge [4]. The significance of performance assessment of mobile networks is motivated by the exigency to utilize the limited radio resources in the most efficient manner. The increase in demand for high-quality service, coupled with the future telecommunication network target of providing integrated services with multimedia applications, over low-powered mobile computing devices, has further increased the need for evaluating the performance of mobile networks [5 – 8].

According to available literature, [9-17] has investigated the QoS of network operators and came out with reports of poor QoS and this has triggered the essence of this research. This work investigates the QoS of the major network operators (Airtel, MTN, Globacom and 9mobile) in Calabar, taking into consideration Call Setup Success Rate (CSSR), Drop Call Rate (DCR), Handover Success Rate (HOSR), Call Setup Time (CST), signal level and signal quality. The result

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of this research will serve as a guide to the regulatory body, NCC, the subscribers and importantly, the network operators, so that they optimize their network.

## 2. Material and methods

A Garmin Global Positioning System (GPS), four W995 TEMS mobile phones, four SIM cards, one for each network, TEMS 15.1 investigation software, a laptop, a USB hub, a car inverter and a car are the materials used for this study.

The SIM cards were slotted into the TEMS phones while the TEMS investigation software was installed in the laptop. The TEMS phones were powered by connecting them to the USB hub which is plugged to the laptop. The GPS, which is also powered by the laptop, gives the location for the drive test. An extensive drive test measurement was conducted and the KPIs (CSSR, DCR, CST, HOSR, and network quality and network coverage) were collected over base stations in Calabar, using TEMS investigation software running on a Windows 10 operating system laptop.

The fulcrum of this research is to investigate the KPIs of the major mobile networks and to further make comparative analyses, so as to deduce which network performs best. The study location of this research is Calabar and the cellular networks investigated are Airtel, MTN, Globacom and 9Mobile networks.

### 2.1. Definition of Terms

#### 2.1.1. Call Setup and Call Setup Success Rate

A call setup is an exchange of signaling information in the call process that leads to Traffic Channel (TCH) seizure. The **Call Setup Success Rate** (CSSR) is calculated by taking the number of the unblocked call attempts divided by the total number of call attempts. It has a performance threshold of at least 98% [18].

Mathematically,

$$\text{CSSR (\%)} = \frac{\text{Number of unblocked call attempts}}{\text{Total number of call attempts}} \times 100(1)$$

Or  $(1 - \text{Blocking Probability}) \times 100\%(2)$

#### 2.1.2. Dropped Call and Dropped Call Rate

A dropped call is a call that is prematurely terminated before being released normally by either the caller or called party (i.e., the call is dropped before the exchange of Released Message "RL\_M" and Released Complete Message "RLC\_M" in the signaling flow). Dropped Call Rate (DCR) is the number of dropped calls divided by the total number of call attempts. It has a performance threshold of at most 1% [18].

Mathematically,

$$\text{DCR (\%)} = \frac{\text{Number of prematurely terminated calls}}{\text{Total number of call attempts}} \times 100(3)$$

Or  $(1 - \text{Call Completion Ratio}) \times 100\%(4)$

#### 2.1.3. Call Setup Time (CST)

It is the average time between pressing send button (after pressing correct digits) and getting a ring back tone. This is also called post dialing delay or time to connect a call. It has a performance threshold of at most 6 seconds.

#### 2.1.4. Handover Success Rate (HOSR)

This is the ratio of the number of successfully completed handovers to the total number of initiated handovers. This ratio can be expressed as a percentage. It has a performance threshold of at least 98% [18]. Handover failure rate is an important indicator for monitoring mobility. Handover failure means that the mobile station tries to make a handover (inter/intra cell) but for some reasons, it fails [19-20].

2.1.5. Network Coverage

This is the measure of the downlink coverage penetration. Voice, SMS and data services depend on the penetration of the downlink coverage. It has a performance threshold of at least -85dBm [21].

2.1.6. Network Quality

This is the measure of the signal quality during a call. It is measured and used to evaluate a network’s quality of reliability and it measures the amount of bit errors received by the mobile station. It has a performance threshold of at least 4 [21].

3. Results and discussion

The performance evaluation of four major mobile networks (Airtel, MTN, Globacom and 9mobile) was analyzed based on their KPI data obtained from a benchmarking drive test. A summary of the drive test result for DCR, HOSR, CSSR and CST given in Table 1. Figure 1, Figure 2, Figure 3 and Figure 4 summarizes coverage results for Airtel, MTN, Globacom and 9mobile, while Figure 5, Figure 6, Figure 7 and Figure 8 summarizes coverage plots for Airtel, MTN, Globacom and 9mobile.

Table 1 Summary of CSSR, DCR, HOSR and CST

SN.	KPIs	Unit	Airtel	MTN	Glo	9mobile
1	DCR	%	1.52	1.47	0	3.03
2	BCR	%	0	0	0	8.33
3	HOSR	%	99.53	97.13	99.54	98.64
4	CSSR	%	100	100	100	91.67
5	CST	s	3.442	2.901	3.259	3.782
6	Call Attempt	counts	330	340	315	360
7	Handover Attempt	counts	429	522	434	221
8	Handover Failure	counts	2	15	2	3
9	Blocked Call	counts	0	0	0	30
10	Call Established	counts	330	340	315	330

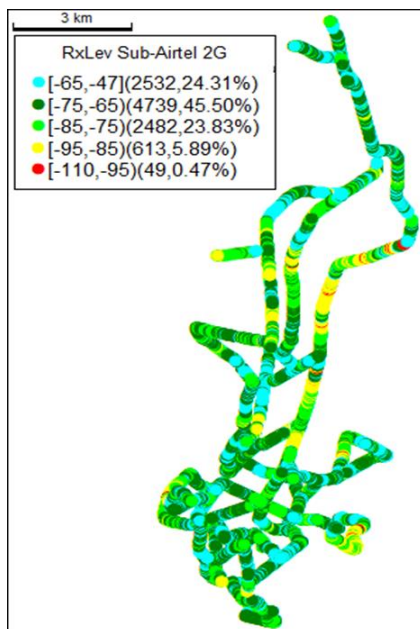


Figure 1 GSM coverage plot for Airtel Network

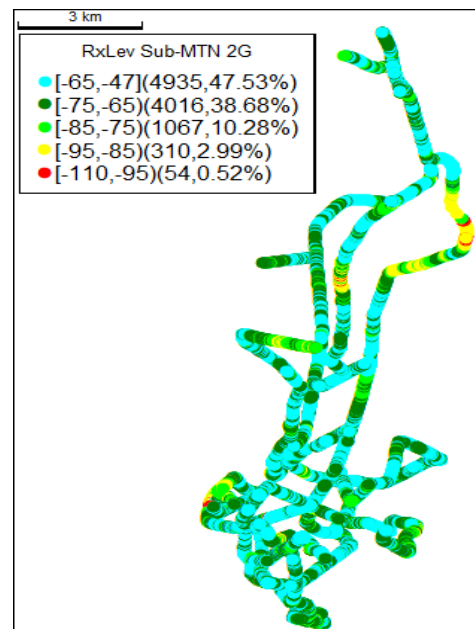
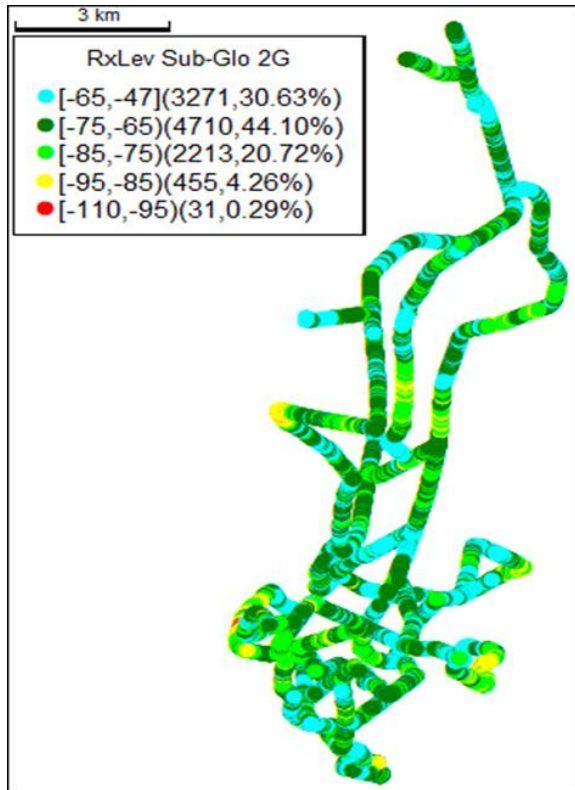
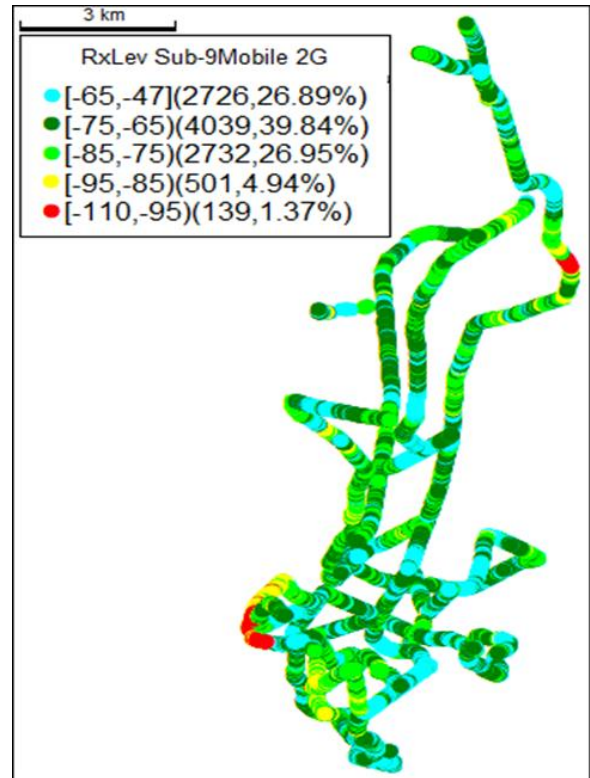


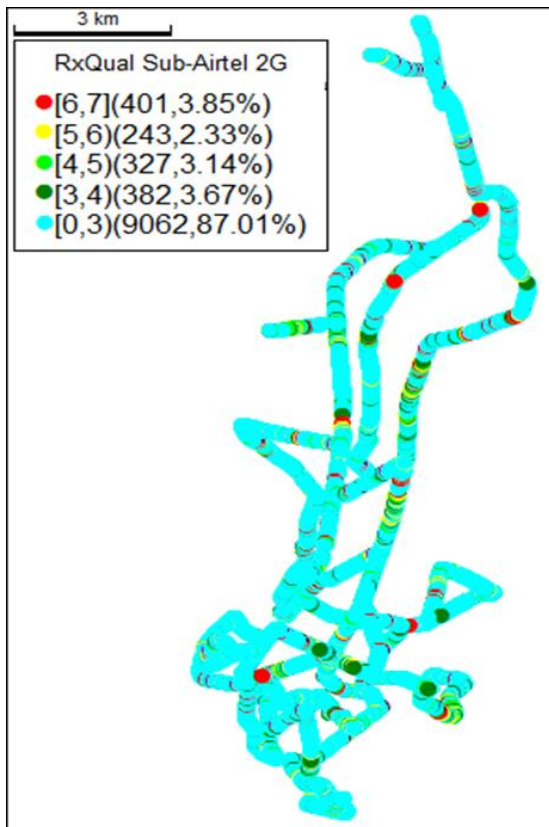
Figure 2 GSM coverage plot for MTN Network



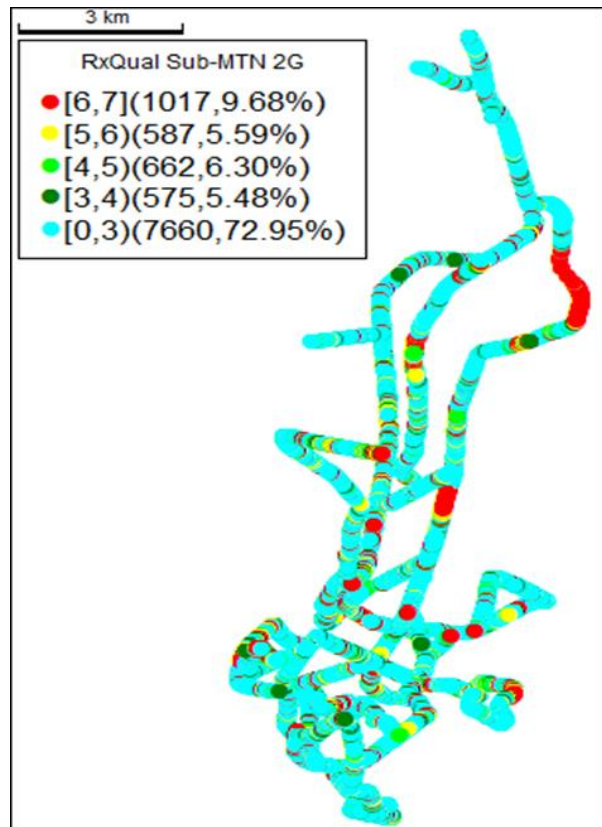
**Figure 3** GSM coverage plot for Globacom Network



**Figure 4** GSM coverage plot for 9mobile Network



**Figure 5** GSM quality plot for Airtel Network



**Figure 6** GSM quality plot for MTN Network

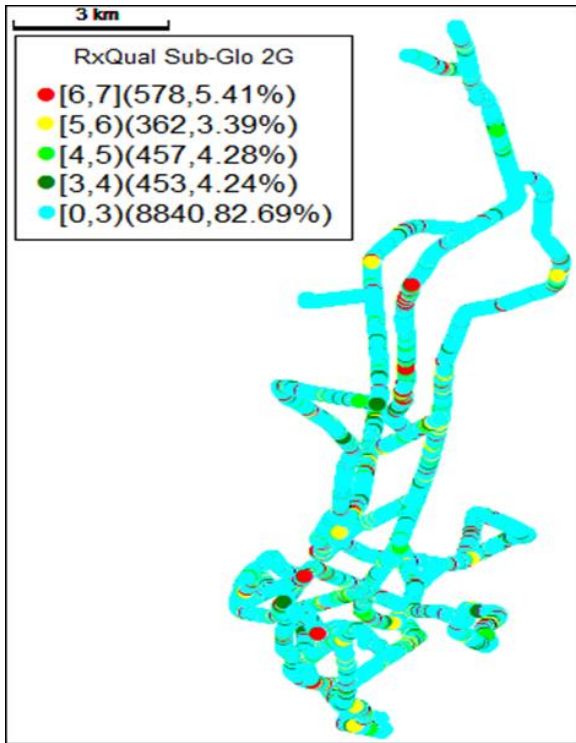


Figure 7 GSM quality plot for Globacom Network

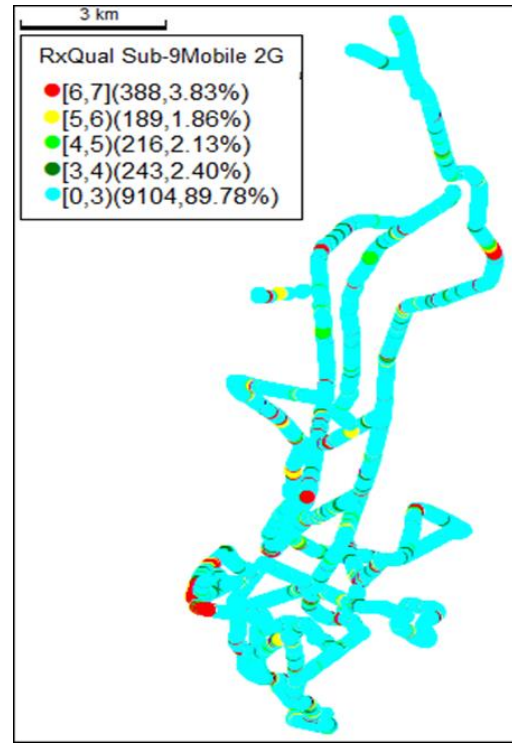


Figure 8 GSM quality plot for 9mobile Network

As shown in table 1, a total of 330 calls were attempted for Airtel network, 340 for MTN, 315 for Globacom and 360 for 9mobile. This led to 330, 340, 315 and 330 established calls for Airtel, MTN, Globacom and 9mobile network. It was observed that all networks, except 9mobile, successfully setup their calls. 9mobile had 30 blocked calls and fell below the performance threshold of NCC.

In terms of CST, MTN was the fastest, followed by Glo, Airtel and 9mobile. However, the four network operators were within the threshold limit set by NCC. This was not the same for DCR as 9mobile had the worst performance, followed by MTN and Airtel. In fact, in terms of DCR, they fell below NCC threshold level, except Globacom. A poor link margin was observed in MTN network which led to poor handover. All other network operators were within the minimum threshold of NCC in terms of their HOSR.

In the coverage plots and quality plots, regions denoted with light green had excellent coverage and signal quality with remarkably satisfied subscribers. Regions with deep green had very good coverage and signal quality with very satisfied subscribers. In the blue region, subscribers were satisfied because they had good coverage and signal quality. The yellow region is characterized by dissatisfied subscribers, fair coverage and signal quality with moderate interference. Finally, the red region has poor coverage and signal quality, higher interference and very dissatisfied subscribers.

In comparing the coverage of the four networks with respect to NCC performance threshold of – 85dBm, MTN had the best coverage, followed by Globacom, Airtel and then 9mobile network. This shows that MTN has an excellent downlink coverage penetration. Voice, SMS and data services depend on the penetration of the downlink coverage. For signal quality, the reverse was the case as 9mobile took the lead followed by Airtel, Globacom and then MTN.

#### 4. Conclusion

A benchmarking drive test to assess 2G network operators in Calabar has been analyzed taking CSSR, DCR, CST, HOSR, network coverage and network quality into consideration. No network had perfect performance in all the KPIs as they have been fluctuations in their QoS. Mobile networks operating in Calabar are advised to monitor and optimize their networks frequently for good QoS.

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## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors declare that there was no conflict of interest in this work.

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