NETWORK PERFORMANCE AND QUALITY OF SERVICE EVALUATION OF GSM PROVIDERS IN NIGERIA: A CASE STUDY OF AMBROSE ALLI UNIVERSITY

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Abstract

Mobile networks are assessed to enhance customer experience and revenue creation by evaluating network performance. This study examines the performance of two mobile networks at Ambrose Alli University, Nigeria, referred to as Network A and Network B, which provide voice communication services. Key performance indicators (KPIs) for accessibility, retainability, mobility, and service integrity were evaluated using a *drive test technique* and compared to the Nigerian Communications Commission (NCC)-defined goal for each. The KPI data were combined to provide each network operator's overall network performance for the chosen drive route—the main campus. The performance of the Wideband Code Division Multiple Access (WCDMA) network for both Networks falls far short of the NCC's defined KPI target and customer satisfaction. In contrast, the performance of the Global System for Mobile Communications (GSM) network in both Networks is largely satisfactory. This study recommends that network operators regularly analyze, optimize, and enhance the services they offer to subscribers, as well as invest in network resources to fulfill consumer expectations and boost revenue creation.

Keywords: GSM, WCDMA, Drive Test, Key Performance Indicator (KPI), Quality of Service (QoS), Nigerian Communications Commission (NCC)

1 INTRODUCTION

1.1 Background to the Study

For excellent Quality of Service (QoS), accurate radio network design is critical (Badejo & Ojewande, 2017). Mobile networks offer the foundation for global interconnection and digital inclusion, both of which are needed to meet the 2030 Sustainable Development Goals (SDGs) agenda's objectives. The demand for cellular network connection is growing at an exponential rate, with projections of over 100 billion smart devices and sensors linked by 2020 due to trends in Internet of Things (IoT) and Machine-to-Machine (M2M) communication technologies (Popoola et al., 2018).

The parameter Received Signal Level (RxLev), measured in dBm, is used to assess coverage performance, with a minimum signal strength of -95dBm defining service coverage availability during a drive test (Isabona & Azi, 2013). The rise of smartphones and social media has resulted in a significant increase in demand for Internet connection, driving technical advances and a paradigm shift towards packet-switched communication systems (Dahiya, 2017). While communication networks have progressed through five generations, the fifth-generation (5G) network had yet to be deployed in Nigeria at the time of this study, precluding 5G testing (Imozie & Adegbite, 2018).

1.2 Statement of the Project

The competitive academic environment necessitates improved Mobile network quality. Students' experience is often characterized by issues such as slow internet, poor voice quality, and call drops. To address these flaws that may impede student learning and communication, a *drive test* is required to identify the underlying cause of localized network issues. This project utilizes the TEMs Investigation software to conduct a 2G and 3G cluster drive test scenario for two mobile network operators on the Ambrose Alli University Campus.

1.3 Aim and Objectives

The overall aim of this project is to evaluate the network performance and quality of service of GSM providers within Ambrose Alli University main campus. The specific objectives are to:

1) Identify the Mobile Network operators and determine a suitable test site on or around the campus where the drive test will be carried out;
2) Identify the parameters deployed for Quality of service evaluation of Mobile Networks;
3) Obtain the KPIs for the Mobile Networks operating within Ambrose Alli University Main Campus.

1.4 Research Methodology

The following methods will be employed:

1) A survey will be carried out to identify various cell sites on or around the campus to determine the suitable drive paths for testing.
2) The KPIs will be identified theoretically based on Nigerian Communications Commission (NCC) standards.
3) The TEMs Investigation Software will be deployed to obtain and analyze the KPIs for the Mobile Networks within Ambrose Alli University.

2 METHODOLOGY

2.1 Study Area and Equipment Setup

The study took place at Ambrose Alli University's Main Campus in Ekpoma, Nigeria (Latitude: 6°45'N, Longitude: 6°08'E, Elevation: 364m). The experimental setup utilized in the drive test procedure included a Personal computer, a TEMS mobile phone, a GPS antenna, a Scanner, a Dongle (Lee & Dave, 2016), a Compass, and an Inverter. The software tool used for data collection and analysis was the TEMS Investigation software (version 9.1.3) (Khalid et al., 2015).

2.2 Performance Evaluation Metrics

The network performance is assessed using the NCC-defined Key Performance Indicators (KPIs), as shown in Table 1 (Ojo et al., 2019).

Table 1: NCC KPIs Definition and Target

KPIs	CSSR	CDR	HSR	CST	Rx Level	Rx Quality	RSCP
NCC Target	$\geq 98\%$	$\leq 1\%$	$\geq 98\%$	≤ 6sec	≥ -85dBm	≤ 4	≥ -85dBm

The fundamental KPI equations are:

1) **Call Setup Success Rate (CSSR):**

$$\text{CSSR} = \frac{\text{Number of call established}}{\text{Total number of call attempt}} \times 100 \quad (3.1)$$

2) **Call Drop Rate (CDR):**

$$\text{CDR} = \frac{\text{Number of dropped calls}}{\text{Total number of call established}} \times 100 \quad (3.2)$$

3) **Handover Success Rate (HSR):**

$$\text{HSR} = \frac{\text{Number of successful handover}}{\text{Total handover attempt}} \times 100 \quad (3.3)$$

4) **Coverage Reliability:**

$$\text{Coverage} = \frac{\text{Samples} \geq -85\text{dBm}}{\text{Total coverage sample}} \times 100 \quad (3.4)$$

2.3 Testing Procedure

The log files data were generated using a Sony Ericson W995 test phone with built-in TEMS software (TEMS Pocket) and the Subscriber Identification Modules (SIMs) for the networks under investigation. The handset had a typical accuracy of ± 4dBm.

2.3.1 Call Procedures

- **Short Calls (**50/10s**):** Enabled accessibility measurement (CSSR) with 50 seconds dedicated mode and 10 seconds idle mode.
- **Long Calls (**120/10s**):** Enabled retainability measurement (HOSR and CDR) with 120 seconds dedicated mode and 10 seconds idle mode.

3 RESULTS AND DISCUSSION

The GSM (2G) and WCDMA (3G) radio frequency drive test data obtained on the main campus of Ambrose Alli University were analyzed using the TEMS discovery device and Microsoft Excel 2013. The performance of Network A and Network B was compared against the defined NCC benchmarks (Table 1).

3.1 GSM Performance Evaluation

3.1.1 GSM Received Signal Level (RxLev)

The coverage penetration results, categorized into six bands, highlight differences in signal strength distribution between the two networks.

- Excellent Coverage (0 to -70dBm): Network B demonstrated superior performance, with approximately 29.76% of its collected samples falling within this range. Network A only achieved 10.43% in the same range. This suggests that Network B offers a significantly stronger GSM signal for a larger portion of the surveyed route, providing robust service quality even in areas with high attenuation.
- Fair/Poor Coverage (-95 to -110dBm): Both networks maintained minimal poor coverage, with Network A recording 0.31% and Network B recording 0.22%. This near-zero poor coverage rate for both operators indicates highly reliable basic service availability across the campus, meeting the minimal signal strength requirement of -95dBm for nearly all samples (Isabona & Azi, 2013).

3.1.2 GSM Received Signal Quality (RxQual)

The quality of the signal samples was analyzed against the NCC target of RxQual ≤ 4. The quality was categorized from Excellent (0 to 3) to Poor (> 7).

- Excellent Quality (0 to 3): Both networks displayed exceptional signal quality, a critical factor for clear voice communication. Network A achieved 97.14% of samples in the excellent range, while Network B followed closely with 93.84%.
- Overall Quality: With the remaining samples falling into the 'Very Good' quality range (3-5), the data confirms highly satisfactory signal integrity for both operators. This indicates low levels of bit errors received by the Mobile Station, leading to stable voice calls.

3.1.3 GSM Accessibility, Retainability, and Mobility

The operational KPIs showed stellar results for both providers, exceeding the NCC's minimum benchmark of $\geq 98\%$ across the board.

Table 2: Summary of GSM KPIs obtained for the Networks

GSM KPIs	Network A (%)	Network B (%)	NCC Target
Coverage	83.75	84.25	≥ -85dBm
RxQuality ≤ 4	98.73	99	≤ 4
SQI	87.97	98.89	-
Accessibility (CSSR)	**100**	**100**	≥ 98
Retainability (100-CDR)	**100**	**100**	≤ 1 (CDR)
HSR	**100**	**100**	≥ 98

The Call Setup Success Rate (CSSR) for both networks was 100%, indicating perfect accessibility, meaning every call attempt was successfully established. Similarly, the Call Drop Rate (CDR) was 0% (or 100% Retainability), confirming that zero calls were dropped during the testing period, which is significantly better than the NCC target of $\leq 1\%$. Furthermore, both Network A and Network B achieved a 100% Handover Success Rate (HSR) on the GSM network, demonstrating flawless mobility support as the test equipment moved across cell boundaries.

3.2 WCDMA Performance Evaluation

In contrast to the strong GSM performance, the WCDMA (3G) performance revealed significant deficits when measured against the NCC standards, a crucial finding given the widespread reliance on 3G for mobile data services.

3.2.1 WCDMA Received Signal Code Power (RSCP)

RSCP is the coverage metric for WCDMA, with the NCC target set at $\geq$ -85dBm.

- Excellent RSCP (0 to -60dBm): Network B (7.71%) outperformed Network A (0.59%), suggesting Network B has slightly better 3G coverage in certain areas.

- Poor RSCP (-105 to -90dBm): Network A recorded 31.36% of samples in this poor coverage range, compared to Network B's mere 0.48%. This substantial figure for Network A indicates frequent and prolonged periods where the 3G signal strength is weak, leading to poor data experience.
- Compliance: As shown in Table 3, neither network met the NCC benchmark for RSCP (58.64% for A and 72.62% for B when compared to the NCC target of ≥ -85dBm).

3.2.2 WCDMA Ec/No (Energy per chip over Noise density)

Ec/No is the quality metric for WCDMA, with the NCC target set at $\geq$ -9dBm. This metric measures the ratio of energy per chip to noise power spectral density, which is critical for data throughput and stability.

- Excellent Quality (0 to -6dBm): Network A (71.01%) showed a clear advantage over Network B (50.48%). This indicates that where Network A's WCDMA signal is available, its quality is generally cleaner and less noisy than Network B.
- Compliance: Despite the superior Ec/No distribution, both networks failed to meet the NCC benchmark (≥ -9dBm) with 92.01% for Network A and 91.43% for Network B. The ideal Ec/No is essential for supporting higher data services, and falling short of the benchmark suggests inconsistent data rates and potential service degradation for users.

3.2.3 WCDMA Accessibility, Retainability, and Mobility

In contrast to the poor RSCP and Ec/No figures, the operational KPIs for WCDMA largely remained strong:

- Accessibility and Retainability: Both Network A and Network B maintained 100% CSSR and Retainability, meeting the NCC targets, indicating that once a connection is initiated, it is successfully established and held.
- HSR: Network A maintained a 100% HSR. Network B recorded a slightly lower rate of 97.02% (Table 4.3), which falls just below the NCC target of $\geq 98\%$. This suggests minor mobility issues for Network B during 3G operation.

3.3 Overall Findings

The detailed analysis confirms the findings presented in the original report:

1) The performance of the GSM Network for both Network A and Network B is highly satisfactory and meets the NCC's benchmark to a large extent.
2) The performance of the WCDMA Network for both Network A and Network B falls significantly below NCC Standards in the technical metrics (RSCP and Ec/No).

Table 3: Summary of WCDMA KPIs obtained for the Networks

WCDMA KPIs	Network A (%)	Network B (%)	NCC Target
RSCP	58.64	72.62	≥ -85dBm
Ec/No	92.01	91.43	≥ -9dBm
Accessibility	100	100	≥ 98
Retainability	100	100	≤ 1 (CDR)
HSR	100	97.02	≥ 98

4 CONCLUSION AND RECOMMENDATION

4.1 Conclusion

The study successfully analyzed the performance of Network A and Network B on the Ambrose Alli University main campus, employing the drive test technique against NCC-defined KPIs. While both operators provide robust GSM voice services that comply with all operational NCC benchmarks, their WCDMA (3G) performance

is substandard. The critical shortfall lies in signal quality (Ec/No) and coverage (RSCP), which directly impact the data experience of subscribers. Network A showed better Ec/No quality, while Network B showed better RSCP coverage, but both were ultimately non-compliant in these technical areas.

4.2 Recommendations

1) **Operator Action:** GSM operators should focus on deploying more Base Transceiver Station (BTS) sites to close coverage gaps and improve QoS to satisfy customer demand (Sangodoyin & Otti, 2019). Given the non-compliance in WCDMA RSCP and Ec/No, substantial investment and optimization efforts are critically needed for their 3G infrastructure.

2) **Regulatory Oversight:** The NCC is advised to inspect the country's GSM performance profile on a regular basis to ensure carriers upgrade their networks.

3) **Future Studies:** Further research is urged to include data services offered by network operators and to accommodate 4G technology.

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