Assessment Of Data Over 3G and 4G LTE Networks in Ibadan Metropolis, Nigeria

Tolulope Tola Awofolaju, Oluwaseun Joel Olasunkanmi, Olowookere Oluwasomidotun Emmanuael

Department of Electrical and Electronics Engineering, Osun State University, Osogbo, Nigeria.

Email: oluwaseun.olasunkanmi@cset.uniosun.edu.ng

Article Information:

Received:
7 September 2024

Received in revised form:
12 November 2024

Accepted:
28 November 2024

Volume 6, Issue 2, December 2024
pp. 85 – 94

http://dx.doi.org/10.23960/jesr.v6i2.173

Abstract

This study assesses the signal quality of 3G and 4G networks in Ibadan, Oyo State, Nigeria. The research aims to compare the coverage and service quality of four service/network providers in relation to location, and identify areas with weak signal strength that require optimization. A comprehensive analysis of the received signal strength indicator (RSSI) of each network provider was conducted. The findings provide valuable insights for network providers to improve their services and for subscribers to make informed decisions about their internet usage and voice calls. The study's results have significant implications for enhancing the overall quality of telecommunications services in the region. The research highlights areas with poor network coverage and provides recommendations for network optimization. By addressing these issues, network providers can improve their services, increases customer satisfaction, and contribute to the region's economic development by addressing these issues. Additionally, the study's findings can inform policy decisions and infrastructure development initiatives to enhance region's telecommunications sector.

Keywords: *Signal Quality, Coverage, Strength, Internet Usage, User*

I. INTRODUCTION

The rapid evolution of mobile communication technology has transformed the way people communicate, access information, and utilizes services. The transition from 1G to 5G has been driven by the increasing demand for high-speed data transmission, reliable connectivity, and service-compatible technologies [1]. This growth has been fueled by the exponential increase in telecom customers and the need for advanced network infrastructure [3].

The mobile cellular era, which began in 1980, has witnessed significant advancements, from the introduction of the first mobile phones in 1982 to the development of 4G, as shown in Table 1 and then 5G networks [7]. Each generation of mobile technology has brought improvements in quality, accessibility, and functionality, enabling users to transition from basic voice and text services to high-speed internet access, live streaming, and other data-intensive applications [4].

The International Telecommunication Union (ITU) worked on 3G international standardization through its project IMT-2000 (International Mobile Telecommunications-2000) that aims at setting the global standard for 3G. The full transition to 3G was completed throughout 2005/2006 in Japan. In 2005, there have been twenty three networks worldwide, operative 3G technology [11]. The main reason for the evolution of 3G was attributable to the restricted capability of the 2G networks. 2G networks were engineered for voice calls and slow information transmission. However these services were unable to satisfy the wants of gift wireless revolution. These technologies act like bridge between 2G and 3G.

Generally speaking, in designing 3G applications and planning profitable business models, the end-users' needs and wants should be in the hot spot [5, 8]. The main challenge when exploring user needs and wants lies in the intersection of unknown future customers' needs and wants and new technology that is not even available for many users. Therefore, it was suggested that service developers can only meet the needs and wants with a profound understanding of the mobile communication system, ranging from voice-centric services to multimedia centric services [8].

As wireless network systems became increasingly user-centric, the 4th Generation wireless network (4G) was designed with key features such as user-friendliness, user personalization, terminal heterogeneity, network heterogeneity, evolutionary design, and personalization transfer as its basis. User-friendliness and personalization meant that terminals and users should interact naturally without hassle. Terminal heterogeneity should allow various terminal types and technologies to interact smoothly. Network heterogeneity refers to the growing amount of available network access technologies which, when used together, should provide a seamless service while still differing in terms of coverage, rate of loss, data rate, and latency. As devices were created using evolutionary design to be adaptable, personalized, and less specialized, 4G needed to provide a complete package, maximize the variety of services supported and exploit the variety of personalized terminals in use. Hence, 4G allows interoperability between heterogeneous network technologies to provide better coverage almost anywhere while respecting Quality of Service (QoS) requirements, bandwidth resource QoS utilization optimization, and better power consumption among all the available networks [6].

However, this increased demand for mobile data services has also introduced new challenges, such as network congestion, signal quality degradation, and varying levels of service quality across different network providers [10]. Therefore, it is essential to assess the performance of 3G and 4G LTE networks in terms of signal quality, coverage, and service reliability.

Table 1: Summary of Network Generation from 1G – 4G

TECHNOLOGY	1G	2G	2.5G	3G	4G
YEAR	1970	1980	1985	1990	2000
STANDARDS	AMPS, NMTS,ETACS, TACS	GSM, D-AMPS	EDGE, GPRS	CDMA2000, WCDMA	SINGLE STANDARD LTE-ADVANCED
DATA BANDWIDTH	1.9Kbps	14.4Kbps	384Kbps	2Mbps	200Mbps
CORE NETWORK	PSTN	PSTN	PSTN, Packet Network	Packet Network	Internet
MULTIPLEXING	FDMA	CDMA, TDMA	CDMA, TDMA	CDMA2000, WCDMA	OFDMA
SERVICE	Analog Voice	Digital Voice	Packet data and high capacity	High capacity and broadband data	Broad-bandwidth high speed

The rapid growth in mobile subscriptions and demand for diverse multimedia services has significantly impacted network performance and quality of service (QoS) provided by mobile operators. Consequently, mobile users have been plagued by numerous issues, including poor network coverage, dropped calls, blocked calls, high call tariffs, subpar internet services, slow browsing speeds, and inadequate interconnectivity between network providers [1].

These challenges have led to widespread customer complaints and dissatisfaction, potentially resulting in substantial losses for network providers. Effective monitoring and management of wireless networks are crucial to meeting user expectations and ensuring high-quality services [3].

In Nigeria, the Nigerian Communications Commission (NCC) is responsible for establishing minimum QoS standards for the telecommunications industry. The demand for good QoS has been a longstanding challenge for the industry, prompting the NCC and the government to address these concerns [7]. A public forum was held to identify factors affecting QoS and to seek solutions to these challenges. The NCC subsequently issued benchmarks for Key Performance Indicators (KPIs) to all network operators, ensuring that mobile users have access to quality services [12].

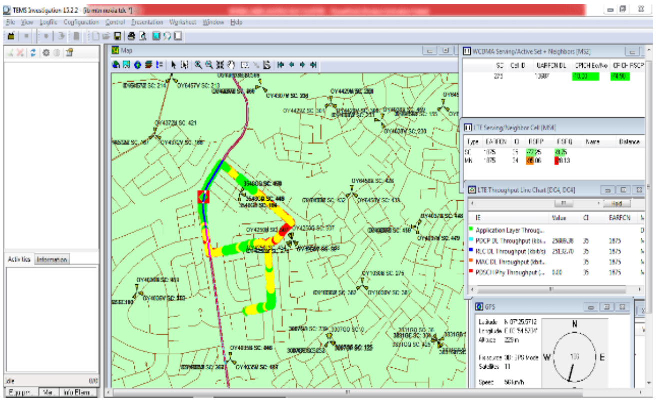

Figure 1: TEMS Investigation View

The city of Ibadan, Oyo State, Nigeria was selected as the study area for this research. Ibadan is the largest and most populous city in Nigeria, with a high demand for mobile communication services. However, the city's mobile network infrastructure faces several challenges, including high utilization, poor coverage, and low quality of service, resulting in dropped calls, blocked calls, and poor network quality. High utilization was identified as a major issue in the area. Figure 1 shows the TEM investigation view, with longitude and latitude coordinates enabling GPS tracking. Figure 2 illustrates the routes covered in the study area, so it is essential to understand some parameters which includes;

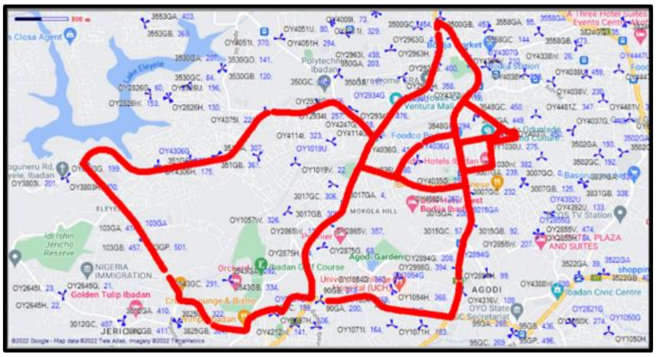

Figure 2: Network Provider Closter Route

Handover (HO)

Handover is a process of transferring an ongoing call or data session from one cell site to another without interruption [3, 9]. Soft and Hand Over Success Rate (SHOSR) can be calculated by using equation [7]:

$$SHOSR = \frac{Number\ of\ successful\ handover}{Total\ number\ of\ handover\ attempts} \times 100 \qquad (i)$$

Call Setup Success Rate (CSSR)

CSSR is the probability of establishing a call [10]. It is the ease with which calls are established or setup and it is given by equation [13]:

$$CSSR[\%] = \frac{Number\ of\ unblocked\ calls\ attempt}{Total\ number\ of\ attempts} X\ 100 \qquad (ii)$$

Block Call Rate (CBR)

This is the probability of calls blocked due to congestion in the service provider's network [5]. It is given by equation [13]:

$$CBR[\%] = \frac{Number\ of\ blocked\ calls}{Total\ number\ of\ call\ attempts} \times 100 \qquad (iii)$$

Call Drop Rate (CDR)

CDR is also called Drop Call Rate (DCR) which is probability of a call terminating without the will of either party [10];

$$CDR[\%] = \frac{Number\ of\ dropped\ calls}{Total\ number\ of\ call\ attempts} \times 100 \qquad (iv)$$

Call Completion Rate (CCR)

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 [13]:

$$CCR[\%] = \frac{Number\ of\ normally\ ended\ calls}{Total\ number\ of\ call\ attempts} \times 100 \qquad (v)$$

Received Signal Code Power (RSRP)

RSRP 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 [3].

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. The ratio of received pilot energy, Ec, to the total received energy or the total power spectral density, Io. Ec/Io should be up to -13dB, value less than this could be due to bad terrain interference or increased number of users [3].

Transmitting Power (Tx power)

This is the performance metric used to measure the transmitting ability of enodeB. It is measured in dBm. Tx Power control determines how the transmit power of the receiving base station will vary. This power should be up to -20, any value less than -20 will indicate interference that can result in call drop, call blocks and voice breaks [3].

Rx Level

The power level corresponding to the average received signal level of the downlinks as measured by the mobile station. It ranges from -30 to -80dB, and any level lower than -80 shows low signal level. New site proposal, hardware check could alter the low signal level. This is the power of mobile station which is only measured in the dedicated mode.

Carrier to Interference (C/I)

Co-interference is the term used for interference in a cell caused by carriers with the same frequency present in other cells. Normal range of C/I should be less than 12dB, value greater indicates interference with a certain frequency that results in a low throughput. Neighbor sites should be properly planned to overcome interference problems.

Signal to Noise Ratio (SNR)

This is the signal to noise ratio of the carrier. SNR should be less than 6% and any value greater than that will result in low throughput, voice quality breaks. It has its equation to be:

$$SNR = \frac{\text{Average Received Signal Power}}{Interference + Noise\ Poweer}$$

Where; S= Average Received Signal Power, I= average interference power, & N= noise power.

Received Signal (RSCP) has its range from -30 to -75dB to be good, -75 to -85dB to be acceptable and -85 to -140dB to be bad for the signal.

Signal Quality: has its range from 0 to -7 to be good, -7 to -10 to be acceptable and -10 to -36 to be bad for the signal.

Received signal strength indicator (RSSI) has its equation to be RSCP + EcNo, and it ranges from 0 to -75dB to be good, -75 to -85dB to be acceptable and -85 to -140dB to be bad for the signal.

Therefore, the various parameters information such as RSCP level, Ec/No, path loss, transmitted power etc. would be presenting in plots. The computations of key parameters would be adopted using equations i, ii, iii, iv & v to calculate the SHOSR, CSSR, CBR, CDR and CCR respectively.

II. MATERIALS AND METHODS

This study employed drive-testing using the TEMS (Test Mobile System) software to collect data on the performance of 3G and 4G networks in Ibadan, Nigeria. Specifically, TEMS version 15.2.2 was used for data collection, while TEMS Discovery version 10.0.3 was utilized for data analysis.

The received signal strength index (RSSI) and speech quality index (SQI) were analyzed using Microsoft Excel. This analysis enabled the identification of areas requiring optimization to improve network performance.

This research adopted a field test approach, commonly known as drive testing, to measure network performance from the user's perspective. The test setup consisted of a phone (Samsung Galaxy S5) connected to a computer running TEMS software, ensuring objective measurements.

Figure 1 illustrates the TEMS investigation interface, where automatic measurements were conducted. The measurement process involved testing 3G and 4G networks across multiple locations in Ibadan, both indoors and outdoors. The same locations were used to test the four mobile carriers, with parameters such as SHOR, CDR, CSSR, CCR, and CBR recorded for comparative analysis.

The measurements obtained reflect various factors affecting Quality of Service (QoS). Figure 2 shows the route covered during the investigation, which was defined using GPS.

A. *Experimental Set Up of the Drive Test Drive Test Algorithm*

The following steps outline the drive test algorithm employed in this study:

1. Equipment Setup: Configure and set up all necessary equipment, including the TEMS software, phone, and computer.
2. Initialize Drive Test: Launch the TEMS software and initialize the drive test, ensuring all settings are correctly configured.
3. Network Selection: Switch the user's equipment to the respective network provider (e.g., MTN, Glo, Airtel, 9mobile).
4. Data Collection: Take readings of the received signal strength index (RSSI) and speech quality index (SQI) for each network provider.
5. Repeat Measurements: Repeat steps 3-4 for all network providers to ensure comprehensive data collection.
6. Data Analysis: Analyze the drive test results using TEMS Discovery and Microsoft Excel to identify trends, patterns, and areas for optimization.
7. Terminate Drive Test: Stop the drive test and equipment setup.

B. *Methods and Material*

The following materials were used for data collection in this research:

1. HP Laptop installed with TEMS software
2. TEMS mobile phone or User Equipment (UE) (e.g., Sony Ericsson or Huawei)
3. MODEM and My-Fi
4. Built-in GPS of the TEMS phone
5. Subscriber Identity Modules (SIM) for four network providers (MTN, GLO, AIRTEL, and 9MOBILE)
6. TEMS Pocket software-based release with built-in scanner phones supporting GSM and WCDMA
7. Reliable vehicle
8. Dongle key (license for unlocking the drive-test software)
9. Flash memory for data transfer
10. TEMS software and TEMS Discovery installed on the laptop
11. Mini-inverter for alternative vehicle charging

C. *Drive Test Procedure*

The drive test procedure consisted of the following steps:

Step I: Conducted static and dynamic drive tests on MTN, GLO, AIRTEL, and 9MOBILE networks. Static drive test analyzed 3G to 3G voice calls and 3G to 2G voice calls to determine the best RSCP and Ec/No while dynamic drive test examined coverage of all sectors using long and short calls. Long calls lasted 120 seconds, while short calls lasted approximately 50 seconds.

Step II: Inserted the Subscriber Identity Module (SIM) for the network being tested.

Step III: Conducted voice call tests with automatic selection of the 3G network technology. Configured WCDMA coverage indicator, GPS features active and idle call duration, and stick memory /internal recorder.

Step IV: Exported generated files during tests/measurements to the PC.

Step V: Tested all four networks' SIMs and moved the measurement setup to the next route/point. Otherwise, revisited previous steps to check for errors.

Step VI: Stopped measurements when all predefined eNodeBs or base stations had been considered. Otherwise, revisited the previous step for error correction.

Step VII: Repeated the procedure for 4G_LTE to determine RSRP, Quality, Throughput, and SINR.

III. RESULTS AND DISCUSSIONS

A. *Case Study 1: Third Generation (3G) Network Performance Evaluation.*

This case study presents the results of the drive test measurements for the 3G network. The measurements were taken using the TEMS software and hardware equipment, as described in the methodology section.

Table 2: Range of value, colour and the signal strength for RSCP

S/N	RANGE OF VALUES (dB)	COLOUR INDICATOR	SIGNAL STRENGTH INDICATION
1	00.00 - - 75.00	GREEN	EXCELLENT
2	-75.00 - -85.00	LIGHT GREEN	V. GOOD
3	-85.00 - -95.00	LIGHT BLUE	GOOD
4	-95.00 - -105.00	YELLOW	ACCEPTABLE
5	-105.00 - -115.00	ORANGE	POOR
6	-115.00 - -00.00	RED	BAD

According to Fig. 3, this incorporates the data from Table 3, the received signal code power (RSCP) values within the range of -0 to -70 dB account for 60.98% of the total measurements.

Table 3: Range of values, colour and signal quality for Ec/No

S/N	RANGE OF VALUES (dB)	COLOUR INDICATOR	SIGNAL STRENGTH INDICATION
1	00.00 - - 10.00	GREEN	EXCELLENT
2	-10.00 - - 12.00	LIGHT GREEN	V. GOOD
3	-12.00 - - 14.00	LIGHT BLUE	GOOD
4	-14.00 - - 16.00	YELLOW	ACCEPTABLE
5	-16.00 - - 18.00	ORANGE	POOR
6	-18.00 - - 00.00	RED	BAD

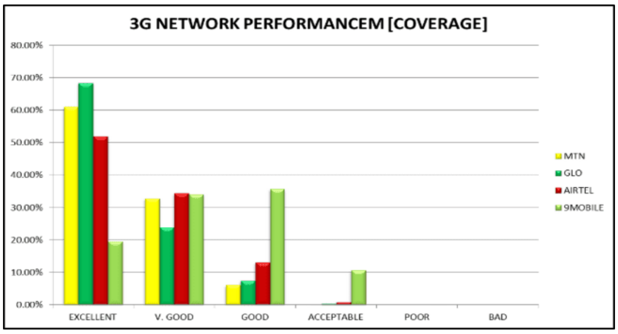

Figure 3: Performance of Third Generation Network Coverage

3G coverage with RSCP >-95dBm (MTN = 99.79%, GLO =99.66%, AIRTEL = 99.23% & 9MOBILE = 89.29%)

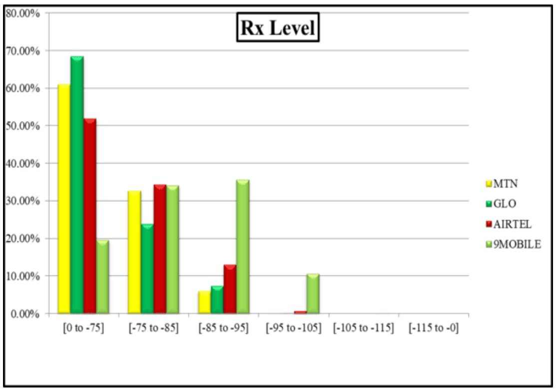

Figure 4: Rx Level of Third Generation Network Coverage

Fig. 5, which combines data from Table 2, reveals the following results, MTN: Ec/No range of 0 to -10 is 14.66%, and RSSI range of -0 to -70 is 46.32%. GLO: RSCP range of -0 to -70 is 68.37%, Ec/No range of 0 to -10 is 11.13%, and RSSI range of -0 to -70 is 57.24%. AIRTEL: RSCP range of -0 to -70 is 51.84%, Ec/No range of 0 to -10 is 38.63%, and RSSI range of -0 to -70 is 13.12%. 9MOBILE: RSCP range of -0 to -70 is 19.57%, Ec/No range of 0 to -10 is 37.9%, and RSSI range of -0 to -70 is 18.33%.

The analysis of these parameters indicates varying quality-of-service providers in the Bodija/Eleyele/Sabo Ibadan cluster. Notably, all network providers have a total coverage area above 80%, as stipulated by the Nigerian Communication Commission (NCC). The coverage areas are as follows: MTN (99.79%), GLO (99.66%), AIRTEL (99.23%), and 9MOBILE (89.29%) [1].

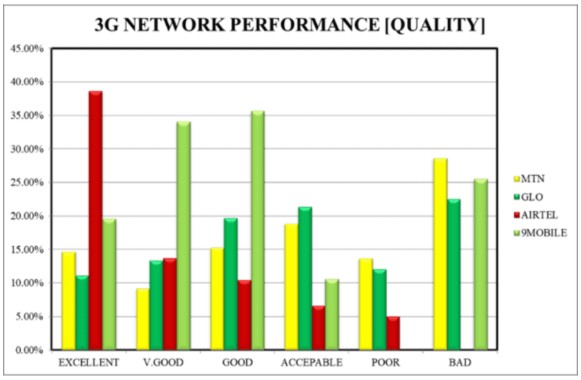

Figure 5: Third Generation of Network Performance (Quality)

3G quality with EcNo >-16dB (MTN = 57.8%, GLO = 65.45%, AIRTEL = 69.44% & 9MOBILE = 67.56%)

Fig. 4 reveals that the transmitting power for all network providers differs significantly. Additionally, Fig. 6 shows that the received signal quality (Rx Quality) for most base stations in the area is relatively low, which is also reflected in the low Speech Quality Index (SQI) values.

Tables 3 and 4 provide a summary of call events and key performance indicators (KPIs) for the four network providers: Table 3 and 4: Summary of Call Events and KPIs for MTN and GLO Network Providers and Table 5 and 6: Summary of Call Events and KPIs for AIRTEL and 9MOBILE Network Providers.

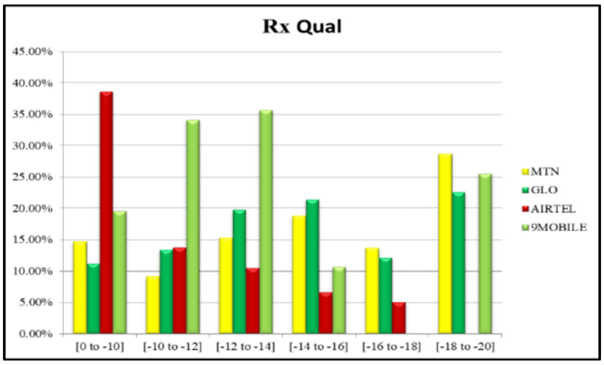

Figure 6: Rx Qual of Third Generation Network Performance

Table 3 & 4: Summary of Call Events and KPI's for MTN & GLO Network Providers

Operator	Events	Number
MTN	Call Attempt	58
	Call Established	58
	Block call	1
	Dropped Call	0
	Handover	449
	Handover Failure	55
Operator	**KPI**	**Value**
MTN	CSSR	98.48%
	HSR	100.00%
	DCR	98.51%
	Blocking	0.00%
Operator	**Events**	**Number**
GLO	Call Attempt	54
	Call Established	41
	Block call	13
	Dropped Call	9
	Handover	323
	Handover Failure	36
Operator	**KPI**	**Value**
GLO	CSSR	75.93%
	HSR	88.85%
	DCR	21.95%
	Blocking	24.07%

Table 5 & 6: Summary of Call Events and KPI's for AIRTEL & 9MOBILE Network Providers

Operator	Events	Number
AIRTEL	Call Attempt	45
	Call Established	58
	Block call	0
	Dropped Call	3
	Handover	650
	Handover Failure	60
Operator	**KPI**	**Value**
AIRTEL	CSSR	100.00%
	HSR	90.77%
	DCR	6.67%
	Blocking	0.00%
Operator	**Events**	**Number**
9 MOBILE	Call Attempt	39
	Call Established	39
	Block call	0
	Dropped Call	1
	Handover	449
	Handover Failure	55
Operator	**KPI**	**Value**
9 MOBILE	CSSR	100.00%
	HSR	87.75%
	DCR	97.44%
	Blocking	0.00%

Fig. 7 illustrates the frequency band utilization for 3G networks. The results show that two bands, U900 and U2100, are present at every site. Notably, the subscribers' device determines the band prioritization.

The band utilization percentages for each network provider are as follows, MTN: U900 (64.48%) and U2100 (35.52%), AIRTEL: U2100 (100%), GLO: U2100 (99.52%) and 9MOBILE: U2100 (100%)

These results indicate that all bands are highly utilized across all network providers.

Figure 7: 3G (U2100 and U900) Bands

B. *Case Study 2: 4G Long-Term Evolution (LTE) Network Performance Evaluation*

This case study presents the results of the drive test measurements for the 4G LTE network. The measurements were taken using the TEMS software and hardware equipment, as described in the methodology section.

According to Fig. 9, which incorporates data from Table 3 and Fig. 8, the 4G coverage with a reference signal received power (RSRP) range of -0 to -70 dB accounts for 4.09% of the total measurements.

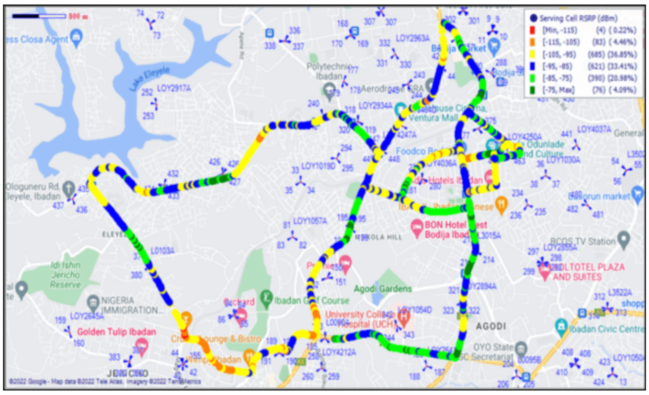

Figure 8: Fourth Generation Network Performance Coverage

4G coverage with RSRP >-95dBm (MTN = 58.48%, GLO = 71.81%, AIRTEL = 60.52% and 9MOBILE = 32.06)

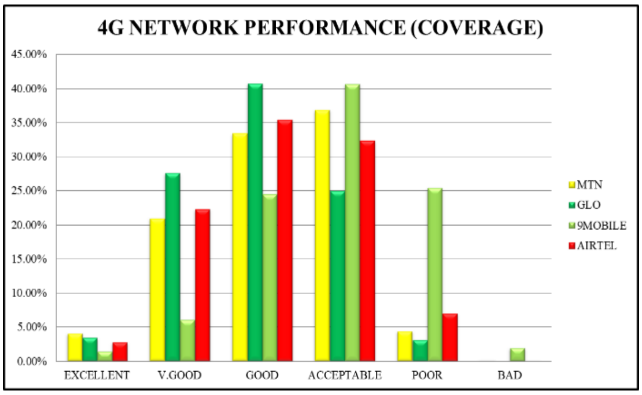

Figure 9: Fourth Generation Network Performance Coverage

4G coverage with RSRP >-95dBm (MTN = 58.48%, GLO = 71.81%, AIRTEL = 60.52% & 9MOBILE = 32.06)

Fig. 10, which combines data from Table 3, reveals the following results:

Overall 4G quality: RSRQ range of -0 to -10 accounts for 31.31% of the total measurements.

Network provider-specific results: MTN: 4G coverage with RSRP range of -0 to -70 dB accounts for 3.49%, while 4G quality with RSRQ ranges of -0 to -10 accounts for 39.57%.

GLO: 4G coverage with RSRP range of -0 to -70 dB accounts for 2.82%, while 4G quality with RSRQ ranges of -0 to -10 accounts for 37.65%.

AIRTEL: 4G coverage with RSRP range of -0 to -70 dB accounts for 1.45%, while 4G quality with RSRQ ranges of -0 to -10 accounts for 64.46%.

9MOBILE: 4G coverage with RSRP range of -0 to -70 dB accounts for an unspecified percentage, while 4G quality with RSRQ range of -0 to -10 accounts for an unspecified percentage (please provide the actual percentages for 9MOBILE).

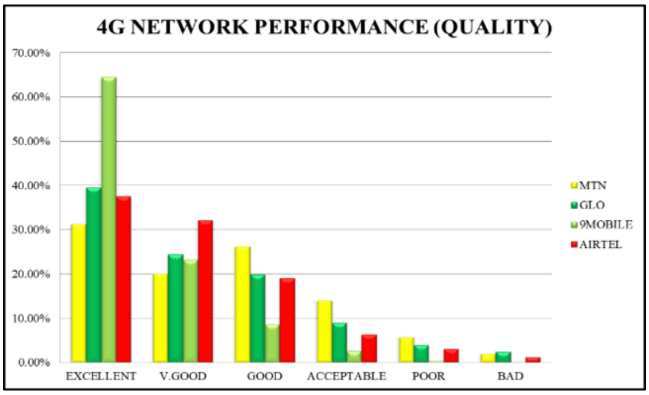

Figure 10: Fourth Generation Network Performance Quality

4G Quality with RSRP >-14dB (MTN = 77.84%., GLO = 84.19%, AIRTEL = 89.02% & 9MOBILE = 96.46%)

B. *The Challenges OF 3G and 4G_LTE*

Fig. 14 illustrates the frequency band utilization for 4G networks, revealing the presence of multiple bands

(800, L900, 1800, 2600, and L700) at every site. The subscribers' devices determine the band prioritization.

The band utilization percentages for each network provider are as follows: MTN: L800 (24.22%) and L2600 (74.81%), GLO: L800 (2.94%), L1800 (94.57%), and L2600 (2.2%), AIRTEL: L900 (7.89%), L1800 (54.56%), and L2600 (17.99%) and 9MOBILE: L1800 (99.61%)

These results indicate that all bands are highly utilized, suggesting that transitioning to 5G networks may not be challenging for some network providers.

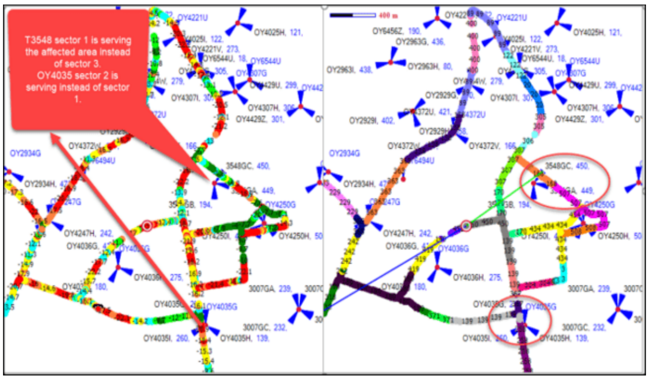

Figure 11: 3G Call Events and Failure Analysis – Poor Quality

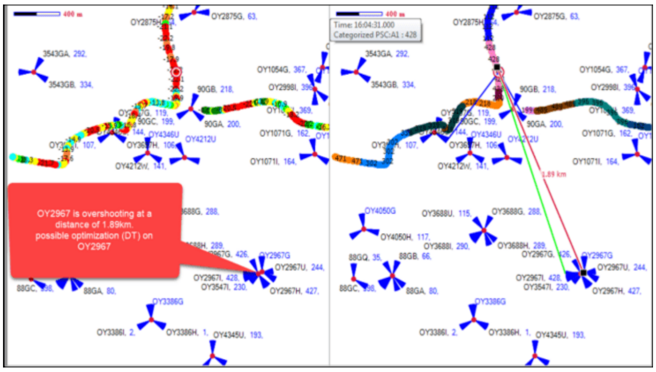

Figure 12: 3G Call Events and Failure Analysis – Overshooting

Table 7: Result Analysis of Ec/No and RSCP Values by Area

S/N	LAT/LONG	RSCP				EC/NO			
		MTN	GLO	AIRTEL	9 MOBILE	MTN	GLO	AIRTEL	9 MOBILE
1	7.419/3.8590	-85.8	-69.7	-55.8	-57.8	-14.8	-9.6	-5	-2.9
2	7.4242/3.3596	-87.1	-70.7	-64.2	-90.3	-13.7	-10.8	-5.4	-12
3	7.4205/3.8597	-64.7	-83.4	-78.4	-76.2	-18.4	-14.7	-9.1	-6.4
4	7.4215/3.8622	-78.4	-95.5	-84.9	-89.4	-9.2	-21.8	-21.7	-12.8
5	7.4202/3.8642	-80.4	-77.9	-91.3	-94.6	-8.5	-11.9	-21.1	-15.1
6	7.4185/3.8667	-58.7	-48.4	-79.6	-101.4	-21.9	-6.5	-9.5	-17.2
7	7.4188/3.8697	-67.7	-52	-86.4	-88.8	-6.1	-5.8	-17.1	-21.7
8	7.4191/3.8711	-89	-67.8	-66.3	-77.9	-19.5	-14.9	-8.7	-22.2
9	7.4198/3.8748	-90.9	-82.8	-80.6	-101.4	-22.2	-18.6	-15	-17.2
10	7.4201/3.8771	-85.3	-91.9	-89.8	-91.4	-18.8	-20.8	-21.2	-20.8

Table 7 presents a comparative analysis of the Ec/No and RSCP values for different areas, providing insights into the network performance and coverage in each region.

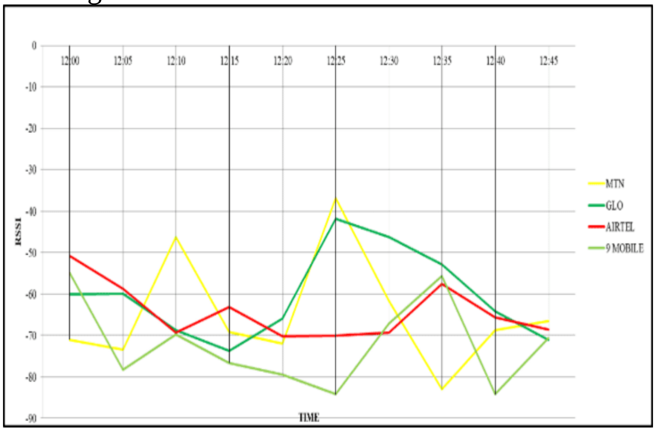

Figure 13: RSSI Vs Time Graph

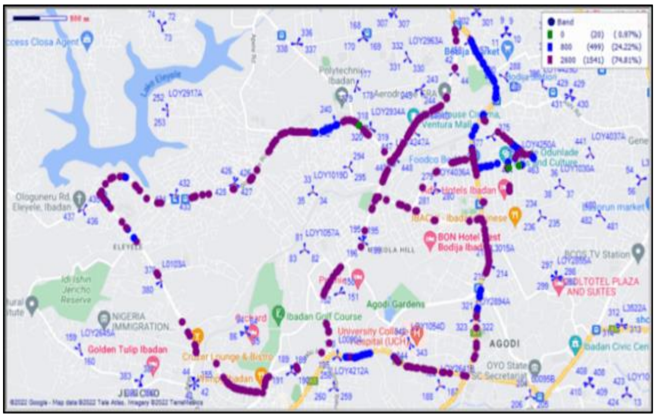

Figure 14: 4G (L900 & L2600) Bands

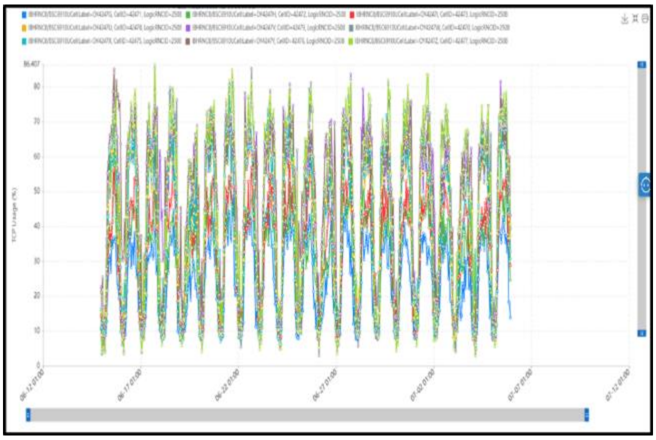

Figure 15: 3G Utilization

This subsection presents an in-depth examination of the impact of Signal-to-Noise Ratio (SNR) on throughput. A comparative analysis is conducted to investigate the relationship between SNR and throughput. Specifically, the study compares the SNR versus the percentage of measurement slots (Fig. 17) and throughput versus the percentage of measurement slots (Fig. 16).

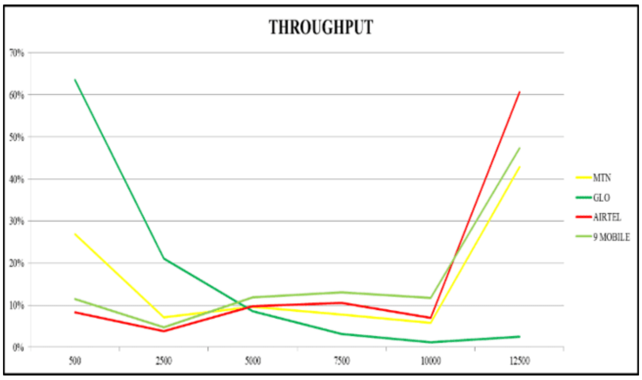

Figure 16: Throughput of the 4G_LTE Vs Percentage Slot

The throughput analysis for each network provider reveals the following results:

MTN: The maximum throughput of 2.813e+5 occurs at count slot 1871, while the mean throughput of 8800.609 is observed at the minimum slot 0.

GLO: The maximum throughput of 1.134e+5 occurs at count slot 2006, with a mean throughput of 923.571 at the minimum slot 0.

AIRTEL: The maximum throughput of 1.608e+5 is recorded at count slot 1506, while the mean throughput of 1.081e+5 occurs at the minimum slot 0.

9MOBILE: The maximum throughput of 1.313e+5 is observed at count slot 1741, with a mean throughput of 7724.228 at the minimum slot 0.

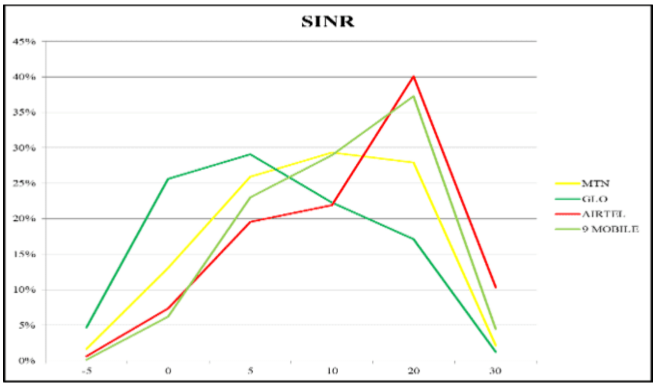

Figure 17: SINR Vs Percentage Slot

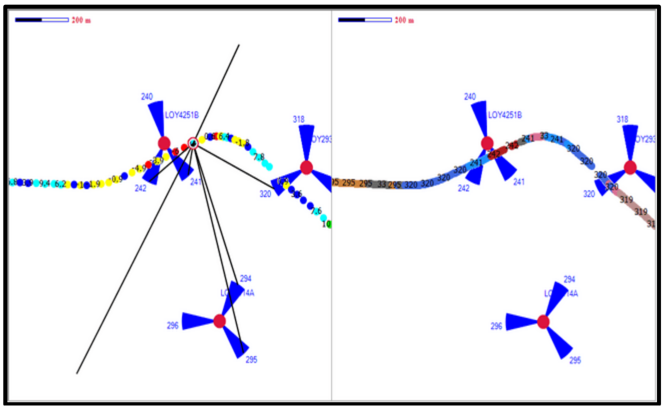

Figure 18: 4G Poor SINR Analysis

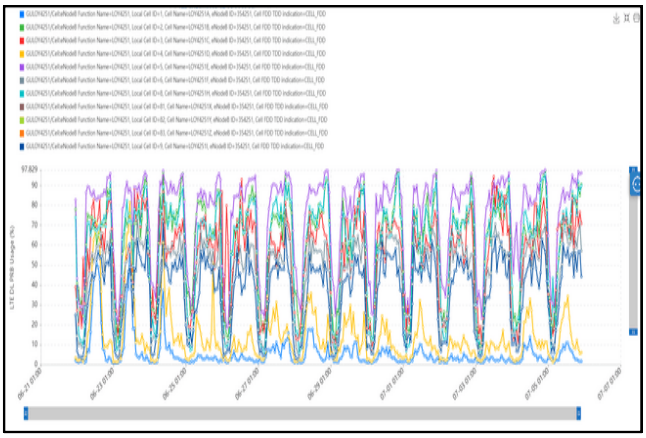

Figure 19: 4G Utilization

IV. CONCLUSIONS

This study evaluated the performance of 3G and 4G networks in Ibadan, Nigeria. The results show varying levels of quality-of-service among network providers. While all providers met the Nigerian Communication Commission's (NCC) coverage requirement of 80%, significant differences were observed in signal strength, quality, and throughput. Key findings include poor transmitting power and lack of surrounding handover antennas, resulting in call block, call drops, and losses, as well as low received signal strength. Dropped calls and poor quality are often caused by high utilization, operational issues, and poor coverage. Network providers' coverage and quality performance vary significantly. Challenges reducing network performance include overshooting and poor quality coverage. Proposed solutions include integrating multi-sector antennas to solve high utilization problems, load balancing between two sites using CELL ON WHEEL (COW) to reduce or share load, and optimizing cell parameters, such as down-tilting, to improve coverage and reduce overshooting. To optimize network performance, innovative solutions can be employed, for cells down-tilting Artificial Intelligence (AI) can be utilized to automatically adjust cell tilting between 0 to 9 degrees, mitigating overshooting and incorrect coverage. For high utilization management Internet of Things (IoT) integration can notify network providers of high utilization, enabling proactive measures. Optimizing mobile device settings: Analysis reveals that 3G is highly utilized for voice calls. To improve performance, mobile devices can be configured to use 3G for voice calls, 4G for data transmission and 5G (where available) with Python code-based enablement. These solutions can enhance network efficiency, reduce congestion, and improve overall user experience. The analysis also highlights the importance of upgrading SIM modules to support 4G and 5G networks and upgrading infrastructure to support emerging technologies. The study's results show varying performance metrics across network providers, including RSCP, Ec/No, CSSR, CDR, and HOSR. The throughput analysis reveals the following results: MTN (42.758% excellent throughput), GLO (2.44% excellent throughput), AIRTEL (60.624% excellent throughput), and 9MOBILE (47.272% excellent throughput). These results provide valuable insights for network providers, policymakers, and subscribers. This research contributes to the existing body of knowledge on network performance evaluation and provides valuable insights for network providers, policymakers, and subscribers. The study's results can inform network optimization strategies, policy decisions, and infrastructure development initiatives aimed at improving the quality of telecommunications services in Nigeria. The specific performance metrics for each network provider are as follows:

RSCP (Received Signal Code Power): MTN: 46.32%, GLO: 68.37%, AIRTEL: 51.84% and 9MOBILE: 19.57%. Ec/No (Energy per Chip to Noise Ratio): MTN: 14.66%, GLO: 11.13%, AIRTEL: 38.63% and 9MOBILE: 37.9% CSSR (Cell Site Selection and Reselection): MTN: 98.48%, GLO: 75.93%, AIRTEL: 100% and 9MOBILE: 100% CDR (Call Drop Rate): MTN: 1.49%, GLO: 78.05%, AIRTEL: 6.67% and 9MOBILE: 2.56% HOSR (Handover Success Rate): MTN: 100%, GLO: 88.85%, AIRTEL: 90.77% and 9MOBILE: 87.75%

REFERENCES

[1] Acharya, S., & Gaba, T. (2014). A Review : Handover in 3G / UMTS Network. *International Journal of Emerging Trends in Science and Technology,* 1(3), 332–339.

[2] Aditi Chakraborty 2013. "A Study on Third Generation Mobile Technology (3G) and Comparison among All Generations of Mobile Communication." *International Journal of Innovative Technology & Adaptive Management (IJITAM),* vol. 1, no. 2, ISSN: 2347-3622, Nov. 2013.

[3] Akinyemi, L. A., Makanjuola, N. T., Shoewu, O. O., & Edeko, F. O. (2014). *Evaluation and Analysis of 3G Network in Lagos Metropolis , Nigeria.* International Transaction of Electrical and Computer Engineers System, 2(3), 81–87. https://doi.org/10.12691/iteces-2-3-1

[4] Begüm K. E., Çetin K., "Comparison of Signal Strengths of 2G/3G/4G Services on a University Campus." *International Journal of Applied Mathematics, Electronics and Computers Advanced Technology and Science,* ISSN: 2147-82282147-6799 http://ijamec.atscience.org

[5] Fenton C. J., Moss J. G. O., Lock D. W., Bloomfield R., Fisher J. F., Pratt D. M., Brookland A., & Gil J. 2001."3G trials and developments." *BT Technology Journal*, 19 (1), 127-137.

[6] Frattasi S., Fathi H., Fitzek F. H. P., Prasad R., (2006) "*Defining 4G Technology from the User's Perspective*," IEEE Network, Vol. 20, No. 1, pp. 35-41

[7] Galadanci, G. S. M., & Abdullahi, S. B. (2018). Performance Analysis of GSM Networks in Kano Metropolis of Nigeria. *American Journal of Engineering Research (AJER),* 7(5), 69–79. Retrieved from www.ajer.org

[8] GerstheimerO.,&Lupp C. 2004. "Needs versus technology—the challenge to design third-generation mobile applications." *Journal of Business Research*, 57 (12), 1409-1415.

[9] Hasdah, R., & Kumar, A. (2013). Study of soft handover in third generation cellular networks. *International Journal of Innovative Research in Technology & Science,* 1(1), 1–8.International Journal of Modern Trends in Engineering and Research (IJMTER) Volume 02, Issue 10, pg. 281 -283 [October – 2015]

[10] International Telecommunication Union-T E.807. Recommendation, 2014

[11] Kazi Asmat and Dr. Sohan Garg 2013."A Pragmatic Survey on 3G Technologies and Prominence." *International Journal of Computing and Corporate Research*, ISSN: 2249054X-V313M7- 05, Vol. 3 , May (2013).

[12] Theodore S. Rappaport, *Wireless Communications: Principles and Practice*, 2nd ed.: Prentice Hall, 2001.

[13] Yuwono, T., & Ferdiyanto, F. (2015). Measurement and Analysis of 3G WCDMA Network Performance Case Study : Yogyakarta Indonesia. *In 2015 4th International Conference on Instrumentation, Communications, Information Technology, and Biomedical Engineering* (ICICI-BME) Bandung, (pp. 294–297).