Performance Evaluation of 4G Mobile Communication Networks for Real – Time Election Results Transmission in Nigeria: A KPI-Based Approach

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Abstract: The advantages of real-time election results transmission are enormous. These include transparency and accountability, and these help to build trust in the electoral process. Hence there is a desire by the Independent National Electoral Commission (INEC) for gradual introduction of electronic voting and real-time results transmission into the Nigeria Electoral System. The feasibility of this dream depends greatly on the ability of the existing telecommunications infrastructure to support the desired real-time elections results transmission. This work therefore evaluates the efficiency and availability of one mobile network provider in Uyo, Akwa Ibom State vis-à-vis its ability to support the transmission and collation of elections results. Four sites were analysed for cell availability, total data volume, uplink throughput and downlink throughput. The result showed that the Base Transceiver Station (BTS) at Ibiam Street had a percentage availability of 99.98%, Brooks Street had 99.97%, Qua Iboe Church, Ikot Ekpene Road recorded availability of 99.87%, and Effiat Offot showed cell availiability of 99.98%. The total data volume recorded were 424.9097GB, 443.7788GB, 430.1485GB and 474.6815GB for Ibiam Street, Brooks Street, Qua Iboe Church Ikot Ekpene Road and Effiat Offot respectively. The uplink throughput was measured at 4.4Mbps, 4.7Mbps, 4.6Mbps and 4.4Mbps, while the downlink throughput were 18.2Mbps, 14.4Mbps, 8.9Mbps and 7.2Mbps in the same order for all the sites respectively. Comparing the results with the approved Nigerian Communications Commission (NCC) standards for 4G networks, some BTS sites in Uyo did not satisfy the NCC approved standard. Therefore, it is recommended that Mobile Network Operators (MNOs) should carry out throughput and availability optimization of their services sites to support critical services such as the electronic transmission of election results.

Keywords: Electoral Technology, Throughputs, Availabilities, Average Active Users, Polling Units, Independent National Electoral Commission Viewing (IReV) Portals.

I. INTRODUCTION

Mobile communication networks are types of telecommunication networks comprising terminals, and nodes connected to each other through links that enable exchange of information between users of the terminals. The operation of mobile communication networks is made possible by many technologies such as Global System for Mobile Communications (GSM), General Packet Radio Service (GPRS), Wideband Code Division Multiple Access (WCDMA), Long Term Evaluation (LTE), and High Speed Downlink Packet Access (HSPDA) (Al-Sividah *et al.* 2014)

Mobile communication network play a critical role in the economy and society and has become an integral part of the modern world. Key performance indicators are metrics that show the functionality level or performance of a system such as mobile communication networks and meeting those identified KPIs allows such networks to reliably support a wide array of applications such as secure data transfer, asset

tracking and navigation, e-commerce, e-health and e-finance services. (Adewola *et al.* 2015)

On the aspect of secure data transfer, the Nigerian electoral umpire, the Independent National Electoral Commission (INEC) has been considering implementing real-time election results transmission from polling units to central election servers. This idea will only be feasible if the mobile networks meet certain defined KPIs.

With the improved performance of mobile networks and noticeable expansion of telecommunications infrastructure, the impact of technology in electioneering processes cannot be overemphasized. This is why INEC through the Electoral Act of 2022 as legislatively amended and signed into law by the President of Nigeria, introduced the electronic transmission of election results. The efficacy and dependability of the system will depend to a large extent on the performance of the telecommunication networks.

Activities covered under the Electoral Act of 2022 includes the real-time accreditation of voters using the Biometric Voter Accreditation System (BVAS), real-time uploading of the results to the results viewing servers (IReV). (Mahmood, 2021).

The INEC Result Viewing (IReV) plays important role in electronic transmission of INEC results. IReV has been deployed to view the transmitted results in several major off-season elections and bye-elections. These include the Edo and Ondo State Governorship elections, six Senatorial and three Federal Constituency bye elections, 15 State constituencies and one Councillorship Constituency in the FCT. It is believed that IReV portal will enhance speed and efficiency, accuracy, reliability and contribute to ensure transparency, openness and reliability and the potential with cyber threats or hacking affecting the integrity of the IReV system during result transmission (Joseph *et al.*, 2024). INEC also reports that results were transferred from different parts of the country to the IReV, although this was not done in real time as the elections were progressing.

These activities in transmissions of INEC election results from different polling units to INEC national central servers, directly depend on the efficiency of the telecommunication networks, hence the desire to investigate their performance. As important as mobile communication networks are, these aspects have not been adequately studied, especially within the context of their performance in southern Nigeria, especially in Uyo, Akwa Ibom State, Nigeria. This is the main motivation for this research.

II. LITERATURE REVIEW

Literature reviews on the existing mobile communication technologies such as 2G, 3G and 4G were performed and some of their Key Performance Indicators were equally reviewed.

Studies have highlighted deficiencies and insufficient information from data.

Various research works have been done to ascertain the quality of service of different mobile network operators by way of analyzing various KPIs. According to the research in (Ekeocha *et al.,* 2021), KPI data were gathered from field measurements. Using a statistical approach, the performance and quality of service offered by 4G LTE networks in Port Harcourt, Nigeria were analyzed. The researchers adopted a drive test approach to measure the KPIs in real time at a frequency of 1800 MHz using TEM's Discovery Software. The work measured the value and determined the probability distribution of the selected KPIs such as; Received Signal Strength Indicator (RSSI), Reference Signal Received Power (RSRP) and Reference Signal Received Quality (RSRQ). They concluded that the KPIs were within the acceptable range, although they could be optimized to provide better services for a greater population.

The research conducted by (Oje *et al.* 2021) was based only within the University of Ilorin campus whereas, there are other student campuses like the National Open University of Nigeria campus which has the highest population of students in Kwara state. Their result were based on data collected through questionnaires. One hundred and fifty (150) questionnaires were distributed physically but only one hundred and one (101) were recovered. This means that the result of this research could have been different if all the 150 questionnaires distributed were recovered. Some of the data on this questionnaires might not be an accurately provided by the student and as such, raised a question: was the data obtained, reflect the real population of students at the University campus? Due to this, results might not prove invalid. Similarly, electronic questionnaires were also generated and sent to various departments and faculties but only 50 students out of thousands of students accessing the electronic device responded. The limited respond by students could have great impact on the result for this research.

There was no primary data as well as having access to the secondary data provided by the mobile Network Providers.

III. METHODOLOGY

This studies applied a mixed – method approach involving: (a) Primary data collection through sites visitations and physical measurements. (b) Collection and processing of raw secondary data which contains: Cell Availability, Uplink and Downlink throughputs, Total data volume, Average Active Users, (c) Extraction of relevant Voters Registrations data from the INEC Results Viewing (IReV) portal such as: Total number of Registered Voters in each polling unit. (d) Microsoft Excel and Python programming language, Numpy and matplolib were deployed for tessellation and visualization of geographic area. (e) Keyhole Markup Language (KML) files were generated for 4G BTS sites under studies including polling units and then plotted into Google Earth to indicate their various locations on the earth surface.

The analysis follows a statistical approach and seeks to uncover geographic, time-based and seasonal dependencies.

> *Data Collection and Processing*

- *Extraction of Relevant Data*

Both primary and secondary data collection were used in this research. Raw Secondary data of sampled network performance was collected from a major MNO for Uyo, Akwa Ibom State. The collected data contained information on cell availability, Uplink and Downlink data volume, Average active users, Uplink and Downlink E-UTRAN throughput, downlink and uplink physical resource block (PRB) utilization rate, and average noise immunity of carrier in dBm. Similarly, Primary data was obtained through sites visitations and physical measurements. A snapshot of the Secondary data is shown in Figure 1.
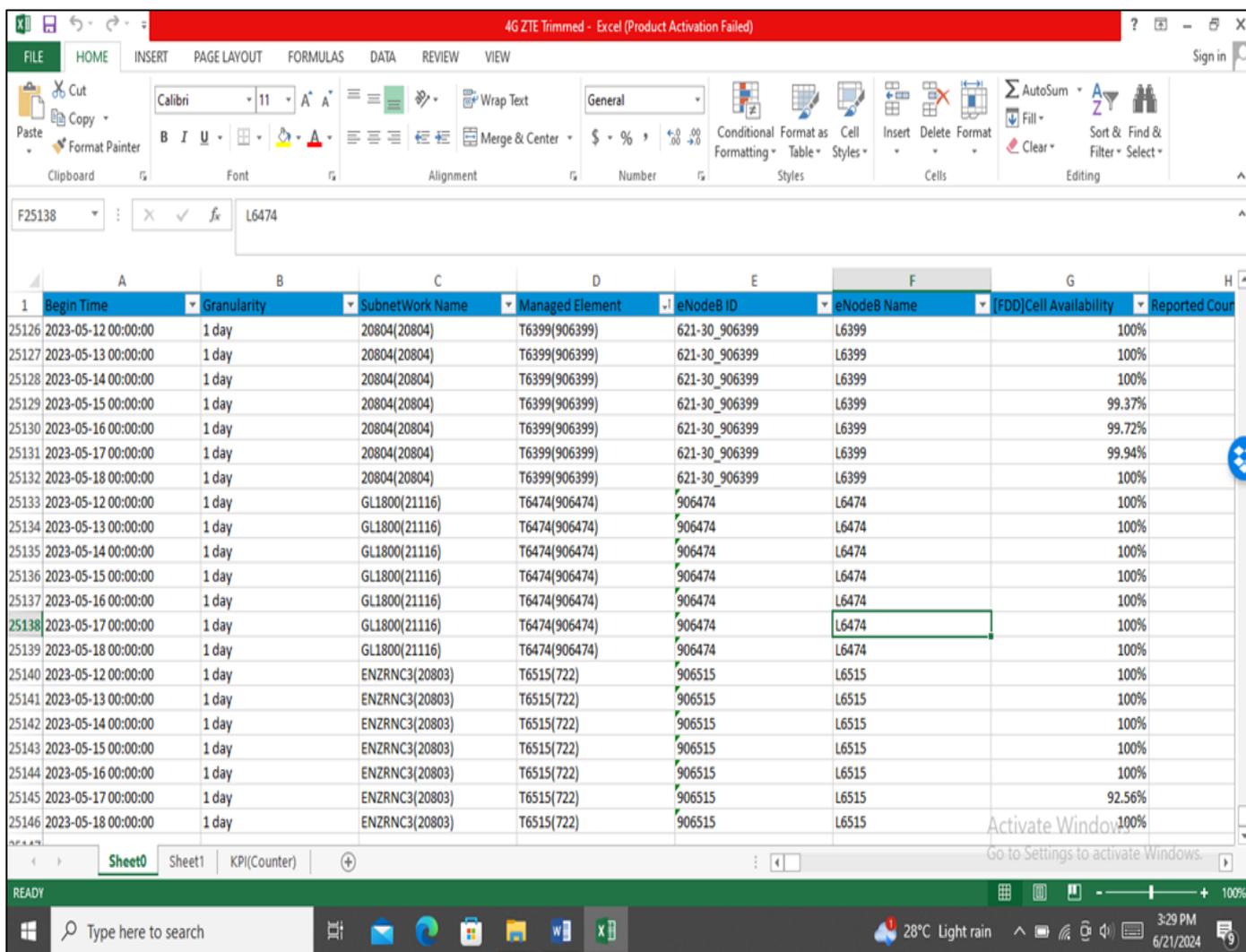
Fig 1 A Snapshot of Extracted Network Performance Data

- *Data Processing*

The data was analyzed using Microsoft Excel and the Python programming language, Numpy and Matplotlib were also deployed for tessellation and visualization of geographic areas. The mean of the daily measured KPI data was used in the analysis and this was calculated by taking the sum of a particular KPI results for a week and dividing it by the number of days measured.

- *Extraction of Relevant Voter Registration Data*

This research obtained voter registration data and extracted the number of people registered in each polling unit. This figure was assumed to be a good estimate of the number of people that can possibly be served by the MNO that covers the geographic area served by the polling unit. To extract the data, the location of each polling unit was determined using Google Maps and the coordinates (longitude and latitude) of the location obtained. The procedure followed is described as follows:

✓ The election results viewing portal (iRev) of INEC was accessed.
✓ Upon accessing iRev, the results data page of the Presidential Election that was held on 25th February 2023 were accessed for different wards in Uyo, Akwa Ibom State.
✓ The relevant ward results sheets were downloaded.
✓ From the results sheet, the name of the polling unit, the number of registered voters and number of accredited voters were extracted. A sample of the result sheet is shown in Figure 2.

Fig 2 Sample of INEC Result Sheet

✓ Using the search function in Google Maps, the coordinates of the polling unit was determined. A compilation of extracted data on polling unit name and coordinates is shown in Figure 3.

Fig 3 Compilation of Extracted Data on Polling Unit Name and Coordinates

The number of subscribers served by each BTS were extracted from the Secondary data. By comparing the number of registered voters at each polling units from the IReV portal with the average active users provided by the secondary data, numbers of active mobile subscribers could be estimated. Site names, name of polling units, average active users and number of registered voters are shown in Table 1.

Table 1 Average Active Users and Number of Registered Voters

BTS	NAME OF POLLING UNIT	AVERAGE ACTIVE USERS	NUMBER OF REGISTERED VOTERS
L0212	51 Ibiam Street	494	473
L2303	Brooks Street	823	730
L2312	Qua Iboe Church Ikot Ekpene Road	841	750
L2343	Effiat Offot	892	788

- *Delineation of Geographic Areas and Populations Served by BTSs*

  To delineate the geographical areas served by each polling unit and estimate the population density in those areas, use was made of Voronoi tessellation and the process proceeded as follows:

✓ Access the online portal of Colab by Google and navigate to the code cell to harness the functionalities of Numpy and matplotlib.
✓ Using the Python programming language, generate a code to upload the coordinates of polling units, delineate the areas served by each polling unit and generate a visual plot. A sample code is given as follows:
✓ from scipy.spatial import Voronoi, voronoi_plot_2d
✓ import matplotlib.pyplot as plt
✓ # Latitude and longitude points

✓ points = np.array([
✓ [5.0336, 7.9297], import numpy as np
✓ [5.02769, 7.93242],
✓ [5.02769, 7.93242],
✓ [5.0265, 7.9326],
✓ [5.02265, 7.93552],
✓ [5.03015, 7.93149],
✓ [5.03159, 7.92495],
✓ [5.02342, 7.92461],
✓ [5.02180, 7.92186],
✓])
✓ # Plot Voronoi diagram
✓ vor = Voronoi(points)
✓ voronoi_plot_2d (vor, show_points=True, show_vertices=False)
✓ # Add labels to the points
✓ for i, site in enumerate(points):

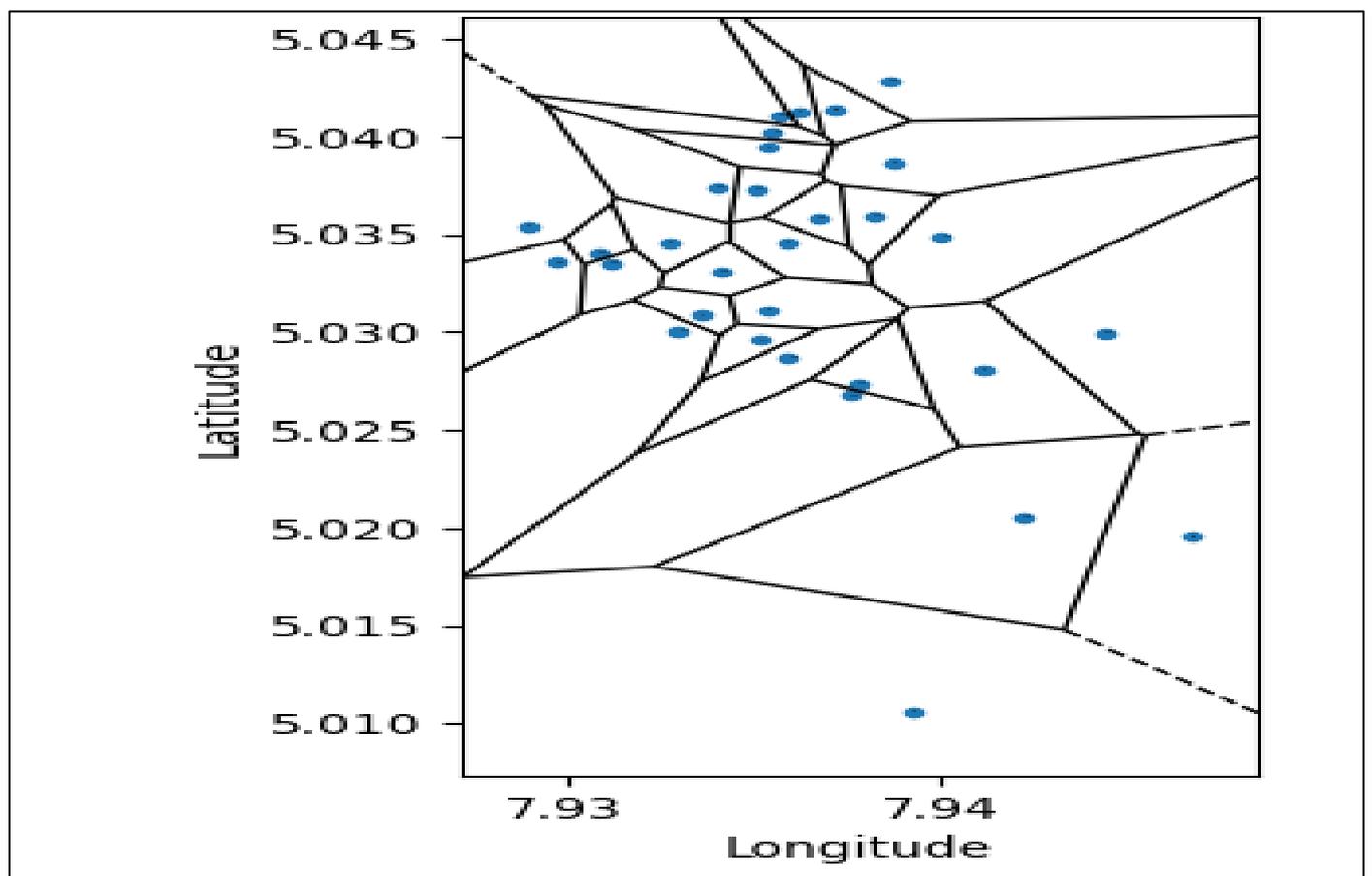Fig 4 Voronoi Diagram Delineating Polling Unit Coverage Areas in Uyo

✓ Upon visualizing the plot in Figure 4, a JPEG version of the plot is generated.

✓ Separate the longitude and latitude data for Uyo Urban 1 to 3 into different columns on an Excel sheet.

✓ In the new Excel sheet, eliminate unwanted rows and columns while leaving both coordinates unchanged.

✓ Copy the information in (f) above into different Excel sheet containing Uyo and Port Harcourt voter data respectively.

✓ Eliminate 4GS BTS sites Uyo not close to any polling units.

✓ Generate KML files for 4G BTS sites and polling units.

✓ Import the KML files of both BTS sites and polling units areas into Google Earth to indicate their various locations on the earth surface.

The screenshot for the locations of BTS sites and polling units sites on the earth surface are shown on the Google Earth in the Figure 5.
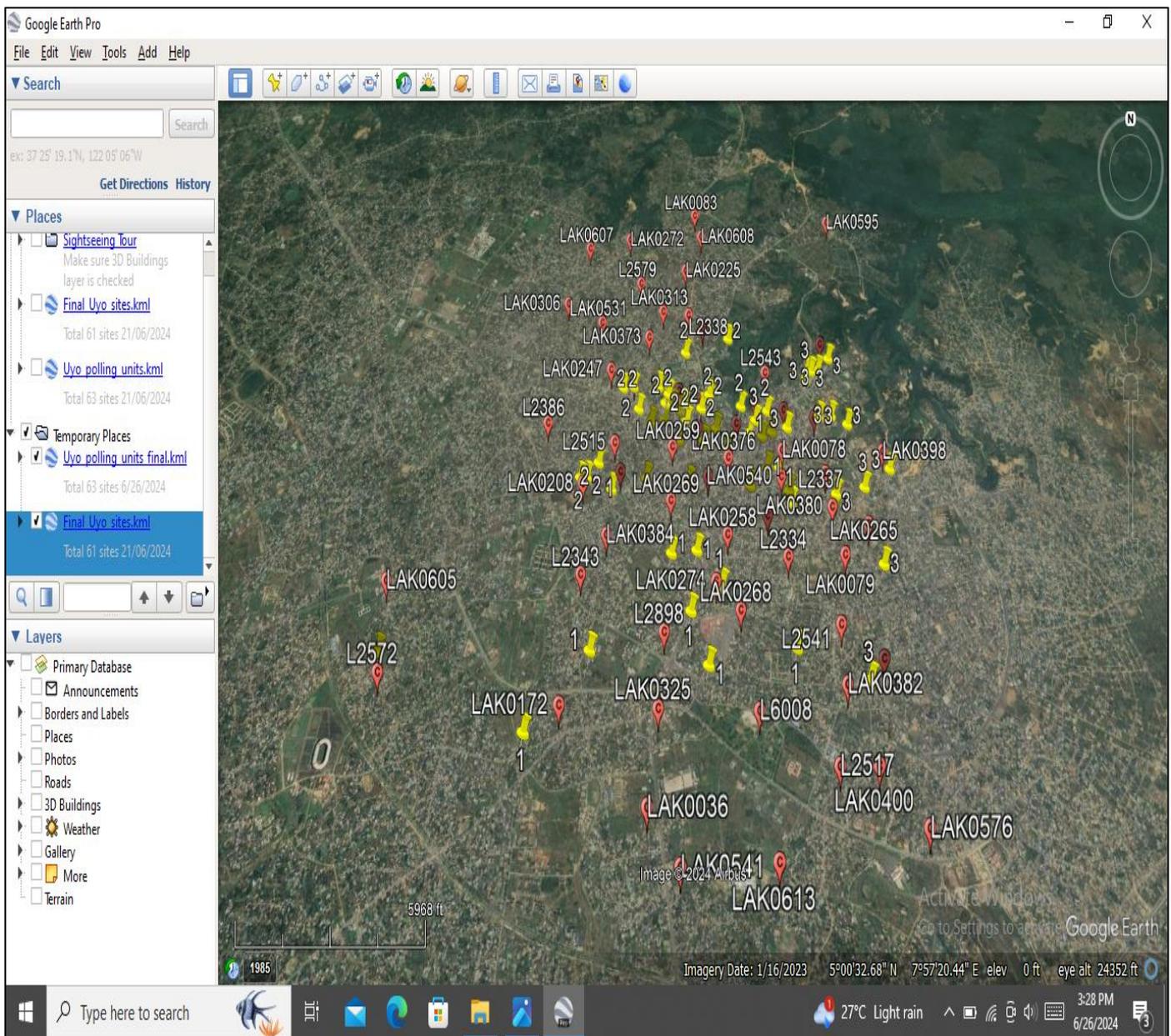
Fig 5 Screenshot for the Location of 4G BTS Sites and Polling Units' on the Google Earth in Uyo

> *Empirical Data Validation*

To assess mobile network operator (MNO) performance from the user's perspective, empirical measurements were conducted using mobile network monitoring tools. These applications provide real-time, user-generated data that reflect actual service conditions and offer a cost-effective means of evaluating network performance

(3GPP, 2022; Toledano & Pérez, 2020). The tools employed in this study were OpenSignal (OpenSignal Inc., 2023) and Cell Signal Monitor (Vitkowsky, 2023). OpenSignal provided data on real-time upload throughput, download speed, and latency, while Cell Signal Monitor captured signal strength metrics, specifically RSRP. Figures 6a and 6b display sample measurement screens from both applications.

Fig 6 Sample Measurement Screens Using Open Signal and Cell Signal Tools

The measured signal provided a valuable window into the real-world performance of the mobile network operator (MNO) within the surveyed locations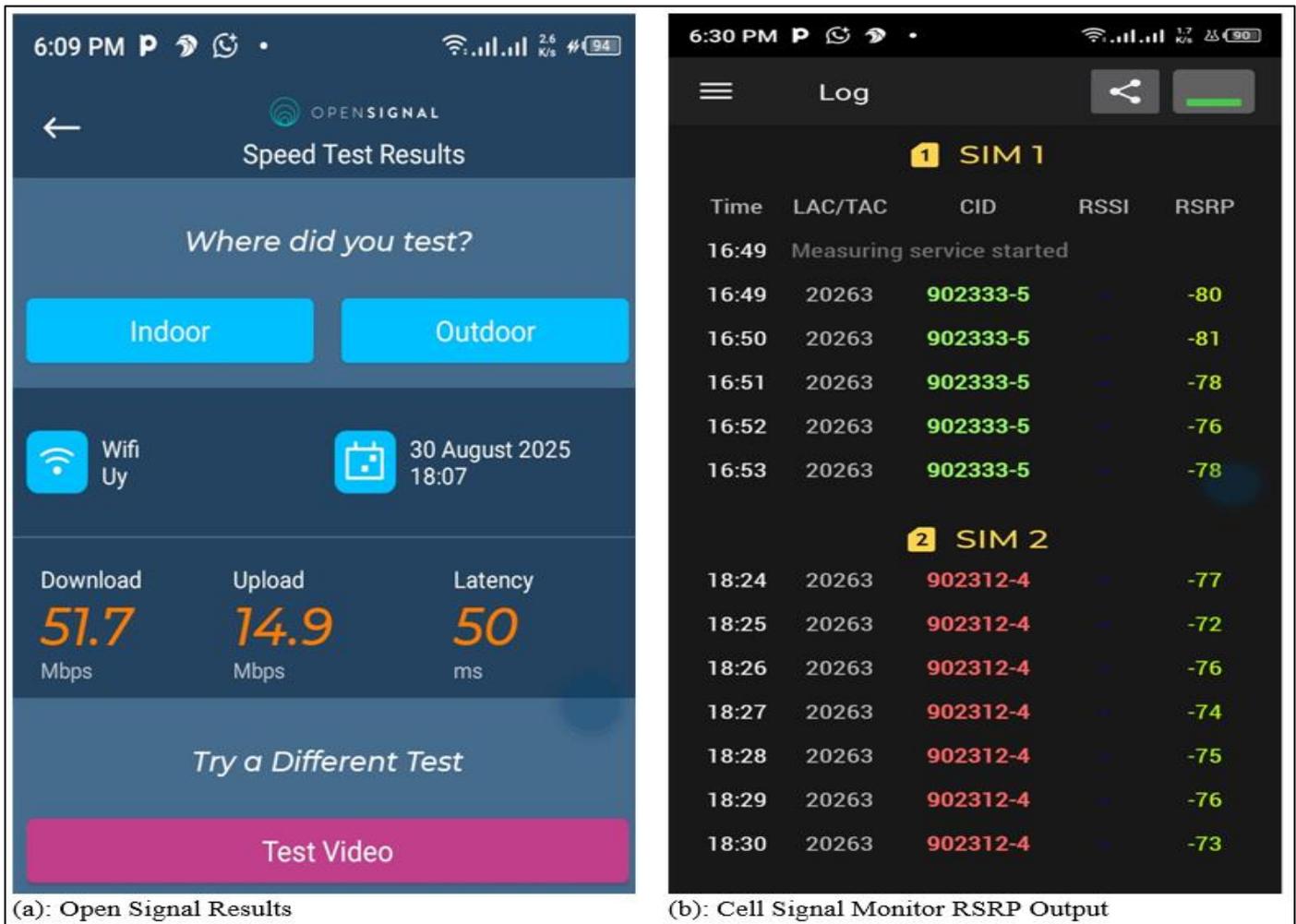. By capturing live data on signal strength, quality, and throughput, the analysis revealed how users actually experience the network, and may highlight areas of stability, zones of congestion, and the impact of environmental and temporal factors on service delivery.

IV. RESULTS

The results of the analysis of the KPIs for one MNO operating in Uyo metropolis are presented in this chapter. The KPIs analyzed are: Cell availability, Uplink throughput and Downlink throughputs. These parameters have direct influence on the election results transmission. In performing the analysis, cognizance was taken of the population density of the defined coverage area.

➤ *Time Dependencies Results*

The time dependency analyzed spanned a time period from 12th May, 2023 to 18th May, 2023. The data analyzed are: Cell availability, Uplink throughput, Downlink throughput and Total data volume.

• *The relevant NCC QoS KPI for 4G networks*

Nigerian Communication Commission (NCC), Quality of Service Business Rules (Issued Pursuant to the Quality-of-Service Regulations), August, 2024 is shown in Table 2.

Table 2 NCC Quality of Service Business Rule

PARAMETERS	NCC KPI
1. Cell Availability	≥ 98.5%
2. E-UTRAN Downlink User throughput (Mbps) per user	≥ 20Mbps
3. E-UTRAN Uplink User throughput (Mbps) per user	≥ 5Mbps
4. Latency	50msec.

• *Cell Availability, Throughput, and Total Data Volume*

Cell Availability, Uplink and Downlink Throughputs and Total Data Volume for all the selected eNodeB in Uyo were plotted. Results are shown in Figure 7. Figures 8, Figure 9, and Figure 10 respectively.
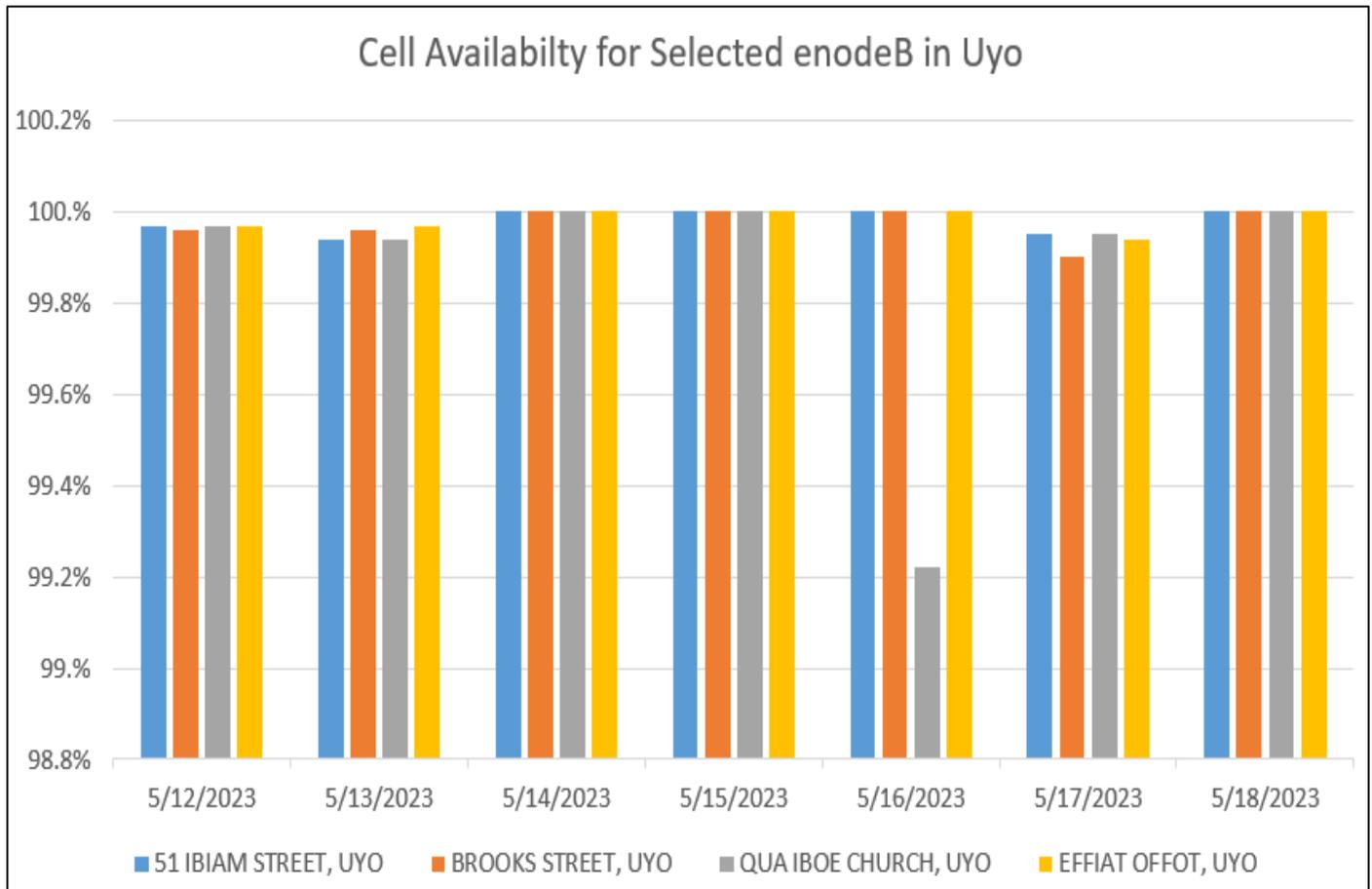
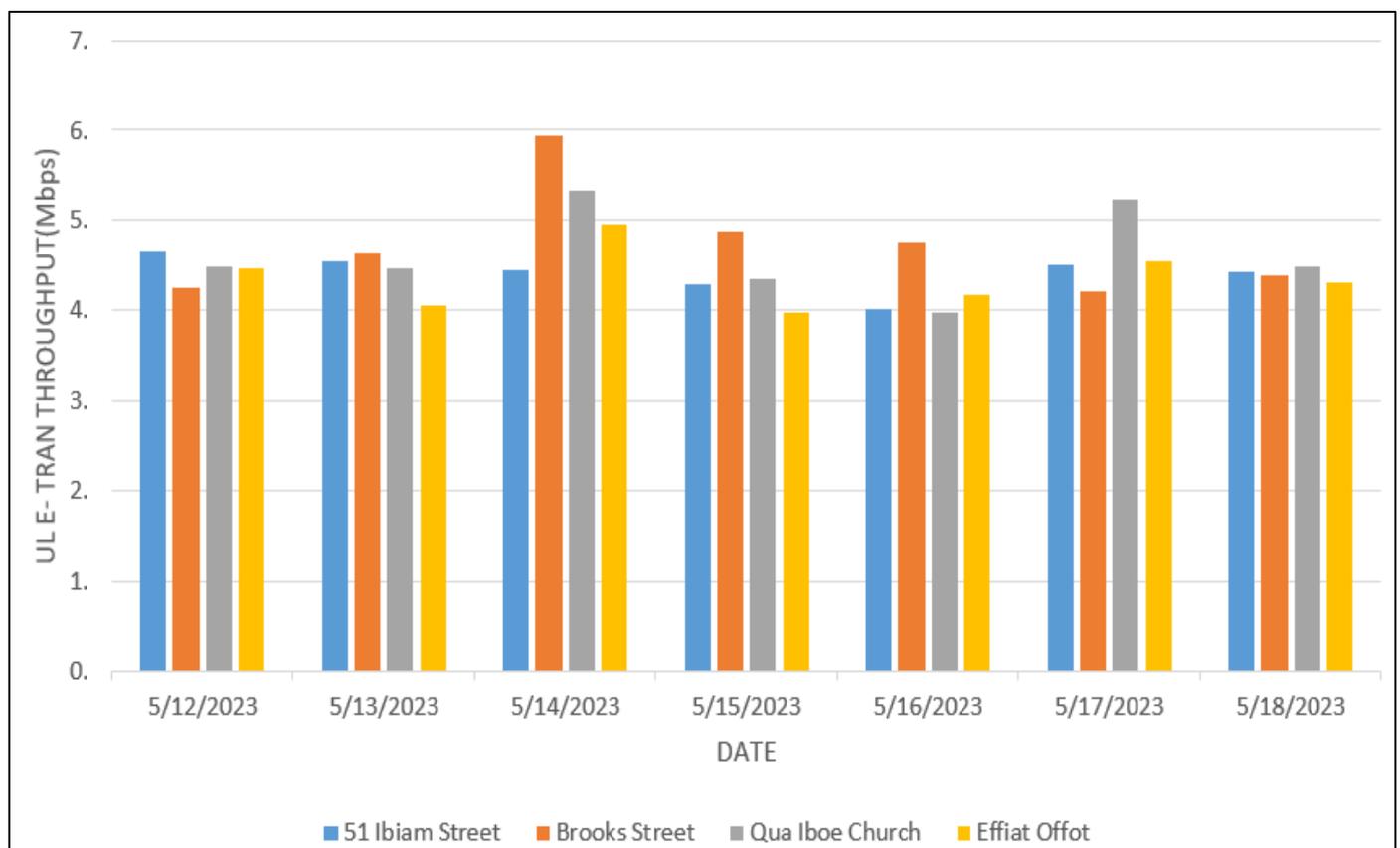Fig 7 Cell Availability for All Selected eNodeB in Uyo

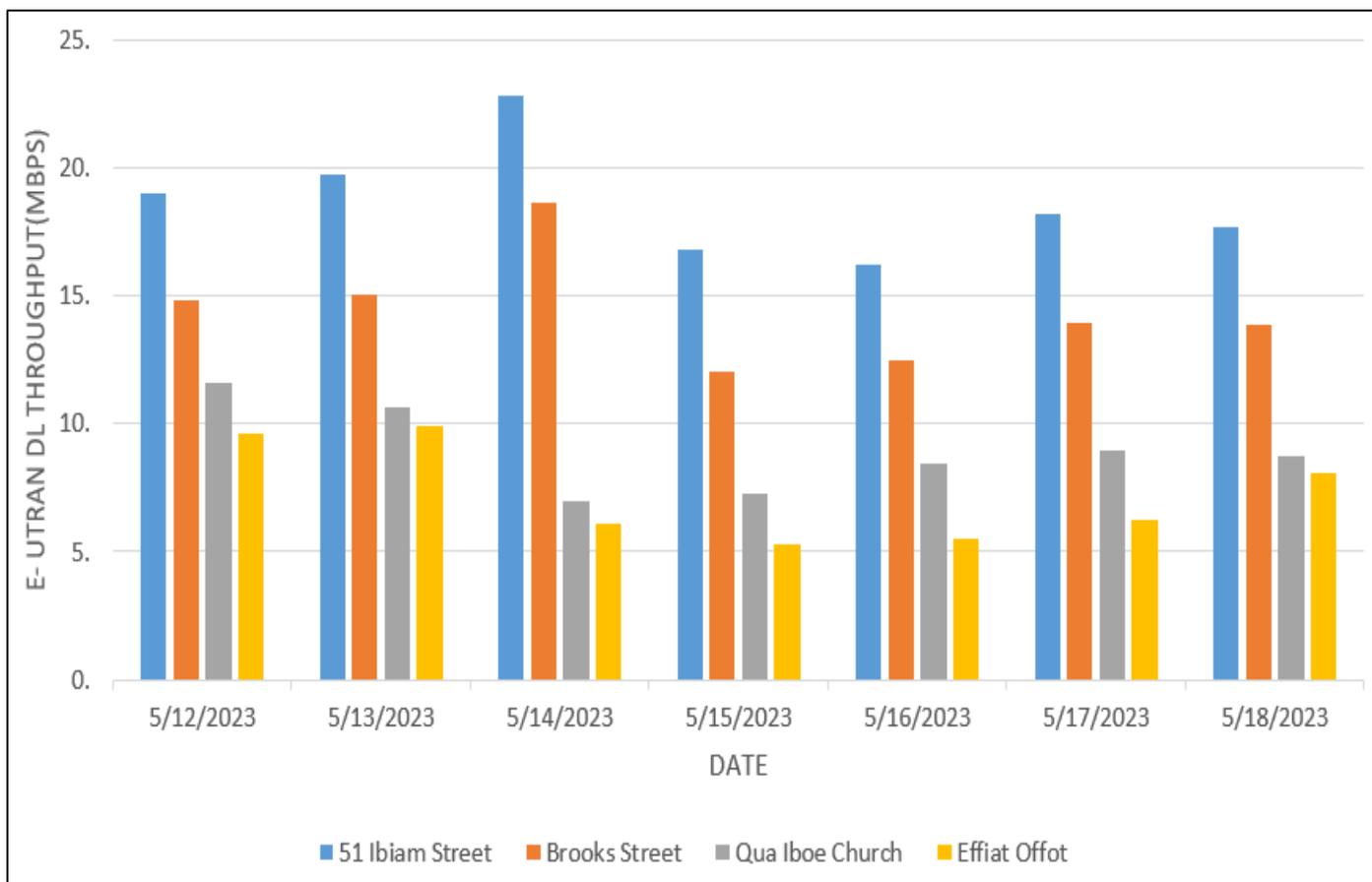Fig 8 UL User Throughput for All Selected eNodeB in Uyo

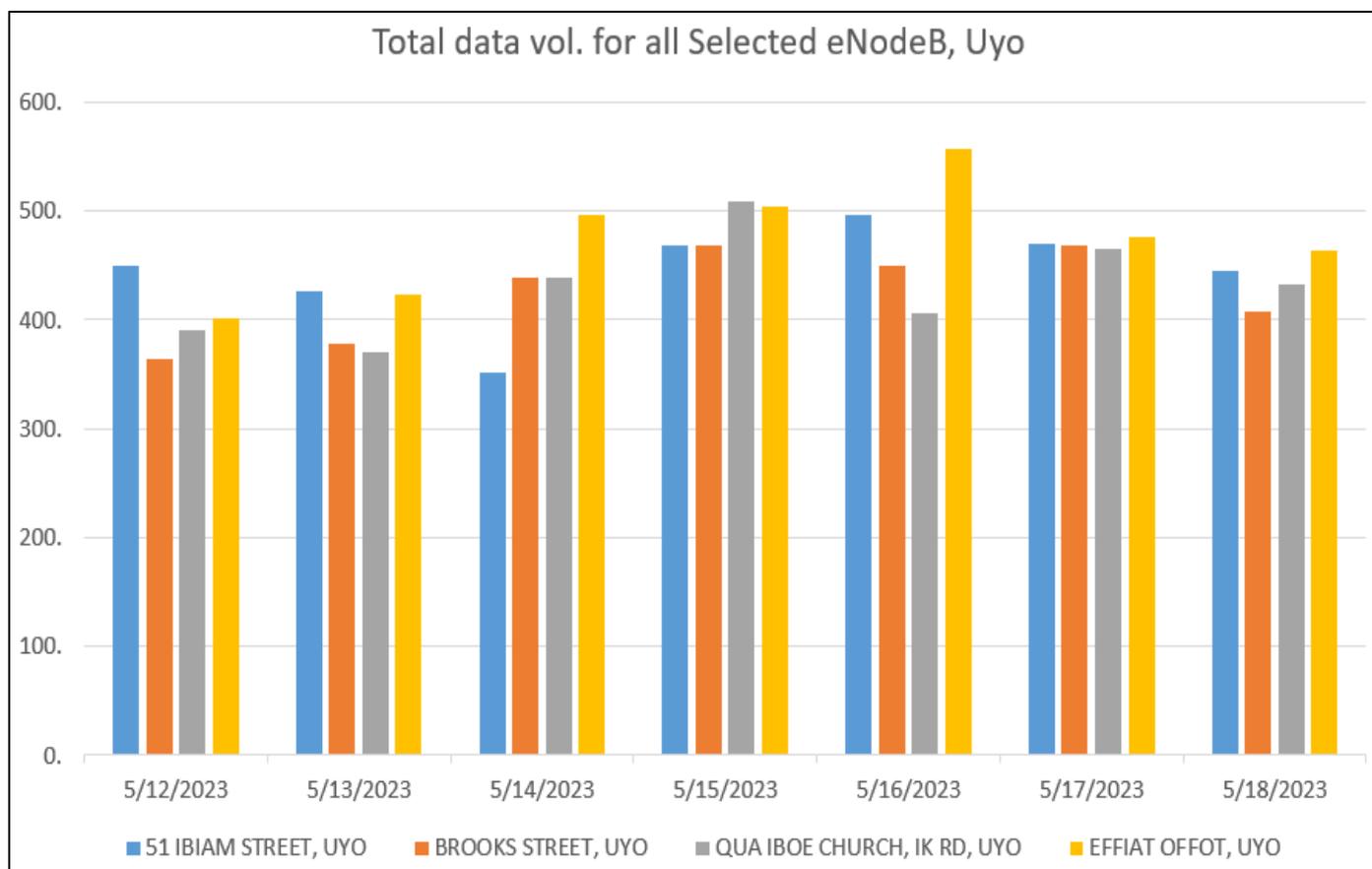Fig 9 DL User Throughput for All Selected eNodeB in Uyo

Fig 10 Total Data Volume for All Selected eNodeB in Uyo

➢ *Results of Empirically Measured Sites Performances*
Physical measurements were conducted at three BTS locations in Uyo, as shown in Table 3.

Table 3 Sites Parameters

S/No	SITE LOCATION	COORDINATES	
		LONGITUDE	LATITUDE
1	Qua Iboe Church, Ikot Ekpene Road	7.914780	5.039267
2	Ibiam Street	7.921760	5.033638
3	Brooks Street	7.937400	5.034818

Each site was assessed during morning and evening periods across weekdays and weekends. Key performance indicators (KPIs) recorded include:

- RSRP (Reference Signal Received Power)
- Downlink and Uplink Throughput
- Latency
- Carrier Identification Code (CIC) Transitions and Cell Availability

- *Signal Strength (RSRP)*
RSRP values across all sites ranged from −66 dBm to −89 dBm, with fluctuations observed during peak and off-peak hours. Brooks Street consistently recorded stronger RSRP values, while Ibiam Street showed weaker performance, especially on weekend mornings. Figure 11 shows the RSRP distribution.
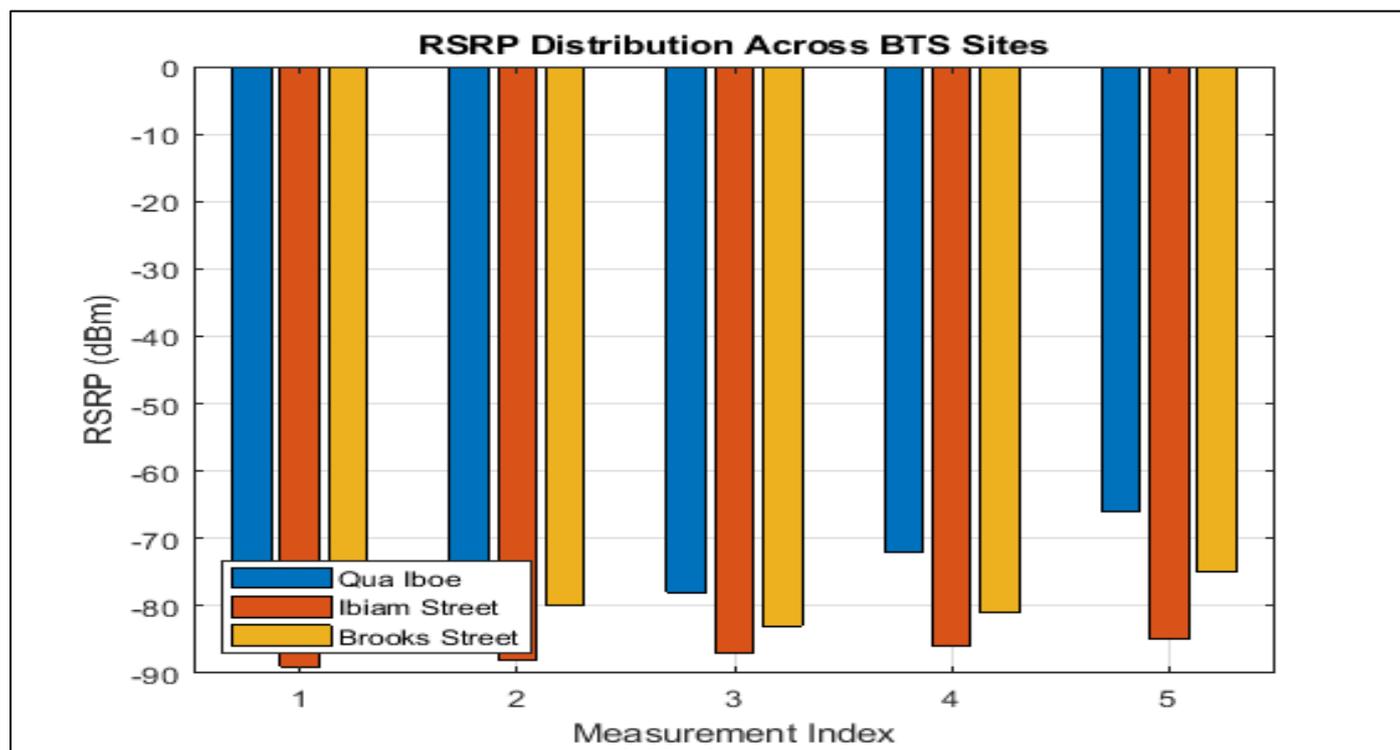
Fig 11 RSRP Distribution for the Measured Sites

- *Throughput Performance*
The throughput measured in the three sites are analysed below.

✓ *Qua Iboe Church:*
Measurements taken on weekday mornings had an average of DL 14.9 Mbps, UL 6.57 Mbps. While at weekend morning, DL increased from 17.9 Mbps to 42.7 Mbps, and at weekend evening, DL dropped from 31.7 Mbps to 26.9 Mbps; UL rose to 21.9 Mbps.

✓ *Ibiam Street:*
Measurement on weekday morning recorded DL 26.8 Mbps, UL 13.2 Mbps, weekend morning: DL 0.44 Mbps → 1.61 Mbps; UL 1.74 Mbps → 1.50 Mbps and Weekend evening: DL dropped from 26.4 Mbps to 7.53 Mbps; UL improved to 16.9 Mbps.

✓ *Brooks Street:*
Measurement on weekend mornings showed that DL dropped from 73.9 Mbps to 35.7 Mbps; UL rose from 1.06 Mbps to 7.95 Mbps. Weekend evening: DL dropped from 51.7 Mbps to 36.2 Mbps; UL rose from 14.9 Mbps to 23.1 Mbps. Figure 12 presents a comparative view of the throughput.
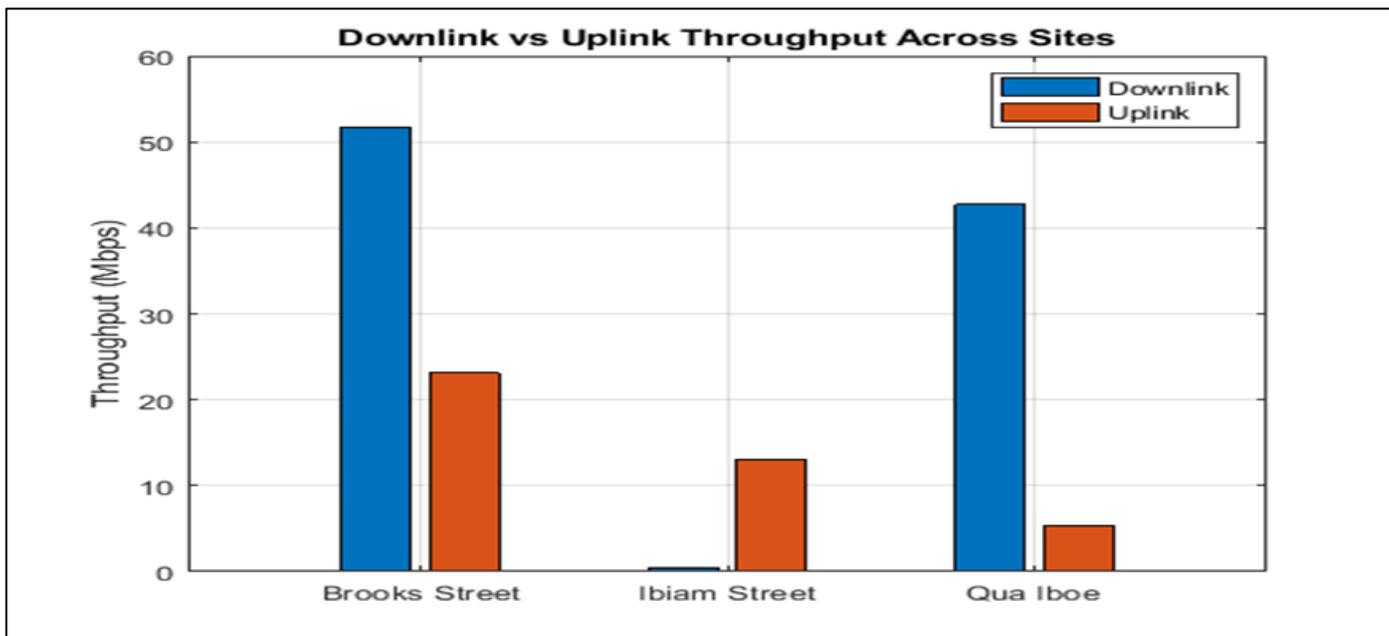
Fig 12 Throughput Performance of the Measured Sites

- *Latency Observations*
  Latency values varied across sites and sessions.

✓ Qua Iboe Church: 36ms–72 ms

✓ Ibiam Street: 46ms–159 ms (exceeding NCC standard during weekend evening)
✓ Brooks Street: 39ms–50 ms.

Figure 13 presents the latency variation of the sites.
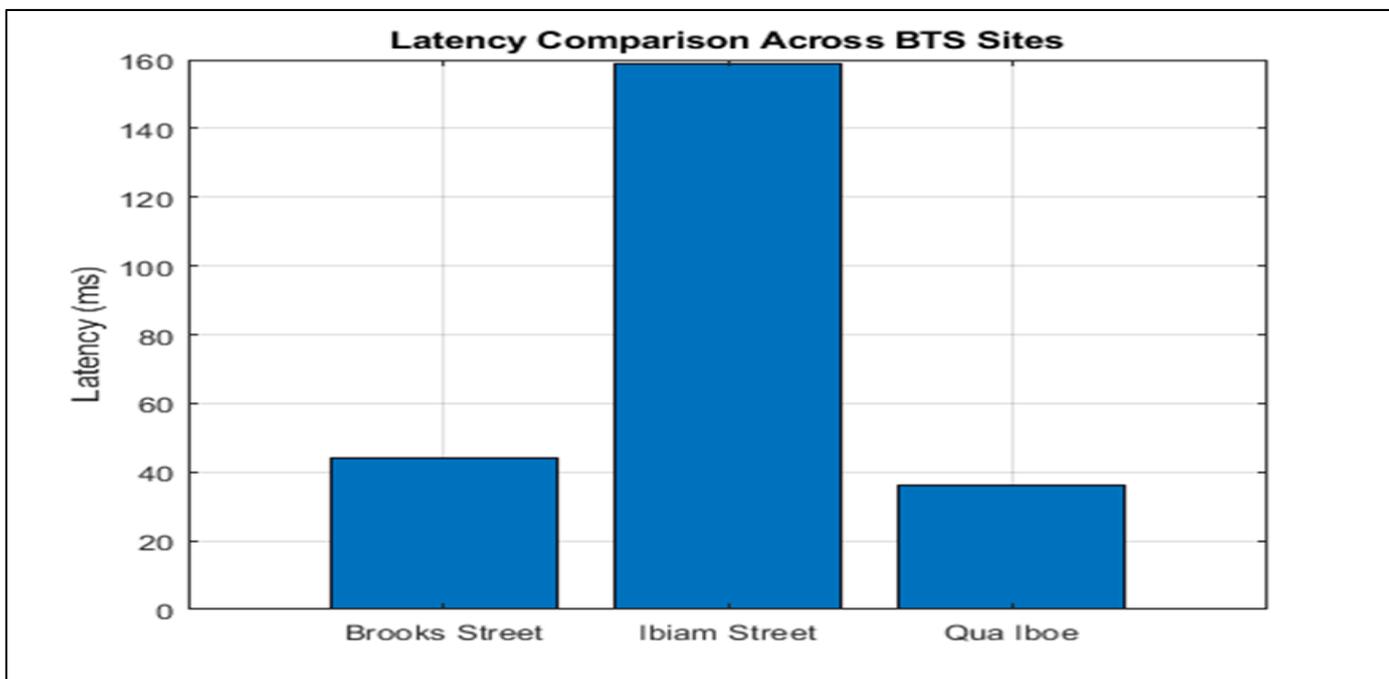
Fig 13 Latency Variation of the Measured Sites

- *CIC Transitions*

✓ Brooks Street: CIC changed multiple times during evening hours (902312-4 ↔ 902312-7, then to 902312-83 and 902312-81), indicating handover activity and possible interference.
✓ Ibiam Street: CIC transitioned from 902303-6 to 902303-5, with instability noted during evening hours.

✓ Qua Iboe Church: CIC remained stable during the weekend evening, suggesting lower traffic and better cell anchoring.

Figure 14 shows the CIC transition across the three sites, while Table 4 gives a summary of the measurements and deductions.
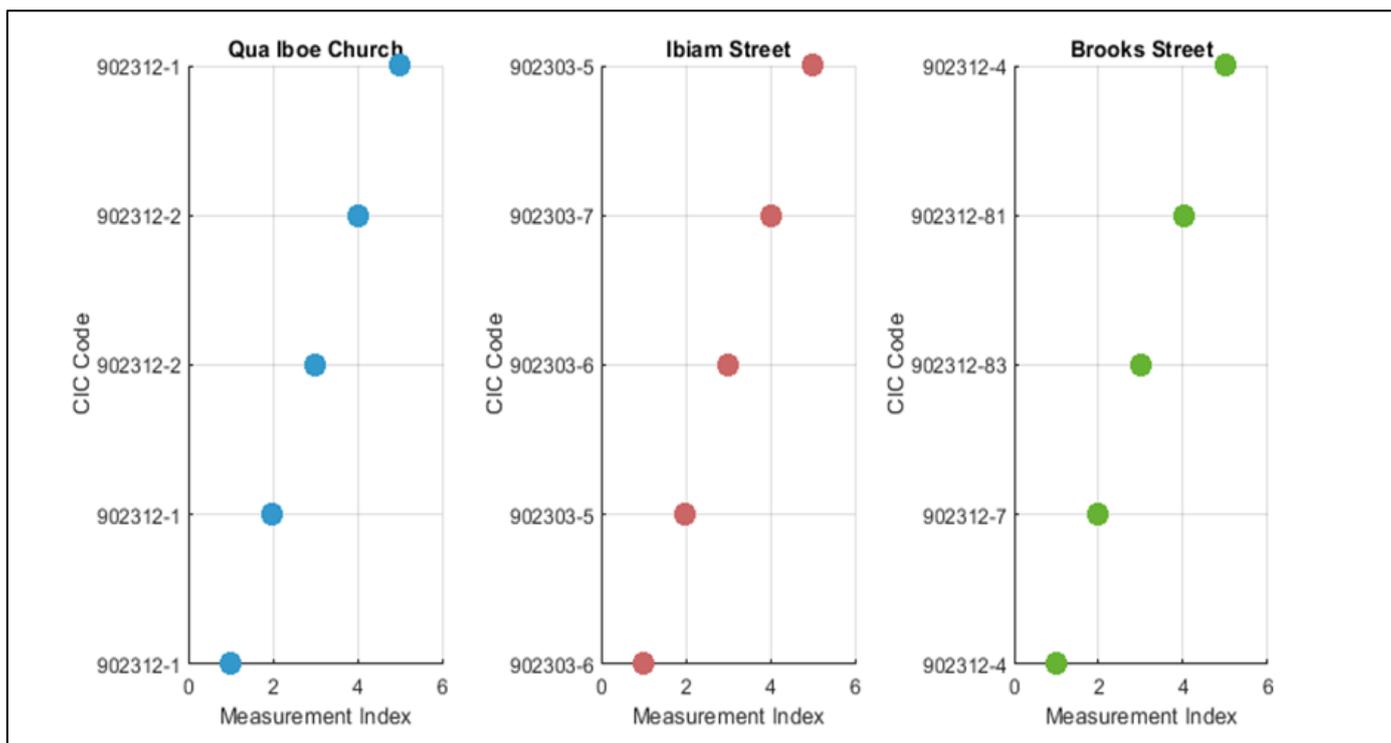
Fig 14 CIC Transitions Across the Sites

Table 4 KPI Summary

Site	RSRP Range (dBm)	Downlink (Mbps)	Uplink (Mbps)	Latency (ms)	CIC Stability
Qua Iboe Church	−66 to −85	17.9 → 42.7	5.41	36 → 72	Stable during weekends
Ibiam Street	−89 to −85	0.44 → 12.4	13.0	50 → 159	Unstable, frequent shifts
Brooks Street	−71 to −83	35.7 → 73.9	14.9 → 23.1	44 → 50	Moderate transitions

V. DISCUSSION

The data analyzed showed that most of the sites met the NCC regulatory standard while a few deviated. In terms of Cell Availability, all Cells met the recommended percentage availability within the days in view. Only Downlink throughput at Ibiam street slightly deviated from the NCC standard, while Cells at Brooks street, Qua Iboe Church, Ikot Ekpene road and Effiat Offot performed below the NCC regulatory standard. This highlights the need for targeted infrastructure upgrades in the underserved zones. In terms of Uplink throughput, only cell sites at Brooks street and Qua Iboe church, Ikot Ekpene road are in compliance with the NCC regulatory standard.

➢ *For Latency, it Was Observed that Latency Varies Across Different Sites and in Different Sessions:*

- Qua Iboe church, Ikot Ekpene road: 36ms – 72ms
- Ibiam street: 46ms – 159ms (Exceeding NCC standard during evening on weekends)
- Brooks street: 39ms – 50ms

These measurements revealed clear diurnal patterns. Evening sessions, particularly on weekends, showed reduced Downlink throughputs and network congestions. This showed that transmissions of election results will be difficult during evening hours and weekends due to increase in traffic densities.

VI. CONCLUSION

This research evaluated the performance of an MNO in Uyo to ascertain its efficiency in the electronic transmission of election results. The data analysed showed that most of the sites met the NCC regulatory standard while a few deviated. In cell availability, all cells met the recommended percentage availability within the days in view. Only the Downlink throughput at Ibiam Street slightly deviated from the NCC regulatory standard while cells at Brooks Street, Qua Iboe Church, ikot Ekpene road and Effiat Offot performed below the NCC requirement. In terms of uplink throughput, only the cell sites at Brooks Street and Qua Iboe church, ikot Ekpene road are in compliance with the NCC regulatory standard. Whereas BTS sites at Ibiam Street and Effiat Offot deviated which translate the service unavailability at the time of results uploading. The field measurements conducted across BTS sites in Uyo provide a data-driven understanding of 4G LTE network performance for real-time result transmission. The results confirm that performance is shaped more by capacity management and interference control than by signal strength alone and therefore advocate changes to improve the

reliability.Brooks Street demonstrated relatively strong performance despite CIC transitions, while Ibiam Street revealed significant throughput degradation and latency spikes during peak hours. Qua Iboe Church showed consistent performance, especially during weekends, suggesting effective load distribution. These results obtained in determining the performance of the chosen sites as they are servicing some polling units in the area. It shows that the networks are capable of supporting realtime election transmission with minor twisting and INEC should be encouraged to go into the full implementation of the electronic voting era.

REFERENCES

[1]. Al-Sividah, G., Safar, M., & Mahdi, K. (2014). Mobile Communication Networks. *Encyclopedia of Social Network Analysis and Mining, 1*, 940 - 950.

[2]. Ademola, A., Olubunmi, A., & Hanat, R. (2015). Using Mobile Communication as a tool for National Growth and Development. *International Journal of Computers and Technology, 14*(12), 6352 - 6356.

[3]. Mahmood, Y (2021) Electronic Transmission of Election Result, 6-18

[4]. Joseph, O. L; Yusuf, S. & Esther, A. O (2024). Effectiveness of IReV Portal for Transmission of 2023 General Election Results in Nigeria: Educator's Perspective. Uniosun Journal of International Research and Review, 7(1), 242-254.

[5]. Ekeocha, A. C., Elechi, P. & Nosiri, O. (2021). Performance Analysis of KPIs of a 4G Network in Seleted Areas of Port Harcourt, Nigeria. *World Journal of Electrical and Electronic Engineering, 1*, 44 - 55.

[6]. Oje, A. & Edeki, S. (2021). Performance Analysis of Service users' Perception of Mobile network quality in the learning settings. *Journal of Physic : International Conference on Recent Trends in Applied Research, 1734*, 1 - 9.

[7]. Abdul-Quadri, O. & Edeki, S. (2020). Performance Analysis of Service User's Perception of Mobile Network Quality in the Learning Settings. *Journal of Physics, International Conference on Recent Trends in Applied Reseach (ICoRTAL), 1734*, 1 - 5.

[8]. Abdulaziz, A. (2014). Evaluation of Packet Loss Effect on Network Performance. *International Journal of Latest Research in Science and Technology., 3*(6), 177 - 182.

[9]. Akbar, M. S., & Behnaam, A. (1999). Joint multipath - Doppler diversity in mobile wireless communication. *IEEE Transaction in Communication, 47*(1), 123 - 132.

[10]. Alberto, A., Kapil, R. & Guanghan, X. (2002). Vector channel modeling and prediction for the improvement of down link received power. *IEEE Transaction on communication, 50*(7), 1121 - 1129.

[11]. Aninyie, P., & Diawuo, K. (2014). Evaluation of CSSR with Direct TCH Assignment in Cellular Networks. *Paula Aninyie International Journal of Engineering and Application, 4*(8), 87- 89.

[12]. Bhandar, S. & Kamman, R. (2016). 4G Technology. *International journel of Scientific Research and Modern Education (IJSRME), 1*(2), 96-98.

[13]. Ezinne, O., Onyebuchi, N., Nkwachukwu, C. & Cosmas, K. (2018). Performance Evaluation of WCDMA Networks in Selected Geolocations using Structured Questionnaire and Emperical Analysis Methods. *International Journal of Advances in Scientific Research and Engineering (ijasre), 4*(12), 62 - 71.

[14]. Ggs, P. & Manas, H. (2018). Fading in Wireless Communication. *International Journal of Engineering Research in Computer Science and Engineering (IJERCSE), 5*(2), 159 - 162.

[15]. Hai, H., XiaoHang, L. & Peng, H. (2014.). Voronoi diagram generation on the ellipsoidal earth. *Computers and Geosciences, 73*, 81-87.

[16]. Hanemann, A., Liakopoulos, A., Molina, M. & Swany, D. (2023). A Study of Network Performance Metrices as updated. *Emrald Group Publishering , 23*(4), 268 - 282.

[17]. Oladejo, L. O., Adebajo. A. V., Oseni, B. A. & Akindele, A. O. (2014). Evaluation of Voice Quality Levels in Mobile Communication: A case Study of Oyo State, Nigeria. *International Journal of Research Studies in Computer Science and Engineering (IJRSCSE), 1*(3), 77 - 83.

[18]. Ibrahim, M., Sule, M. & Ali, S. (2023). Mobile Telecommunication and Economic Growth : Evidence for Authoregressive Distributed Lag (ARDL). *International Journal of Enterpreneurship, Business and Creative Economic., 3*(1), 15 - 16.

[19]. Jagadech, B. I., Kullayamma, I., Vivex & Naresh (2022). Handover Analysis. *International Journal of Engineering Research and Applications (IJERA), 1*(2), 287 - 291.

[20]. Fidel, K., Liljana, G. & Arianit, M. (2019). The Analysis of Key Performance Indicators (KPI) in 4G/LTE Network. *Institute for Computer Science, Social Informatics and Telecommunication Engineering.* Switzerland.

[21]. Lawal, B., Ukhurebor, K. & Adekoya, M. (2016.). Quality of Service and Performance Analysis of a GSM network in Eagle Sqaure Abuja and its Environs, Nigeria. *International journals of Scientific and Engineering Research., 7*(8), 1992 - 1998.

[22]. Mahendra, B. & Amarjeet, S. (September, 2013.). A Case Study on System Issues and Impact of Mobility in Wirelss Computing. *International Journal of Innovative Research in Computer Science and Technology (IJIRCST), 1*(1), 1 - 4.