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Investigation of Radio Frequency Signal Propagation of Wireless Services in Oyo, Oyo State, South Western Nigeria

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Abstract

This study reported the investigation of the Radio Frequency (RF) signal propagation of Global System for Mobile Communications (GSM) coverage in Emmanuel Alayande College of Education (EACOED), Oyo, Oyo State, Nigeria. The study aims at amplifying the quality of service and augment end users' sensitivity of the wireless services operation. The drive test method is adopted with estimation of coverage level and received signal strength. The Network Cell Info Lite application installed in three INFINIX GSM mobile phones was employed to take the measurement of the signal strength received from the transmitting stations of different mobile networks. The results of the study revealed that MTN has the maximum signal strength with a mean value of - 68.33 dBm, directly followed by Globacom (-80.41 dBm) and Airtel with -83.13 dBm. The Airtel signal has a conspicuously invariable poor performance with coverage level of 41.66 %. Conversely, the MTN and Globacom signal reception are observed to surpass the Airtel network within the college premises with 83.33 % and 60.41 % coverage level respectively. This implies that the signal quality for MTN and Globacom networks were comparatively disseminated within the college with inconsequential fluctuations in quality while Airtel signal is subsided and weaken. The poor performance in some areas was due to the presence of physical impediments and far distances location of base station antennas in the promulgation locations. This study therefore suggested that Airtel and Globacom Base Transceiver Stations (BTS) should be positioned within the college to improve good network reportage level.

Article Info.

Keywords:
Radio Frequency, Global System for Mobile Communications, Quality of Service, Signal strength, Network coverage.

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1. Introduction

Global System for Mobile Communication (GSM) is one of the utmost exciting telecommunication applications and innovations with fast development across the globe today [1-3]. The power density of GSM signal is decided majorly by the interferences within surrounding, the power of transmission of the booster stations and its relative distant position to the mobile phone. Telecommunication service providers offer varying network operation services. The pitiable nature of accessible networks providing are most often not satisfactory by a lot of subscribers [4-6]. The second (2G), third (3G), fourth (4G) and fifth (5G) generation of mobile phones networks was prompted by Nigeria Communication Commission (NCC) directives to the network operators to improve the quality of service offered to the subscribers. This in contrary to the analogue systems permits more subscribers to the network transactions [7-9]. The proceeds procreated and customer fulfillment is interconnected to the linkage quality of service appraisal and signal proficiency of GSM signal operations [10-12].

The operation modalities range of the cell phone lies within -30dBm to -120dBm. The precise identification mode of signal strength is the measurement in dBm

contrary to the number of bars on the phone as shown in Table 1 [9, 13, 14]. This signifies that the signal strength of mobile phones is stronger as it approaches zero (0) dBm and dead zone (poor signal) at -120 dBm. By and large, the signal strength from -95 dBm and above as well as -100 dBm and above are rated below average and weak (inconsistent) signal reception, respectively. These rules are germane to all mobile devices in Nigeria and other nations of the globe [15-17].

This study reports the assessment and analysis of the radio frequency signal promulgation of wireless services in Emmanuel Alayande College of Education (EACOED) Oyo, Oyo State, Nigeria. The data was collected employing a drive test approach focusing on the accurate authentication of the definite coverage area in the GSM radio network positioned in EACOED Oyo campus. The data was assessed in post-processing software tool for accessibility levels, professional rejoining resolution of network reportage as well as authorization of the problem sources. The management of result by the network service providers will enhance a good quality of service of radio promulgation, subscribers' appreciation and network expansion.

Table 1: Signal Strength, Quality and Bars' Implications on Cell Phone.

Signal Strength (dBm)	Bars	Signal Quality
-30 to -79	4 – 5	Very Strong
-80 to -89	3 – 4	Good
-90 to -99	2 – 3	Average
-100 to -109	1 – 2	Below Average
-110 to -120	0 – 1	Poor (dead zone)

Source: Bablu*et al*. (2017)

1.1.Review of Related Works

There are a number of studies that addressed the evaluation and optimization of GSM networks operation as shown in Table 2. Most researchers adopted the drive test method with KPIs analysis which simply identifies problems of parametrical issues. On the other hand, the drive test approach with coverage level and received signal strength estimation, as adopted in this study, allows a deeper analysis in the field. The applied technique identifies areas of each zone of coverage, assessment of network changes, interference and various other parameters to appraise the quality of service of signal transmission. All the same, at present, there is no available study in Oyo Metropolis that evaluates and optimizes the quality of service of GSM networks. The drive test method with coverage level and received signal strength estimation adopted gave improved results compared to the KPIs.

2. Materials and Methods

The research was carried out at Emmanuel Alayande College of Education (EACOED), Oyo, Oyo State, South-western Nigeria. The research analyses the effect of GSM radio frequency propagation and signal transmitted by MTN, Airtel, and Globacom network operators in Nigeria[18, 19]. Drive test method with coverage level and received signal strength estimation was adopted. The three (3) installed INFINIX GSM cell phone each assigned for the three networks on network signal info software designed by KAIBITS software were the applied receiving systems. The GSM monitor was harmonized with all network SIMS and employed in the measurement of the received signal strength at various points and duly recorded.

The software enables the signal strength received to be logged in every minute on the mobile phone. Detailed information is provided by Network Signal Info with

precise signal strength output over the presently used network. The mechanism is easily applied irrespective of cellular (mobile) or Wi-Fi (WLAN) connection. The Received Signal Strength Indicator (RSSI) recorded the signal strength in decibel milliwatts(dBm) for Glo, Airtel and MTN networks. The signal quality was determined at Arbitrary Strength Unit (ASU) for the studied networks. The measurement was taken simultaneously four times weekly for three consecutive months (August – October, 2021) at a choice location of the college for the three networks to provide equality of test conditions.

Table 2: Summary of Related Studies.

S/N	Authors	Title	Research Results	Gaps Filled by Present Study
1.	Evans, U.F. Dominic, K.O. and Esin, J. (2017)	Evaluation of Global System for Mobile Communication (GSM) Network Variability for the Safety of Life and Property along the Oron-Calabar Waterway.	The study adopted GSM network cell information Lite monitor version 3.12.5 APK. Globacom and MTN network had the worst signals while Airtel has most reliable network in the study area.	Drivetest method with coverage level estimation adopted gave improved result with MTN and Glo signal receptions surpass Airtel.
2.	Elechi P., Luckyn B. J. & Kum M. N. (2021)	Investigation of Global System for Mobile Communication Signal Coverage in Faculty of Engineering, Rivers State University, Port Harcourt, Nigeria	Drive test method using the Google Earth software is adopted. The study shows that 9mobile has the worst network signal coverage followed by Airtel. However, MTN and Glo have the best signal coverage.	Coverage Level Analysis by Drivetest method applied yielded enhanced outcome.
3.	Abolade,O. R., Okandeji, A.A., Onaifo, F., Oyedeji, A.O., Alao, P.O &Okubanjo , A.A. (2021)	A Performance Evaluation of 4G Mobile Network	Drive test method using Key Performance Indicators (KPIs) was adopted. The study shows that GLO having the least performance and MTN network was observed to be the best network.	Drive test method with coverage level estimation adopted gave improved result to KPIs.
4.	G.S.M. Galadanci & S.B. Abdullahi (2018)	Performance Analysis of GSM Networks in Kano Metropolis of Nigeria	The study proved that S has the worst network quality followed by Q and R, while P has the best network quality. Drive test with KPIs method was adopted.	Received signal strength measurement and coverage level analysis by drivetest method adopted surpasses KPIs.

3. Results

Figs. 1- 4 illustrate the received signal strength of Glo, Airtel and MTN Networks for the months of August, September and October, 2021 at Emmanuel Alayande College of Education (EACOED), Oyo. Every received signal strength consists of

sixteen data points for the three mobile operators used. These epitomize the average measured signal strength for each day of the week.

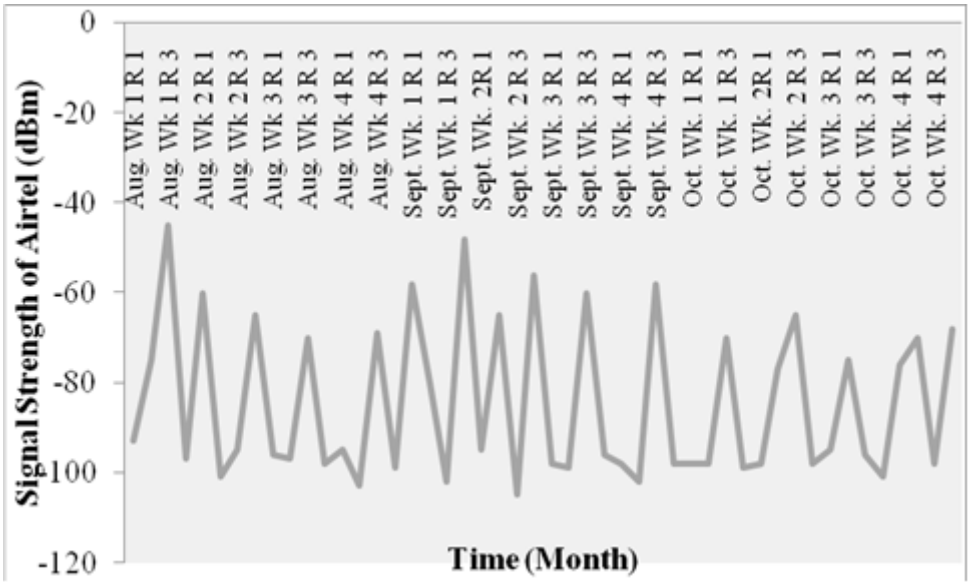

Figure 1: Graphical Representation of Received Signal Strength of Airtel at EACOED, Oyo.

Fig. 1 shows that the Airtel signal reception in the study area was relatively poor with 41.66 % coverage level. The gain of the transmitting and receiving antennas, far distance location of nearby base station, manifestation of attenuating elements in the transmission route and matching impedance of base station antenna are among the features that could be responsible to the dwindling of the signal prior attainment to the receiver end. Existence of edifices, buildings and vegetation in the signal line of sight (LOS) to the receiver are among the probable attenuating elements that could complement significantly to the low signal reception in the research field.

Fig. 2 exhibits that the average received signal strength of MTN was very strong in the study area with 83.33 % coverage level due to presence of the base station in the site. All calls and data operation are optimally in place in and outside EACOED.

The Glo signal reception in the study area was moderately good with 60.41% coverage level due to closeness of the base station to the college as illustrated in Fig.3. All services of 2G, 3G and 4G call and data were significantly enjoyed by Glo subscribers within the college.

The average received signal strength of MTN was very strong in the study area while Glo network enjoyed a relatively good signal whereas the Airtel service was poor as shown in Fig. 4. The availability of three MTN base station antennas within the college is responsible for its very strong network services. The proximity of Glo Mast to the research field is accountable for its fairly good signal reception while the far location of Airtel base station is liable for its poor signal operations.

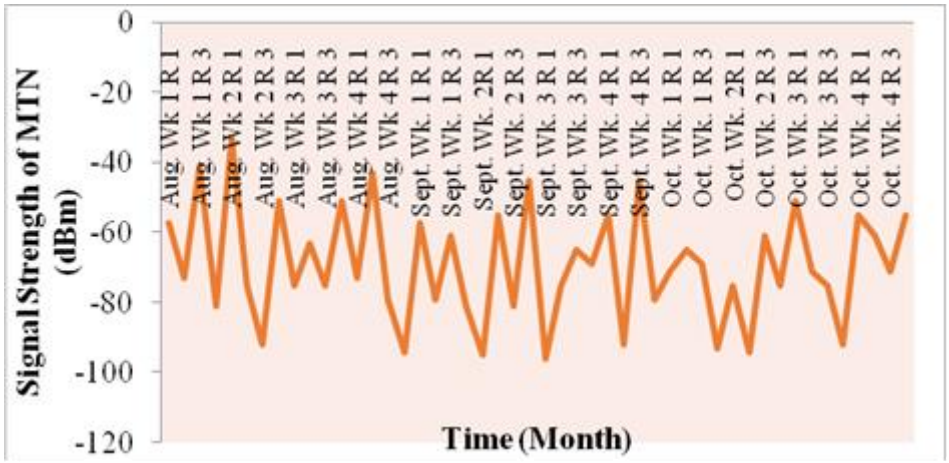

Figure 2: Graphical Representation of Received Signal Strength of MTN at EACOED, Oyo.

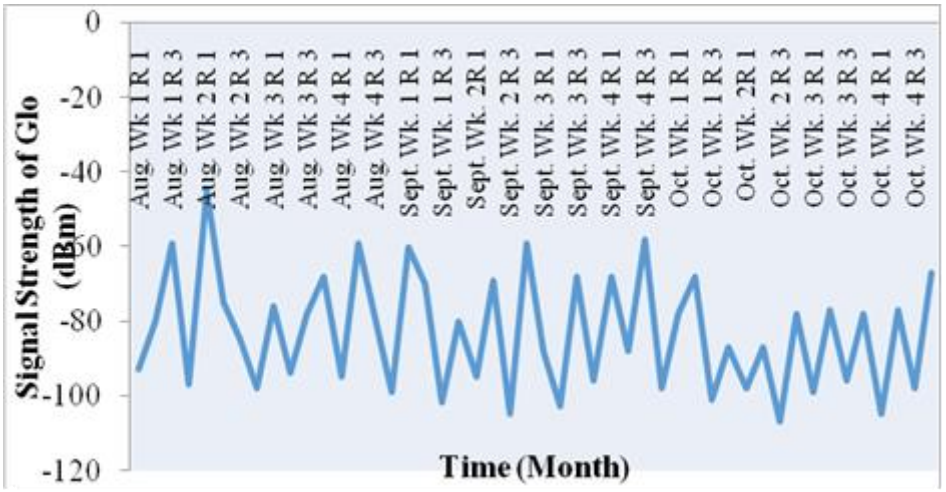

Figure 3: Graphical Representation of Received Signal Strength of Glo at EACOED, Oyo.

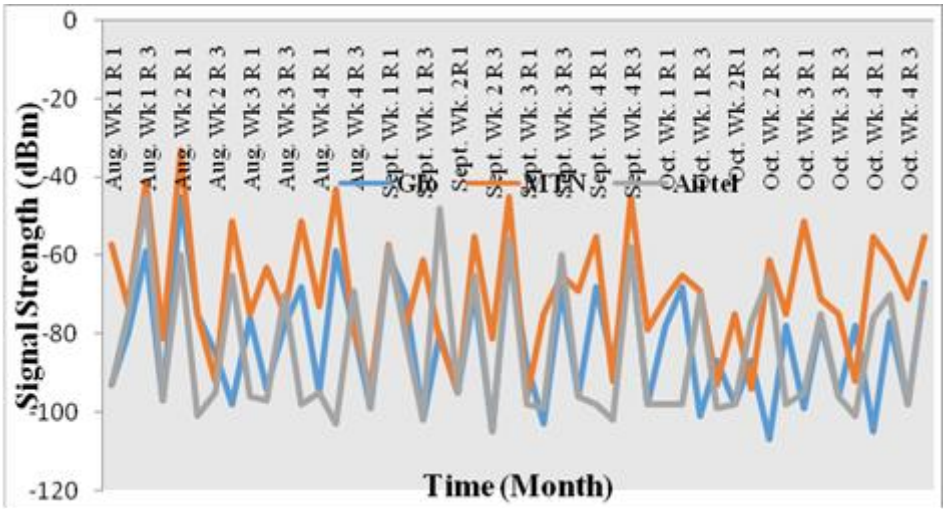

Figure 4: Graphical Representation of Received Signal Strength of Glo, MTN andAirtel at EACOED, Oyo.

The data obtained for the signal strength were used to plot the receiver operating characteristics in Fig. 1 - 4 as a measure of the classification performance of the three GSM networks. The figures indicate that MTN has the maximum signal strength with a mean value of - 68.33 dBm, directly followed by Globacom with a mean value of -80.41 dBm and Airtel with a mean of -83.13dBm. The characteristics figures for the signal strengths inferred that the signal strength for MTN network was the strongest and Airtel was the weakest of the three networks considered in Oyo Metropolis. Conversely, the signal strength for Airtel and Globacom networks gave in higher negative values. These were interpreted as weak signal strength according to NCC targets. Call sustainability is undisputed by the weak signal strength which resulted to calls drop, calls distortion, echo and poor communication experience by subscribers.

4. Discussion

In compliance to the international standard of Radio Signal Strength Level (RSSL), a good received signal strength must be above -90 dBm in any location [20, 21]. The average signals strength level (SSL) and the coverage level (CL) in dBm established from the study site were calculated as presented in Eqs. (1) and (2) respectively.

$$Average\ SSL = \frac{\sum SSL}{N} \tag{1}$$

$$Coverage\ Level\ (CL) = \frac{NSLGC}{TNSL} \times 100\% \tag{2}$$

Eqs. (1) and (2) reveal that ΣSSL represents the summation of the signal strength level, $NSLGC$ denotes the number of study locations with good coverage, $TNSL$ connotes total number of study locations and N is the number of signal strength level measured.

$$\boldsymbol{C}overage\ Level\ for\ Glo\ Network = \frac{29}{48} \times 100\% = 60.41\% \tag{3}$$

$$Coverage\ Level\ for\ MTN\ Network = \frac{40}{48} \times 100\% = 83.33\% \tag{4}$$

$$Coverage\ Level\ for\ Airtal\ Network = \frac{20}{48} \times 100\% = 41.66\% \tag{5}$$

The results exhibited that the Airtel signal as shown in Eq. (5) has a noticeably constant poor performance at the experimental site with coverage level of 41.66 %. Conversely, the MTN and Globacom signal reception as in Eqs. (4) and (3) were observed to surpass the Airtel network within the college premises with 83.33 % and 60.41 %, respectively. This implies that the signal quality for MTN and Globacom networks was comparatively disseminated within EACOED, Oyo with inconsequential fluctuations in quality. The subscribers of the duo at the research site will maximally enjoy the 2G, 3G and 4G voice calls SMS and data operation. Radio

power attenuation, signal limit factor, channel recycle and cellular multipath loss are acknowledged as a number of the difficulties related to weak signal strength in the study area which considered not all right for emergency communication.

5. Conclusion

This study concluded that the performance of the MTN and Globacom were optimal and outperform Airtel signal which subsided and weaken in the study area. Based on the research fallouts, cellular network signal strength and qualities were exceptional and unsurpassed for MTN and Globacom networks. However, the signal quality and strength for Airtel network were considered low and most horrible with notable significant levels of signal fluctuation observed in the study area. Hence, of the three networks examined, MTN network was regarded as the most reliable network in the study area. The study shows that MTN network would experience negligible call drops, network outage and call distortions within EACOED, Oyo very much followed by Globacom. Conversely, the highest call plunge, network failure and call distractions would be conversant by Airtel network.

The research provides parametrical optimum resolution as preeminent technique of signal strength and quality enhancement for the recognized causes of every fault. The contributions proffer by this study includes the same locations investigation of the three cellular phone carriers with the same phone and each SIM card for the mobile networks in consideration. Others are logical assessment of cell phone networks operation and subscribers' familiarity using drive test with coverage level and receive signal strength estimation. Lastly, indoor and difficult areas measurements were well thought-out compared to other methods.

For the enhancement and reliability of radio frequency coverage area and quality of service, the research recommends the installation of Airtel and Globacom booster stations within EACOED by the Radio Network Planning (RNP) crew of the service providers. This will motivate additional subscribers and gains for the telecom operators and offer acceptable services to their consumers. The recommendations above need to be actualized for further research in a live network so that post-drive test can be done to evaluate the performance improvement that is achieved in the network quality.

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Conflict of Interest

We have no conflict of interest.

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