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INVESTIGATING THE PATH LOSS OF CELLULAR MOBILE NETWORK IN SUBURBAN AREAS OF BENIN METROPOLIS OF NIGERIA AT 910MHZ

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ABSTRACT

This paper focuses on investigating path loss of mobile cellular network in suburban areas of Benin metropolis at a propagation frequency of 910MHz. The network Cell Info Lite application installed in GIONEE M5 CDMA was used to measure the received signal strength of the transmitted signal. The relative parameters were obtained from 100meters from the Glo base station from August, 2021 to October, 2021 within an average temperature of 27^0C. The results showed that Hata models are extensively used for the analysis of path loss evident in mobile cellular networks, GSM and CDMA system as depicted by the terrain of sub-urban areas of Benin City Metropolis. It was observed that the more the mobile stations move away from the base station, the higher the signal loss. This paper therefore guides cellular network service provider on accurate method of designing, deploying, and managing network to enhance good network coverage.

Keywords: Hata model, GSM (Global System of Communication, CDMA(Wireless Code Division Multiple Access Systems, Long Term Evolution (LTE)

INTRODUCTION

In this study, the data collected was motivated to capture the variation in received signal strength and path loss for Long Term Evolution (LTE) wireless communication technologies which allow end users to be reachable at any time. The parameter such as path loss is employed in evaluating mobile networks quality and capacity as regards efficient and reliable coverage area in the growth of mobile cellular communication (Nwalozie et al 2014). Path loss and received signal strength by mobile station depends on several factors such as distance from base station to the receiver, condition of the weather and the prevailing environmental conditions(Omoroguiwa and Okundamiya, 2015), type of propagation, height and location of antenna (Nnamani and Alumona, 2015). Path loss is a basic component in the analysis and design of the link budget of a telecommunication system.

The fundamental effects of path loss on received signal are free-space loss, refraction, diffraction, reflection, aperture-medium coupling loss, and absorption. Path loss is highly influenced by terrain contours, vegetation and foliage and moist air in sub urban areas. It is the reduction in power density (attenuation) of transmitted mobile signal as it propagates through space.

This study focuses on the analysis of measured received signal strength and path loss on a plain road consisting of linear and nucleated settlements, high and low building, dual link road that is often agog with the sound of heavy duty and light vehicles. The received signal strength is vital in telecommunication network or technology as it is affected by varying environmental factors such as temperature (T^0C), relative humidity (H%), air quality index (m) and distance from base station (m) (Akhideno and Eguasa, 2022). This paper seeks to find the effects of path loss on received signal strength in suburban areas.

The research also aimed to providing good quality of service of mobile cellular networks in Benin City suburban areas by carrying out the measurement and developing an acceptable model for designing, deploying and managing mobile cellular networks (Nnamani and Alumona, 2015). Since the terrain conditions of this location vary to an extent, the path loss models cannot be generalized. The drawback in this study can be overcome by adjusting the model parameters to suite the desired environments (Syahfrizal and Fransiscus 2020). The objective of this study is to determine why there is low signal in some selected environments and to investigate the influence of path loss and signal strength against distance useful for network planning and development.

The Hata's Propagation Model

The Hata Model is also known as the Hata-Okumura Model. The Hata-Okumura Model, is used for predicting path loss in urban areas (Hata 1981 & Neskovic et al. 2000, Deme et al 2013, Ogbeide and Ojo, 2014). This model takes into account the effects of diffraction, reflection and scattering caused by city structures. The model also has formulations for predicting path loss in Suburban and Open Areas. The Hata's Model for Urban Areas is used within frequency range: 150 MHz to 1500 MHz, transmitter Height: 30 m to 200 m, link distance: 1 km to 20 km and Mobile Station (MS) height: 1 m to 10 m Hata's Model for Urban Areas is given as;

$$L_u = 69.55 + 26.16\, log_{10} f - 13.82\, log_{10} h_B - C_H + (44.9 - 6.55\, log_{10} h_B)\, log_{10} d$$

For small or medium sized cities (where the mobile antenna height is not more than 10 meters), the correction factor C_H is given as $C_H = 0.8 + (1.1\, log_{10} f - 0.7)h_M - 1.56\, log_{10} f$

For large cities,

$$C_H = \begin{cases} 8.29(log_{10}(1.54h_M))^2 - 1.1, if 150 \le f \le 200 \\ 3.2(log_{10}(11.75h_M))^2 - 4.97, if 200 < f \le 1500 \end{cases}$$

Where $\boldsymbol{L_U}$ = path loss in urban areas. Unit: decibel (dB), $\boldsymbol{h_B}$ = Height of base station antenna. Unit: meter (m), $\boldsymbol{h_M}$ = Height of mobile station antenna. Unit: meter (m), $\boldsymbol{f}$ = Frequency of transmission. Unit: Megahertz (MHz), $\boldsymbol{C_H}$ = Antenna height correction factor and $\boldsymbol{d}$ = Distance between the base and mobile stations. Unit: kilometer (km).

The Hata's Model for suburban areas is used to predict path loss of rural areas and outskirts of the city where man-made structures are available but not as high and dense as in the cities. The model is based on the Hata's Model for urban areas and uses the median path loss from urban areas. The Hata's Model equation for Suburban Areas is given as $L_{SU} = L_U - 2(log_{10}\frac{f}{28})^2 - 5.4$

Where L_{SU} = Path loss in suburban areas. Unit: decibel (dB), L_U = Path loss from the small city version of the model; Unit: decibel (dB), f = Frequency of transmission. Unit: Megahettz (MHz).

The Hata Model for open areas predicts path loss in open areas where no obstructions block the transmission link. This model is suited for both point-to-point and broadcast transmissions. Hata model for open areas is formulated as,

$$L_O = L_U - 4.78(log_{10} f)^2 + 18.33(log_{10} f) - 40.94$$

Where L_O = Path loss in open areas. Unit: decibel (dB), L_U = Average path loss from the small city version of the model (above). Unit: decibel (dB) and f = Frequency of transmission. Unit: Megahetz (MHz).

Description of the Investigated Area

Benin is the capital of Edo State of Nigeria. The area of investigation in the City starts form Ramat Park through Aduwawa Community and extends to the outskirt and terminates at Obadan junction along Benin-Auchi road. Its terrain clutter is characterized by the availability of vegetation of tall trees, building height below 10 meters and an average dual road width of about 20 meters each. The concrete ground and tarred roads have very poor electrical conductivity, and therefore, cause attenuation by absorption.

METHODOLOGY

Data Collection Method

This research was carried out during hot sunny eight days within the study location from October 2021 to December 2021 within an average temperature of 27^0C in Benin City metropolis of Edo State, Nigeria. Drive test was employed. Drive test is a measurement tool by operators to determine the status of the signal strength and to solving network problem (Ahmadi et al, 2014). The test was carried out in the city outskirt along Benin-Auchi road from Ramat Park axis through Eyean extending to Obadan junction axis with necessary measurements taken at frequency of 910MHz situated within the terrain. The signal strength and associated factors of the network was monitored with GIONEE M5 phone installed with network Cell Info Lite application, wide band Code Division Multiple Access, Code Division Multiple Access (CDMA) and GSM. It measures the signal sent over the air interface between the base station and the mobile station. The base station antenna height is 42m and operated by a GSM base station over a transmitted power of 25W mounted on a tower.

RESULTS AND DISCUSSION

The chosen base station were selected to cover two groups: Group A location tends to the urban area consisting of near densely population, tall buildings of 2m to 7m, offices fitted with gadgets such as in NTA, Speed FM radio, KU FM radio and Edo Broadcasting Service (EBS) which allow signal to suffer from noise pollution while the Group B location tends to the rural areas which has much vegetation such as trees which allow signal to suffer greatly from diffraction, reflection, absorption and scattering (Emeruwa and Ekah, 2018), nodal and linear settlements, averagely with low buildings as seen at Ogueka, Ekhua, Urokhuosa extending to Obadan community junction axis along Benin Auchi road of Edo State of Nigeria.

The results obtained from the measurements of received signal strength and path loss (dB) over the period of investigation are shown in Table 1 and Table 2 respectively. Figure 1 shows the graphical representation of measured path loss against distance for route A and route B which is influenced by terrain contours and environmental conditions. The significance of this is that the intercept or maximum path loss is about 80dB with an acceptable range of 10dB (Nnamani and Alumona, 2015). Data in Tables 1 and 2 was analyzed based on statistical central tendency parameters and using Microsoft excel package for graphical presentation. The events of path loss and signal strength were investigated at frequency of 910MHz. It means that path loss increases as distance from base station increases.

Table 1: Average measured data for group A

Distance (m)	Average Signal Strength (dBμV)	Average Path Loss(dB)
100	51.7	87.2
200	48.8	91.0
300	44.9	94.3
400	41.7	95.6
500	37.5	84.1
600	33.8	85.3
700	36.8	80.1
800	12.5	110.3
900	26.5	100.3
1000	23.8	106.1
1100	11.5	114.5
1200	19.5	101.6
1300	17.5	105.2
1400	15.7	111.1
1500	13.9	113.2
1600	14.8	123.1
1700	13.0	129.6

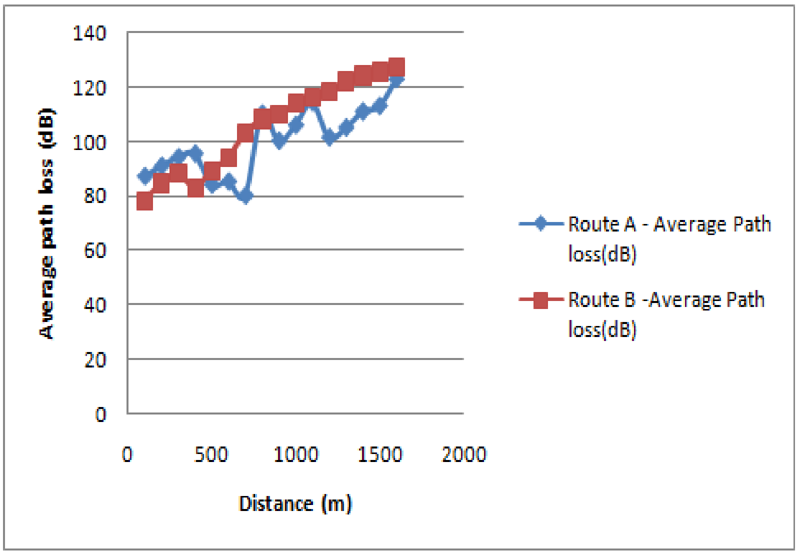

Figure 1: Average signal strength against distance of route A

Figure 2 shows the graphical representation of signal strength (dBµV) against distance. It can be seen that route B has a better signal strength over route A at the range of 100m to 600m with an average path loss of 80dB and averagely poor as the distance increases. This is influenced by the terrain of the environment. At far distance it is relatively the same with distorted signal where ecological factors are considered as major influence to poor signal strength and accurately accounted for during planning a network service budget for an environment. At a distance close to the base station, the signal strength of route A and B are relatively good which shows that the closer the end user is to the base station, the better the signal strength.

Table 2: Average measured data for group B

Distance (m)	**Average signal strength (dBµV)**	**Average Path loss(dB)**
100	60.4	78.2
200	54.9	84.6
300	50.8	88.3
400	47.7	83.0
500	56.0	89.4
600	48.5	94.2
700	42.7	103.3
800	38.7	108.4
900	23.1	110.2
1000	32.0	114.0
1100	28.7	116.3
1200	26.8	118.3
1300	30.7	122.1
1400	21.6	124.2
1500	17.9	125.6
1600	15.3	127.3
1700	12.6	128.6

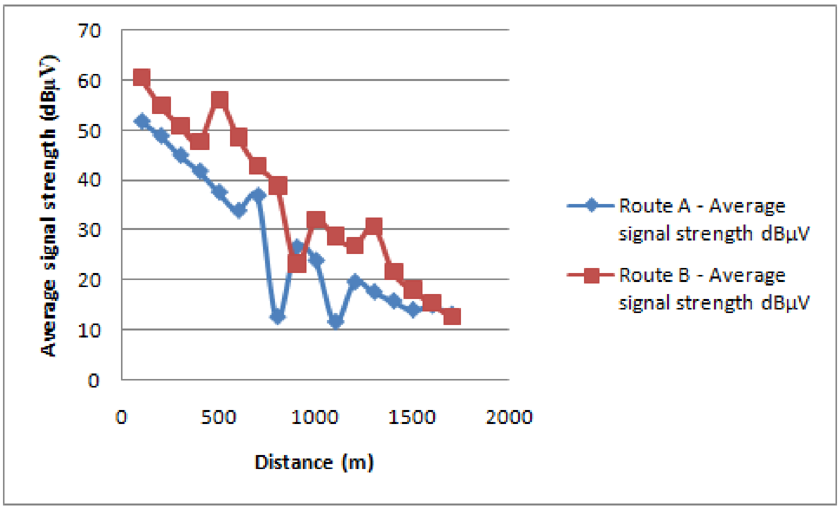

Figure 2: Average signal strength against distance of route B

CONCLUSION

The study presents the mean signal strength and average path loss of a sub-urban area of Benin metropolis. The results of this study shows that route A experience more of poor network coverage due to some physical factors such as distance of end user from base station, the height of transmitting antenna, and few number of repeater stations. The results also proved that the mobile communication signals can be accessed by analyzing the measured signal strength and path loss of urban, suburban and rural areas on a large scale for improvement processes and in addition to the rising use of mobile communication gadgets. The study emphasized that the Hata's model is a commonly used empirical propagation model because of it is simple and effective for the analysis of path loss. From the results of this experiments, the network service providers are encourage to provide more booster stations in some selected location to enhance good quality of service to end users. Repeaters or booster stations are used to increase the maximum interconnection length, clean signal pulses, pass all signals between attached segment, boost signal power and possibly translate between two different media types (such as fibre to twisted-pair cable etc). The best site for the repeaters is a must to enhance effective service delivery.

REFERENCES

Ahmadi, A.L., Capone, P. and Maluccelli, F. (2008) Radio planning and coverage optimization of 3G cellular networks . Journal of Wireless Networks, Vol 14. No 4

Akhideno, I.O. and Eguasa, O. (2022) An Adaptive Local Linear Regression Method For Mobile Signal Strength With Application To Response Surface Methodology. FUDMA Journal of Sciences (FJS). Vol. 6 No. 5, pp 41 - 49

Deme A., Dajab D., Bajoga B., Mu'azu, M. and Choji D. (2013) Hata-Okumura Model Computer Analysis for Path Loss Determination at 900MHz for Maiduguri, Nigeria. Journals and book hosting- Conferences and workshop solutions Vol 3, No 3.

Emeruwa, C. and Ekah, U.J., (2018) Investigation of the variability of Signal Strength of Wireless Services in Umuhia, Eastern Nigeria. Journal of Applied Physics Vol 10.

Hata M., (1981) "Empirical formula for propagation loss in land mobile radio services," IEEE Transactions on Vehicular Technology, vol. vol. VT-29, September 1981.

Neskovic, A., Neskovic, N. and Paunovic, G. (2000).Modern Approaches in Modeling of Mobile Radio Systems Propagation Environment. IEEE Communication. Surveys

Nnamani, K. N. and Alumona, T.L. (2015), Path Loss Prediction of Wireless Mobile Communication for Urban Areas of Imo State, South East Region of Nigeria at 910MHz. International Journal of Sensor Networks and Data Communications.

Nwalozie, G. C., Ufoaroah, S.U., Ezeagwu C.O., and Ejiofor A.C. (2014) Path Loss Prediction for GSM Mobile Networks for urban Region of Aba, South –East Nigeria. International Journal of computer science and mobile computing, Vol 3 267-281

Ogbeide, O.K. and Ojo, J.S., (2014), Statistical Modification of Hata Model for Path loss Prediction in the Coastal City of Warri, Nigeria, Journal of the Nigerian Association of Mathematical Physics, Volume 26.

Omoroguiwa, O. and Okundamiya, M.S. (2015), Investigation on accessibility index and quality of GSM networks in Ekpoma, Nigeria ISERD international Conference New York USA 23 -28

Syahfrizal, T. and Fransiscus, S. (2015) Path Loss Prediction for GSM 900 Signal Strength Measurements. www.researchgate.net/publication/281406942

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