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ON THE PERFORMANCE ANALYSIS OF COST 231 HATA MODEL ON DEPLOYED 1800MHz GSM NETWORKS AT NIFOR, EDO STATE, NIGERIA

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Abstract

The ability to provide seamless communication is one of the challenges faced by radio service providers in the telecommunication industry. This paper presents the performance analysis of COST 231 Hata model on three deployed 1800MHz GSM networks at NIFOR environment, Edo state. The path loss estimated from the measured received signal strength data were compared with path loss predicted using the COST 231 Hata and presented graphically using MATLAB_ R2017b software. The result of this study shows that COST 231 Hata model under predicted the path loss in this environment with a mean prediction error (MPE)error value of 24.90dB and a root mean square (RMSE) error value of 25.51dB. Based on this result, the COST 231 Hata model cannot be used to plan radio networks in this environment.

Keywords**:** Received signal strength level (RSSL), COST 231 Hata model, Mean prediction error (MPE), Root mean square error (RMSE

INTRODUCTION

The characteristics of the environment in which radio signals propagate places a fundamental limit on the design of cellular communication systems. During the planning stage of a cellular network, it is necessary to have knowledge of the effect of the channel characteristics on the propagating signal through extensive measurement of received signal strength data which is difficult to achieve. Propagation models are mathematical equations used by radio planners to ascertain the propagation loss required to optimally plan base stations locations, frequency assignment and configurations in order to provide full coverage on a given geographical area taking into consideration the traffic requirements, and the desired quality of service (QoS) [1]. These models often require details such as the base station antenna height and the radio signal frequency without considering the characteristics of the geographical terrain.

Several researchers have studied the suitability of existing propagation models in environment where they were not developed for. The authors in [2]presented an analytical comparison of propagation path loss models with received signal strength level (RSSL) at 900MHz and 1800MHz for urban, sub urban and rural environment in India using a spectrum analyzer. In order to compare the performance of radio signals in the chosen environment, path loss was estimated using the Log distance path loss model, SUI model, Hata model, Okumura, COST 231 Hata model and ECC-33 model. The result obtained was compared with measured path loss using Matlab software for the different environment. Based on the plot of path loss with respect to distance presented, the researchers reported that COST 231 and SUI model shows better performance in predicting the network behavior especially for urban and suburban environment. The authors in [3] presented an empirical based path loss prediction model for GSM network deployment in Makurdi, Nigeria. In order to evaluate the performance of GSM networks in Makurdi, a drive test was conducted to obtained measured data using Transmission Evaluation and Monitoring System (TEMS) investigation software running on a mobile phone. Measurements were collected in active mode for a period of 30 seconds for each sample point. The received signal strength data were compared with Okumura Hata model, COST 231 Hata model, Standard propagation model and SUI model respectively. The researchers concluded that COST 231 Hata model and Standard propagation model with a root mean square error of 11.59dB and 8.11dB for GSM 900MHz; an RMSE value of 10.75dB and 12.39dB for GSM 1800MHz was suitable for predicting propagation path loss in Makurdi. The authors in [4] presented the applicability of the Okumura Hata model, COST 231 Hata model and Standard propagation model in predicting radio coverage in urban and sub urban area of Lagos state, Nigeria. In this study, received signal strength data was measured via drive test using ATOLL network planning tool. The result of this investigation shows that COST 231 Hata model was better at estimating path loss in the studied environment since it has the least statistical values with a root mean square error value of 12.28dB and a standard deviation of 6.42dB for the suburban area. For the dense urban area, the COST 231 Hata model also gave a root mean square error value of 11.82dB and a standard deviation of 7.88dB. The researchers in [5-7] reported that most propagation models are environment specific which implies that they cannot be used for another environment with a dissimilar terrain profile.

Hence, this study is aimed at investigating the applicability of COST 231 Hata model on GSM 1800MHz signals at NIFOR Edo state, Nigeria.

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PROPAGATION MODEL

The mobile wireless communication system has become a vital tool in maintaining communication among individuals, organizations etc.The success of the communication industry can be traced to the development of propagation models [8]. The propagation model deployed in this research is the COST-231 Hata model.

COST 231 HATA MODEL: The Cost-231 Hata model is a radio propagation model for wireless communication channels that extends the urban Hata model to cover a higher frequency range. It is used to predict path loss in mobile wireless systems. The Cost-231 Hata propagation model is designed for 1500MHz to 2000MHz frequency range. The basic path loss equation in dB as given in [8] is;

$P_L(urban) = A + B\log_{10}(d) + C$ ……………………………………………………………(1)

where A is the median path loss in (dB) and is given in equation (2) as;

A = 46.3 +33.9 $\log_{10}(f)$-13.82 $\log_{10}(ht_x)$- a(hr_x) ……………………………………………(2)

$'f'$ is the frequency of the radio signal in MHz, ht_x is the base station antenna height in meters (m), a(hr_x) is the mobile station antenna height correction factor and it is given in equations (4) and (5).

where B is 10 times the pathloss exponent $'n'$ and is given in equation (3) as;

B = 44.99 - 6.55$\log_{10}(ht_x)$ ……………………………………………………………(3)

And C is the correction factor due to the type of environment. If the environment is an urban or metropolitan area, C is assumed to be 3 else 0 .The validity range of this model is from a frequency band (f) of 1500MHz to 2000MHz, base station antenna height (ht_x) of 30 – 200m, mobile unit antenna height of hr_x of 1-10m and transmitter-receiver separation distance of 1-20km [9].

The parameter a$(hr_x)$is defined for urban environment as given in equation (4) as;

a$(hr_x) = 3.20\,(\log_{10}(11.75hr_x))^2 - 4.97$ for $f > 400MHz$ …………………………………(4)

And for suburban or rural (flat) environments,

a$(hr_x) = (1.1\log_{10}(f) - 0.7)hr_x$ - $(1.56\ \log_{10}(f) - 0.8)$ ……………………………(5)

where ‘hr_x’ is the mobile unit antenna height above ground level in meters.

The path loss exponent (n) of the predictions made by Cost-231 Hata model is given by equation (6) as;

n = $(44.9 - 6.55\log_{10}(h_{tx}))/_{10}$ ……………………………………………………………(6)

This model is however limited to cases where the base station antenna is placed higher than the surrounding buildings and also for large and small macrocells.

METHODOLOGY

To validate the performance of COST 231 Hata model on the three GSM 1800MHz networks investigated, measurements were collected using an Acer smart phone which run a network info lite software for the three 1800MHz networks. Figure 1 is a snap shot of the measurement interface. For this paper, the Networks are referred to as Network 1, 2 and 3. This study was conducted in a rural environment with semi thick vegetation mostly of palm trees, with scattered settlements as well as NIFOR administrative building as in the google map earth view in Figure 2. Received Signal Strength data (RSSL) were collected on active mode for a period of 120 seconds at an interval of 100m due to the size of the cells at a mobile antenna height of 1.5m. RSSL data were collected for three radial directions which corresponds to the three sectorial antennas mounted at $120°$ to achieve $360°$ coverage as shown in the base station site in Figure 3. In addition to RSSL data collected, base station parameters collected were the base station antenna height $(h_{tx})(m)$ and the standard transmit power $'P_t'(dB)$.

Figure 1: A screen shot of the Network cell Info lite software interface

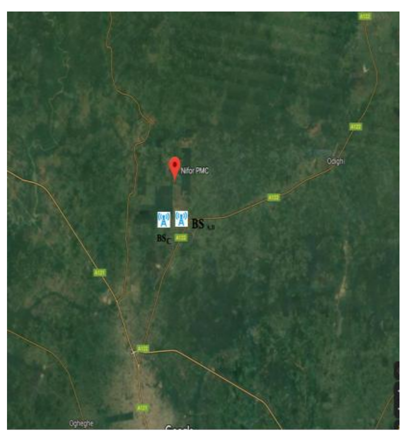

Figure 2: Figure 3: Goggle map of Earth view of NIFOR

Figure 3: NIFOR (Base station site)

RESULTS

The results of the measured received signal strength data were used to estimate the path loss on the transmitted signal and compared with path loss(dB) predicted using the COST 231 Hata model equation in equation (1) for Networks 1,2, and 3. For easy comparison, a graphical plot showing the measured and predicted path loss values plotted with respect to distance with MATLAB_ R2017b software is given in Figure 4 through to Figure 6. The graph in Figure 4 shows that the COST 231 Hata model shows quite large prediction errors, generally under predicted the path loss at NIFOR environment in Edo state, Nigeria. This may be as a result of the different geographical terrain in which the model was developed for.

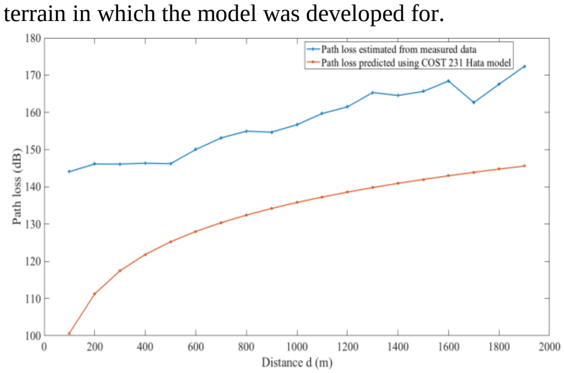

Figure 4: Plot of estimated path loss and pathloss obtained from COST 231 Hata model at 1800MHz for Network 1

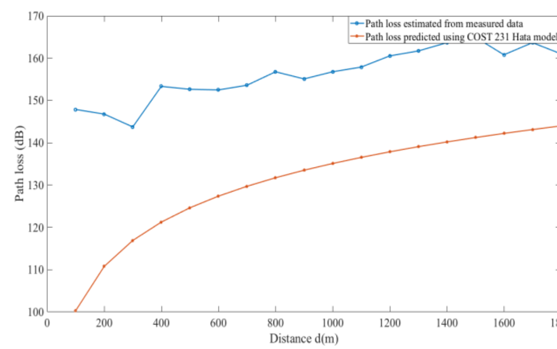

Figure 5: Plot of estimated path loss and path loss obtained from COST 231 Hata model at 1800MHz for Network 2

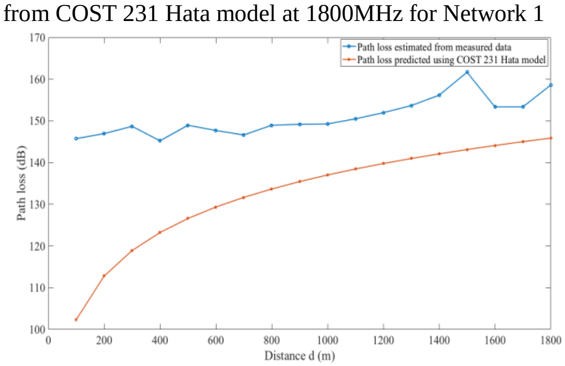

Figure 6: Plot of estimated path loss and path loss obtained from COST 231 Hata model at 1800MHz for Network 3

COST 231 HATA MODEL EVALUATION

For easy understanding of the degree of prediction errors, the Root mean square error value (RMSE) value and Mean prediction error (MPE) values were estimated using equation (7) and equation (8).

$$\text{MPE}=\frac{\sum_{i=1}^{n}(X_{measured\ ,i}-X_{model\ ,i})}{n} \quad \ldots\ldots (7)$$

$$\text{RMSE}=\sqrt{\frac{\sum_{i=1}^{n}(X_{measured\ ,i}-X_{model\ ,i})^2}{n}} \quad \ldots\ldots (8)$$

where $X_{measured}$ is the measured value at the ith distance and X_{model} is the model prediction value at the ith distance. The results of equation (7) and equation (8) gave an MPE value of 24.90dB and a RMSE value of 25.51dB for Network 1, an MPE value of

CONCLUSION

This work presents the result of field measurements of a deployed 1800MHz cellular network at NIFOR Edo state, Nigeria. The results obtained from comparing the path loss estimated from the measured received signal strength data and that predicted using the COST 231Hata model shows that COST 231 Hata model under predicted the path loss at NIFOR environment. This can be seen from the high MPE value and RMSE value of 24.90dB and 25.51dB respectively. This RMSE value is too high for radio planning since an RMSE value of 8dB-10db is required for radio planning.

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