[Ekeocha*, 5(5): May, 2016]
ISSN: 2277-9655
Impact Factor: 3.785

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

OPTIMIZATION OF COST 231 MODEL FOR 3G WIRELESS COMMUNICATION SIGNAL IN SUBURBAN AREA OF PORT HARCOURT, NIGERIA

Akujobi Ekeocha*, Nosiri Onyebuchi, Lazarus Uzoechi and Gordon Ononiwu

* .Department of Computer Science, University of Port Harcourt, Nigeria

.Department of Electrical and Electronic Engineering Futo, Owerri, Nigeria

DOI: 10.5281/zenodo.50980

ABSTRACT

Radio propagation models are important tools adopted for the characterization and optimization of wireless communication signals in a propagation environment. In this paper, the Cost 231 model was optimized for 3G wireless communication signal in Aggrey Road (04° 45 .06"N, 07° 02.24"E), a suburban area in Port Harcourt, Nigeria. Phone-Based Drive Test was adopted for field measurement using TEMS 11 network simulator. The optimization process was implemented through the use of Least Square Algorithm taking into account the initial offset parameters and the slope of the model curve in Cost 231 model for the process. The performance of the optimized model using the statistical tools in Minitab-14 software was evaluated for the Mean Absolute Deviation (MAD) and the Mean Squared Deviation (MSD) respectively. The results obtained demonstrated the following parametric values: 1.196, 2.01 and 1.179, 1.94 for Cost 231 and Optimized models respectively. The optimized model is recommended for deployment for a better and accurate path loss prediction on the environment of study.

KEYWORDS: Characterization, Optimization, least square algorithm, Cost 231.

INTRODUCTION

Radio propagation models are a set mathematical formulations developed for the characterization of radio wave in a propagation environment as a function of frequency of transmission, distance and other conditions that influence the behaviour of the radio channel [1]. During the planning stage of cellular networks, models are employed to predict the behavioural characteristics of signals using similar attributes and constraints of the environment before deployment.

An accurate estimation of channel characteristics is a requirement aimed at maintaining the interference at a minimum level. Also, these models must provide an efficient handoff performance in terms of mobility and availability of service to the subscribers [2]. This will enable subscribers to benefit from the numerous services offered by the network vendors. This can be achieved through a test of the real propagation models [2] in the desired environment of deployment. Although these environments differ and thus there is no generalized approach in their deployment [3].

Optimization of a path loss model is an approach set to adjust chosen parameters of a theoretical model with the help of measured data obtained from an experimental process [4]. The process entails that several parameters can be changed with reference to the targeted environment in order to minimise the error between predicted and measured signal strength [5]. This technique is employed to curb the problem observed in the differences between the used empirical models and the actual measured data in a particular environment [6].

This paper will be presented as thus: section 1, an introduction, section 2, review of Pathloss models followed by a description of the adopted methodology in section 3. The implementation of the least square algorithm will be shown in section 4 and finally section 5 summarizes the key outcomes of the study.

MEASUREMENT PROCEDURE

A drive test methodology was adopted for data collection from the study area. Measurements were conducted along Aggrey Road in River State, Nigeria with co-ordinates (04° 45̀ .06″N, 07° 02̀ .24″E). The received signal strength and Path loss were recorded in the form of logs which were later processed with Actix analyser. Measuring tools used for the drive test include the Global Positioning System (GPS) receiver, two handsets Ericsson (W995), and drive test software TEMS 11.0 installed on a laptop. The network parameters are shown in table 1.0

Table 1: Network parameters

Parameter	value
Frequency (Hz)	900 MHz
Base Station Height (m)	40m
Receiver Antenna Height (m)	1.5m

PROPAGATION MODEL

Cost 231 model

The Cost 231 model is an outdoor propagation model extended from the formulation of Hata. This model covers signals at frequencies within the range of 1500 to 2000GHz, allowing for its use in the simulations of 3G networks. It contains correction factors for urban, suburban and rural environment, the correction factor makes it a widely acceptable and simple model. The basic equation is represented as [7].

$$P_L = 46.3 + 33.9Log_{10}(f) - 13.82Log_{10}(h_b) - a(h_m) + [44.9 - 6.55Log_{10}(h_b)]Log_{10}(d) + C_m \quad (1)$$

Where,

f = frequency in MHz
h_b= Base station height in meters
h_m= Mobile station height in meters
a(h_m) = Mobile antenna height correction factor
d = link distance in km
c_m= 0dB for medium cities or suburban centre with medium tree density
c_m = 3dB for urban environment

For urban environments,

$$ah_m = 3.20[\log_{10}(11.75h_m)]\ 2{-}4.97, \text{ for } f > 400 \text{ MHz} \quad (2)$$

and for suburban or rural (flat) environments,

$$ah_m = (1.1 \log_{10}f - 0.7)h_m - (1.56 \log_{10}f - 0.8) \quad (3)$$

Least Square algorithm for cost 231model Optimization

The least square method is a statistical tuning approach in which all environmental influences are considered. The cost 231 Hata model as given in (1) consists of three basic elements, which are represented as [5].

$$E_o = 46.3 - ah_m + c_m \quad (4)$$

$$E_{sys} = 33.9\log_{10}(f) - 13.82\log_{10}(\log_{10}(h_b)) \quad (5)$$

$$\beta_{sys} = (44.9 - 6.55(\log_{10}(h_b))\log_{10}(d) \quad (6)$$

Where,

E_o =Initial offset parameter,
β_{sys}= slope of the model curve
E_{sys} = Initial system design parameter

The total path loss in (1) is described as

$$P_l(dB) = E_o + E_{sys} + \beta_{sys} \quad (7)$$

Equation (7) may be written as

$$a = E_o + E_{sys}; \quad (8)$$

$$b = \beta_{sys} \quad (9)$$

The Cost 231 model in (1) is expressed as

$$P_r = a + b.logR \quad (10)$$

The Simplified logarithm base $\log R = x$, so the above equation is represented as

$$P_r = a + b.x \qquad (11)$$

Where, P_r = model predicted path loss in decibels

The parameters a and b represent constants for a given set of measured values. Tuning of Cost 231 model would be achieved by considering the parameters E_o, E_{sys} and β_{sys}. In the least square algorithm, to satisfy the condition of best fit for a theoretical model curve with a given set of experimental data, the sum of deviation squares must be minimum as given in (12) [8].

$$E(a,b,c\ldots) = \sum_{i=1}^{n}[y_i - P_{R,i}(x_i,a,b,c)]^2 = min \qquad (12)$$

y_i = exprimentally measured pathloss values at distance x_i

$P_{R,i} = (x_i, a, b, c)$ = model predicted path loss values at distance x_i based on tuning

Where a, b and c are the model parameters based on tuning, n represents number of experiment data set.

The error function E (a, b, c) must be least. To ensure this, all partial differentials of the E function should be equal to zero.

$$\frac{\partial E}{\partial a} = 0;$$
$$\frac{\partial E}{\partial b} = 0;$$
$$\frac{\partial E}{\partial c} = 0; \qquad (13)$$

The solution of (12) is shown as

$$\left(\sum_{i=1}^{n}(y_i - P_R(x_i,a,b,c))\frac{\partial P_R}{\partial a}\right) = \sum(y_i - a - bx_i).1 = 0$$
$$\left(\sum_{i=1}^{n}(y_i - P_R(x_i,a,b,c))\frac{\partial P_R}{\partial b}\right) = \sum(y_i - a - bx_i).x_i = 0$$

By repositioning the elements in the above equations, the following expressions are generated

$$n.a + b\sum x_i = \sum y_i; \qquad (14)$$
$$a\sum x_i + b\sum x_i^2 = \sum(x_i y_i); \qquad (15)$$

Substituting the variables a and b into (14) and (15), the tuned statistical estimates of parameters a and b are given as

$$\tilde{a} = \frac{\sum x_i^2.\sum y_i - \sum x_i.\sum x_i y_i}{n.\sum x_i^2 - (\sum x_i)^2}; \qquad (16)$$
$$\tilde{b} = \frac{n.\sum x_i y_i - \sum x_i.\sum y_i}{n.\sum x_i^2 - (\sum x_i)^2} \qquad (17)$$

The tuned statistical estimates $\tilde{a}$ and $\tilde{b}$ are substituted into the original Cost 231 model and the tuned values of the initial offset parameter and slope of the model curve are obtained as [5].

$$E_{o\ new} = \tilde{a} - E_{sys}; \beta_{sys} = \frac{\tilde{b}}{44.9 - 6.55Log_{10}(h_b)} \qquad (18)$$

IMPLEMENTATION OF LEAST SQUARE ALGORITHM

The implementation of the least square algorithm is based on the work of [9]. The values for $E_{o\ new}$ and $\beta_{sys\ new}$ were determined by substituting measured data into equation (16), (17) and (18). The Linear regression line of fit was adopted in the determination of the initial offset parameter as shown in fig 1. The new E_o value was then introduced into the original Cost 231 model and thus the optimized Cost 231 Hata model is presented as (19)

$$P_l = 38.1 + 33.9\log_{10}(f) - 13.82\log_{10}(h_b) - ah_m + (44.9 - 6.55\log_{10}(h_b))\log_{10}(d) + C_m \qquad (19)$$

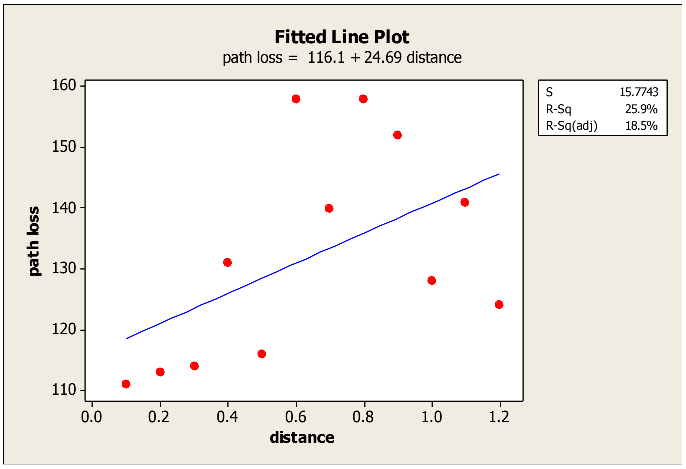

Figure 1: Scatter plot of the measured path loss with linear regression fit

RESULT AND DISCUSSION

The optimized parameters obtained using the least square algorithm is shown in table 2.0. Table 3.0 shows predicted path loss values for existing models, measured data and optimized data. Fig 2 illustrated a comparative plot of existing models and measured data while Fig. 3 showed a plot comparing the optimized with existing models and measured data. From the optimization process of Cost 231 model, the developed model demonstrated better prediction compared to the measured and existing models as shown in fig 3. This result explained the necessity and importance of the model optimization for the existing base stations in the of study area.

Table 2: Parameters obtained after optimization

E_o of Cost 231 Hata model	46.3
"a" from line in fig 1	116.1
$E_o = a - E_{sys}$	38.1
$\beta_{\text{sys new}}$	0.7176

Table 3: Path loss values for existing models, predicted and optimized model

Distance (km)	Ecc-33(dB)	Cost 231 (dB)	Okumura-Hata (dB)	Measured (dB)	Optimized (dB)
0.1	296.60	89.88	90.27	111	81.5
0.2	303.51	100.25	100.63	113	91.5
0.3	307.89	106.31	106.69	114	97.9
0.4	311.15	110.61	110.99	131	102.2
0.5	313.77	113.95	114.32	116	105.5
0.6	315.96	116.67	117.04	158	108.2
0.7	317.86	118.97	119.35	140	110.5
0.8	319.53	120.97	121.34	158	112.5
0.9	321.02	122.73	123.10	152	114.3
1.0	322.38	124.30	124.68	128	115.9
1.1	323.62	125.71	126.10	141	117.3
1.2	324.77	127.03	127.40	124	118.6

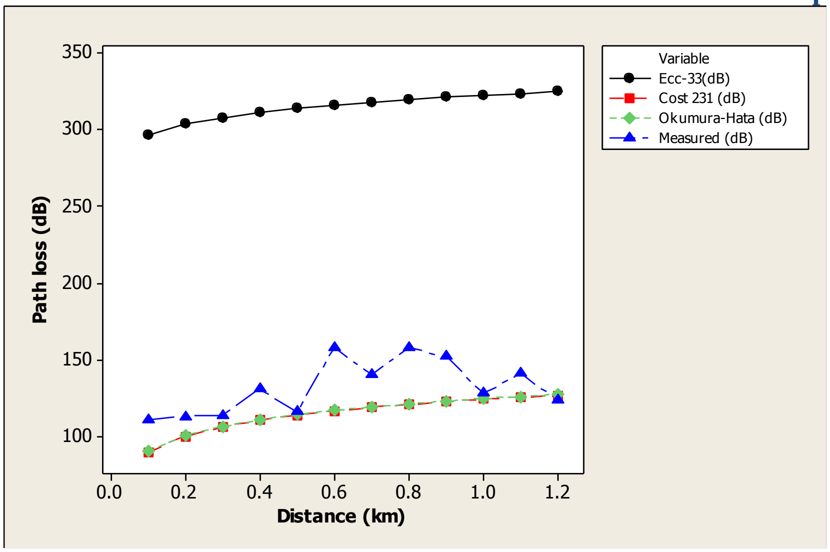

Figure 2: Comparative plot of existing models and measured data

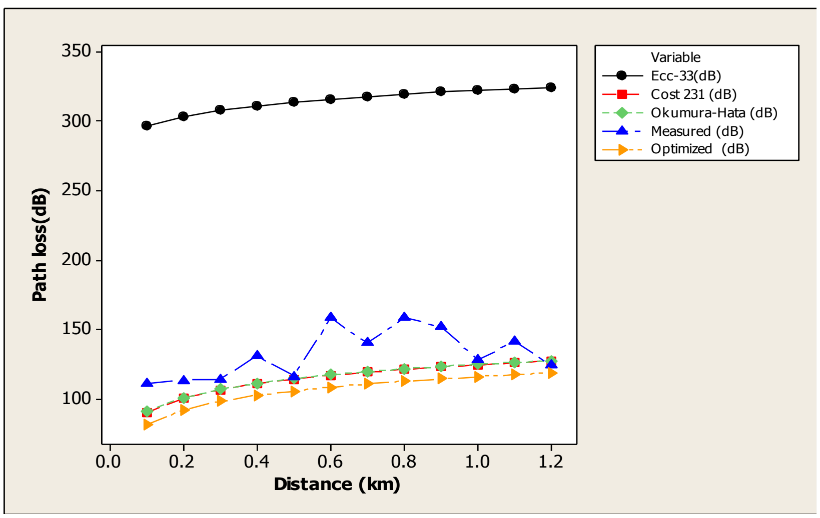

Figure 3: Plot of optimized model with measured and existing models

MODEL PERFORMANCE ANALYSES

To validate the performance of the optimized model, trend analysis was carried out using Minitab software 14 as shown in fig 4 and fig 5. In comparing the performance of the cost 231 and optimized models, results shown in Table 4.0 indicated that the optimised model recorded better fit. The Mean Absolute Deviation (MAD) and Mean Squared Deviation (MSD) values for the optimized model were obtained as 1.179 and 1.94 respectively. These values were smaller from the comparison indicating a better fitting model.

Table 4: Comparative analysis for the models

	COST 231	OPTIMIZED MODEL
MAPE	1.105	1.179
MAD	1.196	1.179
MSD	2.01	1.94

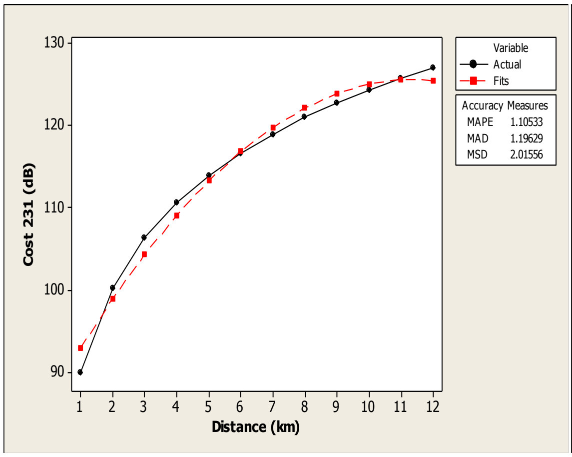

Figure 4: Plot of trend analysis for COST 231 model

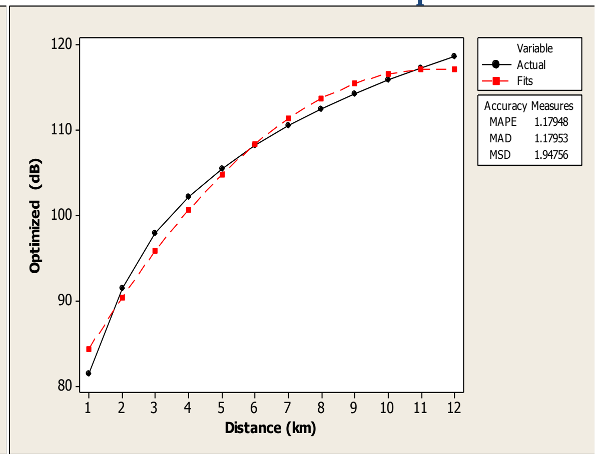

Figure 5: Plot of trend analysis for optimized model

CONCLUSION

In this work, we presented an optimized Cost 231 model using the linear least square algorithm. The main aim was to optimize the Cost 231 propagation model based on measured data to obtain a better fit for the study area. The optimized Cost 231model for GSM 900 MHz signals showed a better path loss prediction compared to the Cost 231 model. This makes it suitable for path prediction as shown through the error statistics in table 4. It is recommended for the telecommunication network operators to adopt the model and offer improved services for customer satisfaction.

REFERENCES

[1] Segun Isaiah Popoola and Olasunkanmi Fatai Oseni. "Empirical Path Loss Models for GSM Network Deployment in Makurdi, Nigeria".International Refereed Journal of Engineering and Science (IRJES). Volume 3, Issue 6, PP.85-94, June 2014.
[2] Deussom Djomadi Eric Michel, Tonye Emmanuel, "Optimization of Okumura Model in 800MHz based on Newton Second Order Algorithm. Case of Yaounde", Cameroon" IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), Vol 10, Issue 2 Ver.I PP16-24, (Mar-Apr 2015).
[3] Syahfrizal Tahcfulloh and Eka Riskayadi. "Optimized Suitable Propagation Model for GSM 900 Path Loss Prediction" Telkomnika Indonesian Journal of Electrical Engineering.Vol. 14, No. 1, 2015, PP. 154 – 162
[4] Isabona Joseph and Konyeha. C.C. "Urban Area Path loss Propagation Prediction and Optimisation Using Hata Model at 800MHz".IOSR Journal of Applied Physics (IOSR-JAP), Volume 3, Issue 4, Pp 08-18, 2013.
[5] Bhuvaneshwari, R. Hemalatha, and T. Satyasavithri. "Statistical Tuning of the Best suited Prediction Model for Measurements made in Hyderabad City of Southern India" Proceedings of the world congress on engineering and computer science Vol II WCECS, San Francisco, USA, 2013.
[6] Diawuo k, Dotche K.A and Toby Cumberbatch, "Data fitting to Propagation Model using Least Square Algorithm: A case of Ghana", International Journal of Engineering Sciences, 2(6), PP 226 -230, June 2013.
[7] Kumari Manju, YadavTilotma and PoojaYadav, "Comparative Study of Path loss Models in different Environments".International Journal of Engineering Science and Technology (IJEST), Vol. 3 No. 4 April 2011.
[8] Mardeni R and K. F. Kwan, "Optimization of Hata Propagation Prediction Model In Suburban Area In Malaysia" Progress in Electromagnetics Research C, Vol. 13, 91–106, 2010
[9] Jadhav A.N and Sachin S. Kale, "Suburban Area Path loss Propagation Prediction and Optimization Using Hata Model at 2375 MHz", International Journal of Advanced Research in Computer and Communication Engineering", Vol 3, Issue 1, PP 5004 -5008, January 2014.