JOURNAL OF ADVANCEMENT IN ENGINEERING AND TECHNOLOGY
Journal homepage: www.scienceq.org/JAET.php
ISSN: 2348-2931 V4I4.01
Research Article Open Access

Pathloss Modelling of less dense urban area in Lagos State using Lee Model

Shoewu, O[1], L.I. Oborkhale[2]
[1]Department of Electronic and Computer Engineering, Faculty of Engineering, Lagos State University, Lagos, Nigeria.
[2]Department of Electrical and Electronics Engineering, Michael Okpara University of Agriculture, Umudike, Abia, Nigeria.
*Corresponding author: O. Shoewu, E-mail: engrshoewu@yahoo.com
Received: February 1, 2017, Accepted: March 5, 2017, Published: March 5, 2017.

ABSTRACT

In this study we aim to adopt a propagation model for a less dense urban area in Lagos state by examining one of the popular empirical path loss models for mobile communication. Lee's model was compared with measured path loss obtain from the field measurement at GSM frequency of 900 MHz . TEMS Investigation tool was used for the drive test. The measurements of the received signal strength were collected through drive test with the aid of an Ericson test mobile system (TEMS). This was conducted around six base station of a mobile communication network at 900MHZ frequency band. The TEMS gives the received signal level at a spherical distance and the height of the mobile station is about 1.5m while the base station consists of heights of 30m and 32m. The width of the road is about 20m. The peak transmitter power is approximately 47dBm for all base station. Microsoft Excel spreadsheet application was used to open log files which has been exported from TEMS and saved as dot txt. We accomplish the investigation in variation in path loss between the measured (values gotten from field) and modeled values through MATLAB graph which was plotted. The average value was calculated between measured path loss values and the modeled values on basis of lee's model for a less dense urban area. It was found out from the MATLAB analysis that site 3107-4877 was the closest with an average measured and model path loss of 124.9dBm and 122.4dBm respectively. Overall, this paper concludes that the path loss modeling and investigation over a less dense terrain, justifies that the Lee's model has a best fit with experimentally measured data.

Keywords: Pathloss Modelling, Lee Model, mobile communication.

INTRODUCTION

In wireless communication the losses occurred in between transmitter and receiver is known as propagation path loss. Path loss is the unwanted reduction in power signal which is transmitted. We measure this path loss in different area like rural, urban, and suburban with the help of propagation path loss models. Also Path loss is the degradation in received power of an Electromagnetic signal when it propagates through space. Path loss is due to several effects such as free space path loss, refraction, diffraction, reflection, coupling and cable loss, and absorption. Path loss depends on several factors such as type of propagation environments, distance between transmitter and receiver, height and location of antennas. The signal from the transmitting antenna may take multiple paths (multipath) to reach the receiving side, which results in either increase or decrease of received signal level depending on the constructive or destructive interference of the multipath waves.

Wireless communications provide high-speed high-quality information exchange between portable devices located anywhere in the world. These models can be broadly categorized into three types; empirical, deterministic and stochastic. Empirical models are those based on observations and measurements alone. These models are mainly used to predict the path loss, but models that predict rain-fade and multipath have also been proposed. Deterministic models often require a complete 3-D map of the propagation environment. An example of a deterministic model is a ray tracing model. Stochastic models, on the other hand, model the environment as a series of random variables. These models are the least accurate but require the least information about the environment and use much less processing power to generate predictions.

Empirical models can be split into two subcategories namely, time dispersive and non-time dispersive

Path loss is usually expressed in decibels (dB), as this method gives us an easy and consistent method to compare the signal levels at various points. Where LP is the path loss i.e. the ratio of power of received signal to that of transmitted.

Propagation models are used extensively in network planning, particularly for conducting feasibility studies and during initial deployment. They are also very useful for performing interference studies as the deployment proceeds.

Many propagation models are available for path loss predictions. Deterministic models are based on the laws of electromagnetic wave propagation and produce accurate predictions of the path loss, however they take high computational effort and require detailed and accurate description of all objects in the propagation path .Free space Model, and Plane Earth model, are easier deterministic propagation methods. Empirical models are based on extensive collection of data for specific case. They are not accurate but predict the most likely behavior the link may exhibit under specific conditions.

Path loss propagation models are used to compute path loss dump transmission of a signal in order to predict the mean received signal strength for an arbitrary transmitter-receiver separation distance these are useful in estimating the radio coverage of a transmitter. A simple mathematical expression for propagation loss P_L in a specific type of built up environment and size of city is represented by

$$P_L = f(h_b, h_m, f_c, d, \Delta h) \dots\dots\dots\dots\dots\dots. (1)$$

Okumura et al ( ) showed an empirical path loss prediction model less bas on field measurements taken in Tokyo metropolis. The work provided an initial path loss estimate for the urban terrain with a quasismooth area (Δh

However, correction factors were adapted to the results obtained in some other, conditions. It was shown that Okumura's method cannot be easily automated because of the curves generated. An attempt was made by Hata ( ) to ensure easy applicability of Okumura's method by some empirical mathematical relationships. This was used to describe the graphical hints given by Okumura. Hata's model presented limitations to certain ranges of input parameters and its applicability over quasismooth terrain.

The mathematical formulations for path loss P_L in dB and their range of applicability in urban terrain are:

$$P_L = 69.55 + 2.16\log f_c - 13.82\log h_b - a\,(hm) + (44.9 - 6.55\log h_b)\log d \; dB \; \ldots\ldots(2)$$

Where

$$150 \leq f_c \leq 1500\ MHz$$
$$30 \leq h_b \leq 200m$$
$$1 \leq d \leq 20\ km$$

a (h_m) is the correction factor for mobile antenna height and is computed as follows:
for small or medium size city

$$a\,(h_m) = (1.1\log f_c - 0.7)h_m - (1.56\log f_c - 0.8) \ldots\ldots\ldots(3)$$

Where $1 \leq h_m \leq 10\ m$

For large city

$$a(h_m) = \begin{cases} 8.29(\log 1.54 h_m)^2 - 1.1;\ f_c \leq 200MHz \\ 3.2\,(\log 11.75\ h_m)^2 - 4.97;\ f_c \geq 400MHz, \end{cases}$$

……………..(4)

For sub urban terrain

$$P_L = P_L\,(urban) = 2\left[\log\left(\frac{f_c}{28}\right)\right]^2 - 5.4\ dB \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

For open Areas

$$P_L = P_L\,(urban) - 4.87\,(\log f_c)^2\ 18.33\log f_c - 40.94\ dB \ldots\ldots\ldots\ .(6)$$

The expressions in equation (1) to (6) have considerably enhanced the practical value of the okumura's method; however Hata's presentations do not include any of the path specific corrections available in the previous original method. We have however adapted some of the formulations of Hata to a less dense urban terrain.

3.3 METHODOLOGY FOR DATA FETCH

A drive test was conducted in a less dense urban area, in Lagos State, with coordinates (6°30′N 3°21′0"E) Lagos State is located at the south west of the country with average building height of 10m. The dense urban area used covers 23 sq. km with a population of 503,975 at the 2006 Nigerian census. Using specially configured dual band handset, GPS and Probe Dongle all coupled to a laptop placed in a vehicle which was driven around through a predefined route. All the drive tests were conducted inside the metropolis.

The concerned methodology deals with drive test tools which contains both software and hardware devices. Here we have deployed TEMS 10.04 for drive test measurements. The complete process of data collection via, TEMS-10.04 or any other advanced version is not a simplistic task. It involves careful setting up of GPS and TEMS enabled hand-set for the purpose of data collection. While driving was going on, the handset was configured to automatically make calls to a fixed destination number. Each call lasted for 300 seconds hold time and the call was dropped. The phone remained idle for some period of time then another call was made. The drive test involves the collection of measurement data in TEMS phone in less dense area of Lagos State.

3.4 Measurement and drive test

The drive test survey route was planned accordingly with the aid of road and vector maps such that the measurement collection process involves base stations marked out for investigation. This was conducted around six base station of a mobile communication network at 900MHZ frequency band. The TEMS gives the received signal level at a spherical distance the height of the mobile station is about 1.5m while the base station consist of heights of 30m and 32m. The width of the road is about 20m. The peak transmitter power is approximately 47dBm for all base station. Most telecom operators make use of the above technology largely to measure, analyze and optimize their mobile networks. The purpose is to collect test data which could be analyze in real time to view network performance or when deploying new networks. Data from cell sites are usually grouped by collection software and stored in various log files. These log files are used to analyze and evaluate various radio frequency parameters of the

Basic Lee's Model

The basic Lee's model is used for flat areas or predictions errors may occur outside these areas. The basic lee's Model however is used for less dense terrain in this study. The model is of the form in equation.

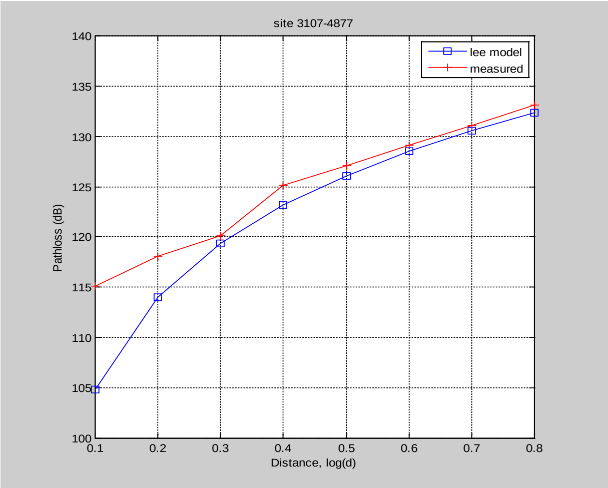
$$P_{re} = 10\log_{10}\left[P_o\left(\frac{d}{d_o}\right)^{-n}\left(\frac{f}{f_o}\right)^{-\beta} a_o\right]$$

The parameters P_{re}, P_o, f and f_o are the receive signal power at a distance from the transmitter at a distance d, the received signal power at a reference distance d_o (typically 1.6km), the carrier frequency, and the nominal carrier frequency at 900MHz.

4.3 RESULT

Table: comparison of measured values and modeled values

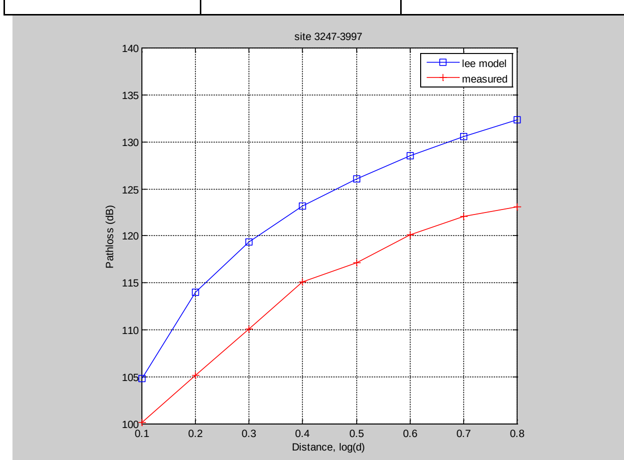
Distance (m)	measured path loss (dB)	LEE'S Modeled path loss (dB)
100	115.11	105.00
200	118.11	114.11
300	120.11	119.00
400	125.11	123.50
500	127.11	126.50
600	129.11	128.11
700	131.11	131.11
800	133.11	133.00



Practically measured data was taken in a less dense urban area using spectrum analyser at a frequency of 900MHz. the close in reference distance taken is 100m. measurements were taken between 100m and 800m. This was done for three sites, 3107-4887, 3247-3997 and 5029-3037. And they are depicted as site A, B, and C. for site A and C, the calculate Lee's path loss results yield better performance while site B for measured path loss yield better performance than the Lee's model.

However, the accuracy of any existing model will suffer when utilized in the surroundings or fields other than those they were designed for and then may be a need for some correction to obtain the accurate results in the particular environment mentioned where we have taken the field measurement.

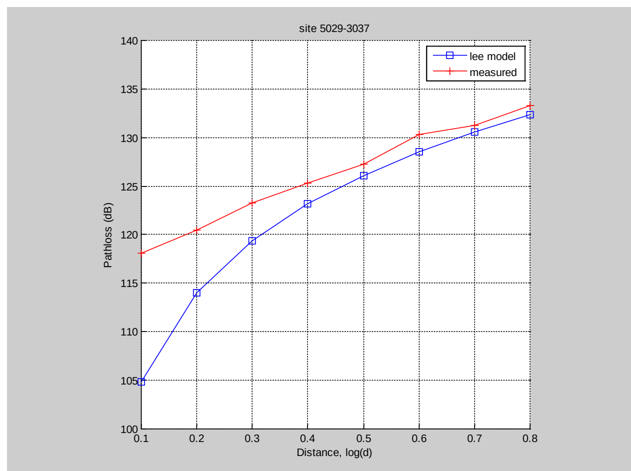
Distance (m)	Measured path loss (dB)	LEE'S Modeled path loss (dB)
100	100.11	105.00
200	105.11	114.11
300	110.11	119.00
400	115.11	123.50
500	117.11	126.5
600	120.11	128.11
700	122.11	131.11
800	123.11	133.00



The analysis of this site has presented in fig.2 reported the average calculated path loss to be 122.4 dB.

Distance	Measured path loss (dB)	LEE'S Modeled path loss (dB)
100	118.11	105.00
200	120.5	114.11
300	123.3	119.00
400	127.3	123.50
500	125.3	126.50
600	130.3	128.11
700	131.3	131.11
800	133.3	133.00

SITE ID	PATH LENGTH(M)	AVERAGE MEASURED PATH LOSS (dB)	AVERAGE CALCULATED PATH LOSS (dB)
3107-4887	800	124.9	122.4
3247-3997	800	114.1	122.4
5029-3037	800	126.4	122.4



5.0 CONCLUSION AND RECOMMENDATION

5.1 RECOMMENDATION

This paper dealt with the selection and modification of Path loss models for applicability in the less urban part of Lagos only, the result of this study can be used for interference estimation, optimization of the network and frequency assignment planning for new network or extension of existing network.

5.2 CONCLUSION

This paper has presented a propagation prediction for a less dense environment that is capable of predicting the field strength by using Lee's model. This paper has also examined one of the popular empirical path loss models for mobile communication. Lee's model was compared with measured path loss obtain from the field in a less dense urban area of Lagos state. It was found out from the MATLAB analysis that site 3107-4877 was the closest with an average measured and model path loss of 124.9dBm and 122.4dBm respectively. It involved the application of a modified and advanced model method enhancing better propagation which yields accurate results. This approach enhances the flexibility of the Lee's model based prediction to adapt to the terrain data base of the environment.

REFERENCES

1. O. Shoewu and F.O. Edeko, "Propagation Path Loss Determination in Cluster based GSM Base Stations in Lagos Environs" International Transaction of Electrical and Computer Engineers systems, Vol 2, No. 1, pg. 28 – 33, 2014
2. O. Shoewu and F.O. Edeko "Investigation of Radio wave Propagation Models in Nigerian urban and Suburban Areas" American Journal of Scientific and Industrial Research, Vol 2, No. 3, Sept. 2010
3. O. Shoewu and F.O. Edeko "Analysis of radio wave propagation in Lagos Environs" American Journal of Scientific and Industrial Research, Vol 2, No. 3, June 2011, pg. 438 – 455, 2011
4. D. Nalineswari and N,Rrakesh "Improving the Performance of Shadowing Effects in Urban Terrains Using Empirical Models" IEEE International conference on Signal processing, Communication and Networking, 2015
5. E.P. Ogherohwo, B. Barnabas and V.S. Yakubu "Seasonal Path Loss Measurement of GSM Network in Jos, Plateau State, Nigeria" International Journal of Electrical, Electronic, Computer Science and Engineering, Vol. 1, No. 3, pg. 16 – 25, 2015
6. S.I. Popoola and O.F. Oseni "Empirical Path Loss Models for GSM Netwrok Deployment in Markurdi, Nigeria. International referred Journal of Engineering and Science, Vol. 3, Issue 6, pg. 85 – 94, 2014
7. Manjish, Adhikari "A Survey and Review of GSM Base Transciever System, Installation, Architecture and Uplink/Downlink" Journal of the International association of Advanced Technology and Science, Vol. 16, 1015

Citation: O. Shoewu *et al.* (2017). Pathloss Modelling of less dense urban area in Lagos State using Lee Model, J. of Advancement in Engineering and Technology, V4I4.01. DOI: 10.5281/zenodo.918331