American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-4, Issue-4, pp-01-05
www.ajer.org
Research Paper Open Access

Evaluation for suitable propagation model to mobile Communications in South-South Nigeria urban-terrain

P. Akinyemi [1], S.O. Azi [1], J.S. Ojo [2], C.I. Abiodun [1]
[1]*Department of Physics, University of Benin, Benin City, Edo State.*
[2] *Departments of Physics, Federal University of Technology Akure, Ondo State.*

ABSTRACT: *One of the underlying difficulties with the application of a predicting path loss models for any environment is that no two areas are identical in the composition of the building and terrain. Many research activities, such as simulation and system design, need a model of the channel under study. This research attempts to investigate the most effective propagation model in South-South part of Nigeria. Two Global Systems for Mobile Communications (GSM) base stations operating at 900MHz and 1800MHz bands were used for the experiment in a typical urban area. The field measurement results were compared with S U I model, Ericsson model, Friis model and Walficsh-Bertoni model for urban area. The results obtained indicate the least variation with Walficsh-Bertoni model for urban area.*

KEY WORDS*: predicting path loss model, GSM, Field measurements, Walficsh-Bertoni.*

I. INTRODUCTION

In wireless communication, signal is transmitted by the transmitting antenna and received by receiving antenna any distortion in signal strength at receiver is known as path loss or Radio wave propagation Model or Radio Frequency Propagation Model. The propagation model is generally of three types. Empirical (statistical) model, Physical (deterministic) model and stochastic model. Empirical models are usually a set of equation derived from extensive field measurements. These models are simple and efficient to use. They are accurate for environments with the same characteristic as those where the measurements were made. One of the main draw backs of empirical model is that they cannot be used for different environment without modification. The deterministic model makes use of laws governing electromagnetic wave propagation to determine received signal power at a particular location. Stochastic model, on the other hand, model the environment as a series of random variable. Stochastic models are the least accurate but require the least information about the environment and use much less processing power to generate predictions. Each individual telecommunication link has to encounter different terrain, path, observation, atmospheric condition and other phenomena; it is intractable to formulate the exact loss for all environments. As a result, different models exist for different conditions. Correct prediction of path loss is a pivotal step of GSM network to estimate external interference level and cell radius accurately in network planning, particularly for conducting feasibility studies and during initial deployment studies to achieve perfect network planning.

II. LITERATURE REVIEW

Path loss is the reduction in power of an electromagnetic wave. Among numerous propagation models, the following are the most significant empirical models providing the foundation of mobile communication services.

1. FREE SPACE PROPAGATION MODEL

In radio wave propagation models, the free space model Predicts that received power decays as a function of T-R separation distance. The path loss for free space model when antenna gains are included is given by

$$PL\,(dB) = -G_t - G_r + 32.44 + 20\log(d) + 20\log(f) \quad (1)$$

Where

G_t is the transmitted antenna gain in dB
G_r is the received antenna gain in dB,
d is the T – R separation distance in kilometers and
f is the frequency (MHz)

2. The hata okumura model

The Hata-okumura model is an empirical formula for graphical path loss data provided by Yoshihisa Okumura, and is valid from 150 to 1500 MHz. The Hata model is a set of equations based on measurements and extrapolations from curves derived by Okumura. However, the model neglects terrain profile between transmitter and receiver, i.e. hills or other obstacles between transmitter and receiver are not considered. This is because both Hata and Okumura made the assumption that transmitter would normally be located or hills. The path loss in dB for the urban environment is given by

$$PL\ (dB) = A + B\ Log\ (d) \quad (2)$$

d is distance in kilometer

A represents a fixed loss that depends on frequency of the signal these parameters are given by the empirical formula.

$A = 69.55 + 26.16 \log (f) – 13.82 \log (h_b) – a\ (h_m)$
$B = 44.9.6.55\log (h_b)$

Where

f is frequency measured in MHz
h_b is height of the base station antenna in meters
h_m is mobile antenna height in meters and
$a(h_m)$ is connection factors in d

For effective mobile antenna height $a(h_m)$ is given by

$a(hm) = [\ 1.1\log (4) – 0.7]\ hm – [1.56\log(f) – 0.8]$

3. COST – 231 Hata Model

To extend Hata – Okumura – model for personal communication system (PCs) application operating at 1800 to 2000 MHz, the European Co-operative for scientific and Technical Research (COST) came up with COST-231 model. This model is derived from Hata model

$$P_L\ (dB) = 46.33 + 33.9\log (f) – 18.82\log (h_b) – a(h_m) + [44.9 – 6.55\log (h_b)] \log (d) \quad (3)$$

Where, $a(h_m) = [1.1\log(f) – 0.7)]\ h_m – [1.56\log(f) – 0.8]$

4. ECC – 33 Model

The ECC 33 path loss model, which is developed by Electronics Communication Committee (ECC), is extrapolated from the original measurements by Okumura and modified its assumptions so that it more closely represents a fixed wireless access (FWA) system.

The path loss model is defined as,

$$P_L\ (dB) = A_{fs} + A_{bm} – G_t – G_r \quad (4)$$

Where,

A_{fs} is free space attenuation,
A_{bm} is basic median path loss,
G_t is BS height gain factor and
G_r is received antenna height gain factor

5 Walficsh-Bertoni model

Considered the impact of the rooftops and building height by using diffraction to predict average signal strength at street level

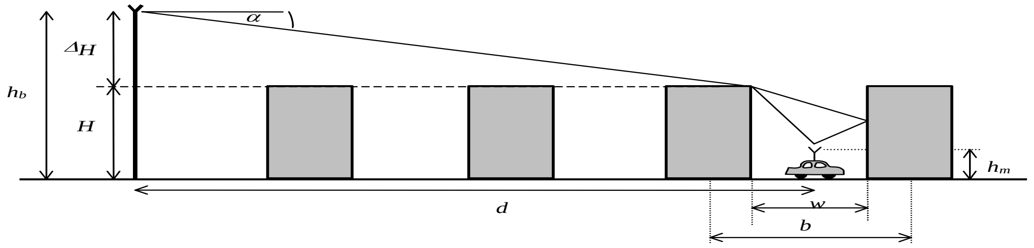

Fig.1: Propagation over rows of buildings from an elevated fixed antenna to a mobile at street level.

Path Gain

PG= $(PG_0)(PG_1)(PG_2)$ (5)

Free Space path gain

$$PG_0 = \left(\frac{\lambda}{4\pi R}\right)^2 \quad (6)$$

Reduction in the field at the roof top just before the mobile due to propagation past previous rows of buildings given by a factor Q

$$PG_1 = PL_{rooftops} = P(g)^2 = \left\{0.1\frac{\left[\sin\delta\sqrt{d/\lambda}\right]^{0.9}}{0.03}\right\}^2 \quad (7)$$

$$\sin\delta = \frac{h_T - H_B}{R}$$

$$PG_1 = PL_{rooftops} = 0.01\left(\frac{h_T - H_B}{0.03R}\right)^{1.8}\left(\frac{d}{\lambda}\right)^{0.9}$$

Diffraction of the roof top field down to the mobile (add ray power to get the small area average)

$$PG_2 = \left[\frac{1}{2\pi k\rho_1}\left(\frac{1}{|\theta_1|} - \frac{1}{2\pi - |\theta_1|}\right)^2 + \frac{|\Gamma|^2}{2\pi k\rho_2}\left(\frac{1}{|\theta_2|} - \frac{1}{2\pi - |\theta_2|}\right)^2\right]$$

(8)

$$pG_2 = \left(\frac{\lambda}{4\pi R}\right)^2 (Q^2)\left(\frac{\lambda\rho}{2\pi^2(H_B - h_m)^2}\right) = \left(\frac{\lambda}{4\pi R}\right)^2\left(0.01\left(\frac{h_{BS} - H_B}{0.03R}\right)^{1.8}\left(\frac{d}{\lambda}\right)^{0.9}\right)\left(\frac{\lambda\rho}{2\pi^2(H_B - h_m)^2}\right) \quad (9)$$

$$= \frac{5.51}{32\pi^4}\left(\frac{(h_{BS} - H_B)^{1.8}\rho d^{0.9}}{(H_B - h_m)^2}\right)\frac{\lambda^{2.1}}{R^{3.8}}$$

For $\mathcal{F}_M$ in MHz and $\mathcal{R}_k$ in km

$$PL_T = 89.5 - 9\log d - 10\log\left(\frac{\rho}{(H_B - h_m)^2}\right) - 18\log\left(h_{BS-H_B}\right) + 21\log\mathcal{F}_M + 38\log\mathcal{R}_k \quad (10)$$

III. MEASUREMENT PROCEDURE

A site verification exercise was done using testing tool (Ericsson k800i mobile station), calls were initiated at each test point until it established and the signal strength information sent over the air interface between the base station and the mobile station were read. For every site, received signal strength was measured at a reference distance of 200m from the base station and a subsequent interval of 200m up to 2000m in two GSM base stations in urban area of Benin, Edo State and Asaba, Delta State. The obtained values from field measurements are then compared with those calculated using the existing models. The essence of this is to investigate the degree of consistence of these existing models with field measurements.

Fig. 2: Image of the site used

Fig. 3: Log file showing the Rx-level distribution

Parameters	Values for Operator A	Values for Operator B
Base station transmitter power	40dBm	40 dBm
Base station antenna height	40m	42m
Mobile antenna height	1.2m	1.5m
Transmitter antenna gain	17.5 dBm	17.5 dBm
Frequency	900MHz	1800MHz
Feeder loss	2.52	2.58Db
Duplexer loss	4.5Db	4.75Db

Table 1: Simulation Parameter

Distances (Km)	Free Space model (dBm)	S U I model (dBm)	Cost 231 model (dBm)	Walfisch -Bertoni model (dBm)	Ericsson model (dBm)	Test Site (dBm)
0.2	77.56	85.74	104	96.90	116.57	98.38
0.4	83.57	99.63	114.36	108.35	125.70	108.29
0.6	87.1	107.75	120.42	115.04	131.05	114.86
0.8	89.6	113.52	124.72	119.79	134.84	120.22
1.0	91.53	117.99	128.05	123.48	137.80	123.79
1.2	93.12	121.65	130.78	126.49	140.19	126.95
1.4	94.5	124.74	133.08	129.05	142.22	128.97
1.6	95.62	127.41	135.68	131.26	143.98	133.90
1.8	96.64	127.41	136.84	133.21	145.54	136.73
2.0	97.56	131.88	138.41	135.00	146.93	139.30

Table 2: Path Loss Distribution Table for Operator A

Distances (Km)	Free Space model (dBm)	S U I model (dBm)	Cost 231 model (dBm)	Walfisch -Bertoni model (dBm)	Ericsson model (dBm)	Test Site (dBm)
0.2	83.58	92.42	113.27	102.37	120.66	104.94
0.4	89.60	106.23	123.58	113.82	129.80	114.30
0.6	93.12	114.30	129.62	120.51	135.14	120.83
0.8	95.62	120.03	133.90	125.26	138.94	126.01
1.0	97.56	124.47	137.22	128.95	141.88	129.80
1.2	99.14	128.10	139.93	131.96	144.28	134.56
1.4	100.48	131.17	142.23	134.51	146.31	137.13
1.6	101.64	133.83	144.22	136.73	148.08	142.32
1.8	102.66	136.18	146.00	138.68	149.63	147.46
2.0	103.58	138.27	147.54	140.43	151.02	150.24

Table 3: Path Loss Distribution Table for Operator B

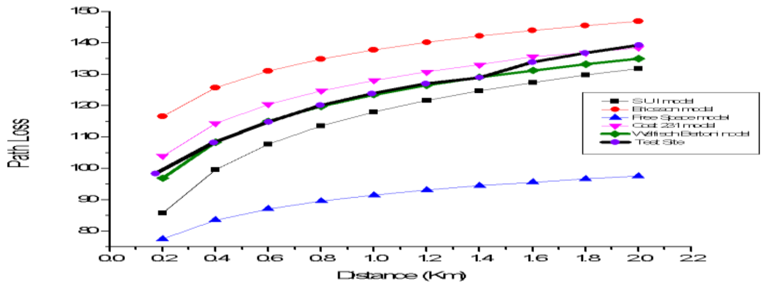

Fig. 4: Path loss Vs Distance Graph for Operator A

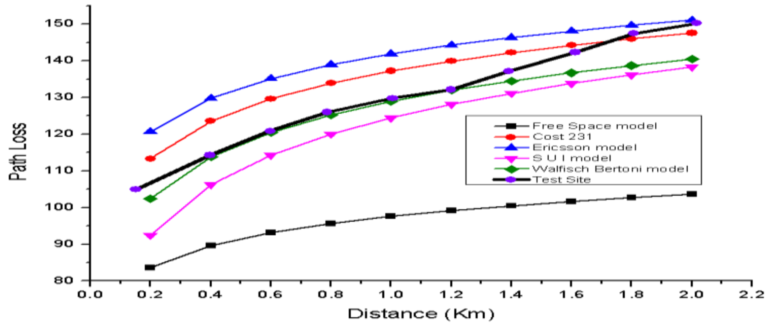

Fig. 5: Path loss Vs Distance Graph for Operator B

IV. CONCLUSION

In this paper, the measured path loss in two cells operating at 900MHz and 1800MHz are compared with theoretical path loss models: Hata, S U I, Ericsson, Cost 231, Free Space and walfish- Bertoni. The path loss distribution graph in Figure 1 and Figure 2 show the relationship that exists among the various propagation in terms of path loss. It can be seen that there are variations between field measurement results and the existing models. An exception is that of Walficsh-Bertoni model in which only a slight variation exists for distance up to 1.4km and 1.2km in operator A and B respectively. For other path loss model examined, there is an appreciable deviation from the measured results. This research thus shows that the Walficsh-Bertoni model for radio wave propagation is very effective for radio wave propagation path loss prediction in two states in South-South part of Nigeria.

REFERENCES

[1] Erceg, V. and Greenstein, L. J., (1999). An Empirically based path loss model for wireless channels in urban environments. IEEE Journal on Selected Areas of Communications, Vol. 17, pp 1205-1211.
[2] Parsons, J. D. (2000). The Mobile Radio Channel, Wiley and Sons, New York.
[3] Rahman, T.A and Ser, G.B; (2000). Propagation measurement in IMT-2000 Band in Malaysia, IEEE Vehicular Technology, Vol. 1, pp 77-81
[4] Raivio, K., and Laiho, J., (2001). Neural analysis of mobile radio access network. In proceeding of the International Conference on Data Mining (ICDM). PP 457-464
[5] Saunders, S. R and Belloul, B., (2002). Making Wireless Networks Deliver, Ingenia of the royal Academy of Engineering, Vol. 12 pp. 36-40.
[6] G. Mao, B. D. O. Anderson and B. Fidan, (2007) " Path Loss Exponent Estimation For Wireless Sensor Network Localization." Computer Network. Vol.51. Iss. 10, pp. 2467-2483.
[7] T.S. Rappaport, (2003) "Wireless Communication", Pearson Education.
[8] Emagbete, J.O and Edeko, F.O., (2009). Measurement Validation of the Hata-Like Models for Radio propagation path loss in Rural Environment at 1.8GHz. Journal of Mobile Communication 3(2), 17-21.
[9] ITU-R Rec.P.526-11, (2009). Propagation by Diffraction. ITU.
[10] Shoewu, O. and Adedipe, A., (2010). Investigation of Radio Waves Propagation Models in Nigeria Rural and Sub- Urban areas. American Journal of Scientific AND Industrial Research 1(2) pp. 227-322.