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Performance Analysis of Empirical Propagation models for WiMAX in Urban Environment

Sachin S. Kale[1], A.N. Jadhav[2]

[1] *Student, M.E. II, Department of Electronics & Telecommunication Engineering, D.Y. Patil College of Engineering & Technology, Kolhapur, Maharashtra, India.*

[2] *Department of Electronics & Telecommunication Engineering, D.Y. Patil College of Engineering & Technology, Kolhapur, Maharashtra, India.*

ABSTRACT: *This paper presents a simulation study of different path loss empirical propagation models with measured field data in urban environment. The results are different if they are used in different environment other than in which they were designed For comparative analysis we use the Free Space path Loss model, ECC-33/hata okumura extended Model, Cost 231 hata Model, Ericsson Model, Stanford University Interim (SUI) Model. The field measurement data is taken in urban (high density region), 3500 MHz frequency. After analyzing the results Ericsson model and SUI Model shows the better results in the urban environment.*
Keywords - *Hata Model, Okumura's Model, Path loss, Received signal strength, Stanford University Interim (SUI) Models*

I. INTRODUCTION

The path loss propagation models have been an active area of research in recent years Path loss arises when an electromagnetic wave propagates through space from transmitter to receiver. The power of signal is reduced due to path distance, reflection, diffraction, scattering, free-space loss and absorption by the objects of environment. It is also influenced by the different environment (i.e. urban, suburban and rural). Variations of transmitter and receiver antenna heights also produce losses. The losses present in a signal during propagation from base station to receiver may be classical and already exiting. General classification includes three forms of modeling to analyze these losses:

Path losses:

1. Empirical 2. Statistical 3. Deterministic

In the above models Deterministic models are better to find the propagation path losses, The Statistical models Uses Probability analysis by finding the probability density function. The empirical models uses with Field Measured Data obtained from results of several measurement efforts .this model also gives very accurate results but the main problem with this type of model is computational complexity. The field measurement data was taken in the urban environments.

II. PROPAGATION PATH LOSS MODELS

2.1 Free Space Path Loss Model (FSPL)

Path loss in free space *PLFSPL* defines how much strength of the signal is lost during propagation from transmitter to receiver. FSPL is diverse on frequency and distance. The calculation is done by using the following equation [1]:

$$PL_{FSPL} = 32.45 + 20 \log_{10}(d) + 20\log_{10}(f) \quad (1)$$

Where,
f: Frequency [MHz]
d: Distance between transmitter and receiver [m]
Power is usually expressed in decibels (dBm).

2.2 Stanford University Interim (SUI) Model

The proposed standards for the frequency bands below 11 GHz contain the channel models developed by Stanford University, namely the SUI models. Frequency band which is used is from 2.5 GHz to 2.7 GHz. Their applicability to the 3.5 GHz frequency band that is in use in the UK has so far not been clearly established [4]. The SUI models are divided into three types of terrains1, namely A, B and C. Type A is associated with maximum path loss and is appropriate for hilly terrain with moderate to heavy foliage densities. Type C is associated with minimum path loss and applies to flat terrain with light tree densities. Type B is characterized with either mostly flat terrains with moderate to heavy tree densities or hilly terrains with light tree densities. The basic path loss equation with correction factors is presented in [2, 3].

$$PL = A + 10\,\gamma\,\log_{10}(d/d_0) + X_f + X_h + S \qquad \text{for } d>d_0 \tag{2}$$

Where the parameters are, d: Distance between BS and receiving antenna [m], d0: 100 [m], λ: Wavelength [m], X_f: Correction for frequency above 2 GHz [MHz], X_h: Correction for receiving antenna height [m], s: Correction for shadowing [dB], γ: Path loss exponent. The random variables are taken through a statistical procedure as the path loss exponent γ and the weak fading standard deviation s is defined. The log normally distributed factor s, for shadow fading because of trees and other clutter on a propagations path and its value is between 8.2 dB and 10.6 dB[2].

The parameter A is defined as:

$$A = 20\log_{10}\left(\frac{4\Pi d_0}{\lambda}\right) \tag{3}$$

And the path loss exponent γ is given by:

$$\gamma = a - bh_b + \left(\frac{c}{h_b}\right) \tag{4}$$

Where, the parameter h_b is the base station antenna height in meters. This is between 10 m and 80 m. The constants a, b, and c depend upon the types of terrain, that are given in Table I. The value of parameter $\gamma = 2$ for free space propagation in an urban area, $3 < \gamma < 5$ for urban NLOS environment, and $\gamma > 5$ for indoor propagation.

Table I: The parameter values of different terrain for SUI model.

Model Parameter	Terrain A	Terrain B	Terrain C
a	4.6	4.0	3.6
$b\ (m^{-1})$	0.0075	0.0065	0.005
$c\ (m)$	12.6	17.1	20

The frequency correction factor Xf and the correction for receiver antenna height X_h for the models are expressed in [2, 4]:

$X_f = 6.0\log_{10}(f/2000)$ For Terrain type A & B

$X_h = -10.8\log_{10}(h_r/2000)$

$X_h = -20.0\log_{10}(h_r/20000)$ For Terrain type C (5)

Where, f is the operating frequency in MHz, and hr is the receiver antenna height in meter. For the above correction factors this model is extensively used for the path loss prediction of all three types of terrain in rural, urban and suburban environments.

2.3 COST 231 Extension to Hata Model

A model that is widely used for predicting path loss in mobile wireless system is the COST-231 Hata model [4, 7]. The COST-231 Hata model is designed to be used in the frequency band from 500 MHz to 2000 MHz. It also contains corrections for urban, suburban and rural (flat) environments. Although its frequency range is outside that of the measurements, its simplicity and the availability of correction factors has seen it widely used for path loss prediction at this frequency band. The basic equation for path loss in dB is [1],

$$PL=46.3+33.9\log_{10}(f)-13.82\log_{10}(h_b)-ah_m+(44.9-6.55\log_{10}(h_b))\log_{10}d+c_m \tag{6}$$

Where, f is the frequency in MHz, d is the distance between Rx and Tx antennas in km, and hb is the Tx antenna height above ground level in metres. The parameter cm is defined as 0 dB for suburban or open environments and 3 dB for urban environments. The parameter ah_m is defined for urban environments as [8].

$$ah_m = 3.20(\log_{10}(11.75hr))^2 - 4.97, \text{ for } f > 400 \text{ MHz} \tag{7}$$

For suburban or rural (flat) environments,

$$ah_m = (1.1\log_{10} f - 0.7)h_r - (1.56\log_{10} f - 0.8) \tag{8}$$

Where, *hr* is the CPE antenna height above ground level. Observation of above two equations reveals that the path loss exponent of the predictions made by COST-231 Hata model is given by,

$$ncost = (44.9 - 6.55\log10\ (hb\ ))/\ 10 \quad (9)$$

To evaluate the applicability of the COST-231 model for the 3.5 GHz band, the model predictions are compared against measurements for three different environments namely, rural (flat), suburban and urban.

2.4 ECC-33/hata okumura extended Model

The ECC 33 path loss model, which is developed by Electronic Communication Committee (ECC), is extrapolated from 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 [4],

$$PL\ (dB) = A_{fs} + A_{bm} - G_t - G_r \quad (10)$$

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. They are individually defined as,

$$A_{fs} = 92.4 + 20\log_{10}(d) + 20\log_{10}f$$
$$A_{bm} = 20.41 + 9.83\log_{10}(d) + 7.894\log_{10}(f) + 9.56[\log_{10}(f)]^2$$
$$G_t = \log(h_b/200)\ [13.98 + 5.8(\log(d))^2] \quad (11)$$

For medium city environments,

$$G_r = [42.57 + 13.7\log(f)]\ [\log(h_m) - 0.585] \quad (12)$$

The performance analysis is based on the calculation of received signal strength, path loss between the base station and mobile from the propagation model. The GSM based cellular d is distance between base station and mobile (km) h_b is BS antenna height in meters and h_m is mobile antenna height in meters.

2.5 Ericsson Model

To predict the path loss, the network planning engineers are used a software provided by Ericsson company is called Ericsson model [9]. This model also stands on the modified Okumura-Hata model to allow room for changing in parameters according to the propagation environment. Path loss according to this model is given by [9]:

$$PL = a_0 + a_1 \log_{10}(d) + a_2\log_{10}(h_b) + a_3\log_{10}(h_b)\log_{10}(d) - 3.2(\log_{10}(11.75h_r)^2) + g(f)$$

Where, *g(f)* is defined by[9]:

$$g(f) = 44.49\log_{10}(f) - 4.78(\log_{10}(f))^2 \quad (13)$$

And parameters

f: Frequency [MHz]

h_b: Transmission antenna height [m]

hr: Receiver antenna height [m]

The default values of these parameters (*a0, a1, a2 and a3*) for different terrain are given in Table II:

Table II: Values of Parameter for Ericsson model [9], [10].

Environment	a_0	a_1	a_2	a_3
Urban	36.2	30.2	12.0	0.1
Suburban	43.20*	68.93*	12.0	0.1
Rural	45.95*	100.6*	12.0	0.1

*The value of parameter a0 and a1 in suburban and rural area are based on the Least Square (LS) method in [10].

III. SIMULATION EXPERIMENTS

The comparative study of empirical propagation models the Free Space path Loss model, ECC-33/hata okumura extended Model, Cost 231 hata Model, Ericsson Model, Stanford University Interim (SUI) Model. The field measurement data is taken in urban (high density region), the performance of these propagation models against the issues are path loss (PL), distance between Tx & Rx and Rx height

Table III: Summary of WiMAX parameters and values

Parameter	Value
Base Station Tx Power	43dBm
Mobile Tx Power	30dBm
Tx Antenna height	30m
Rx Antenna height	3, 6,10m
Operating frequency	3.5GHz
Distance between Tx-Rx	5km

3.1 Comparison with Measurements

The following graphs represent the variation of path loss in with distance between transmitter and receiver Field measurement data which is taken in the urban (high density region means market area, Fig I shows graph showing plots for 3m receiver antenna height and Ericsson path loss model gives minimum Path loss among compared path loss models for specified conditions. Fig II and Fig III shows graph showing plots for 6m and 10m resp. receiver antenna height and SUI path loss model gives minimum path loss among Compared path loss models for specified conditions.

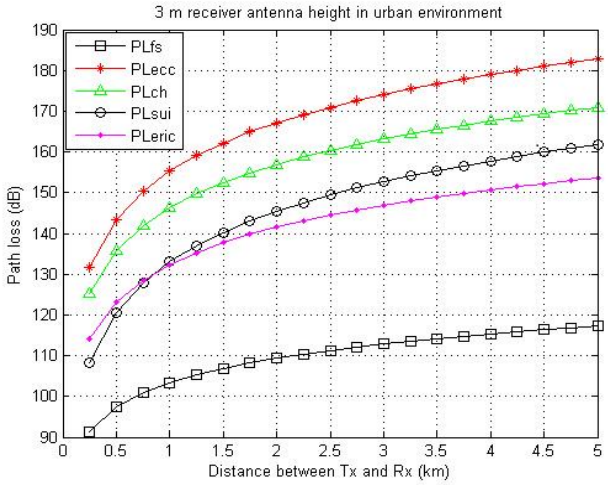

Fig. I: Path loss in urban environment at 3 m receiver antenna height.

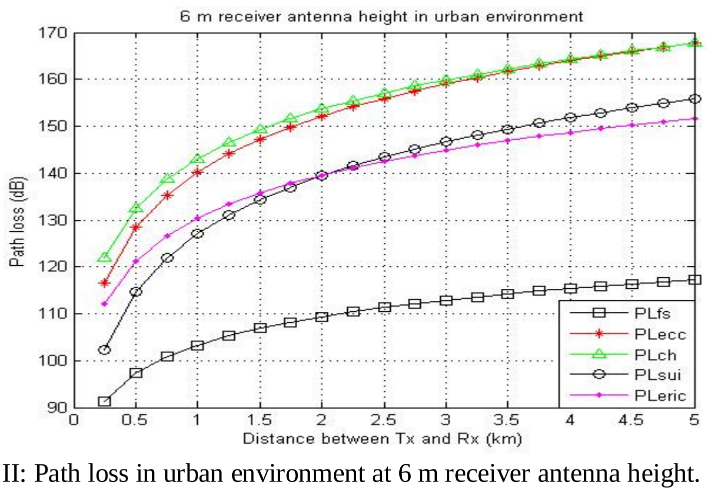

Fig II: Path loss in urban environment at 6 m receiver antenna height.

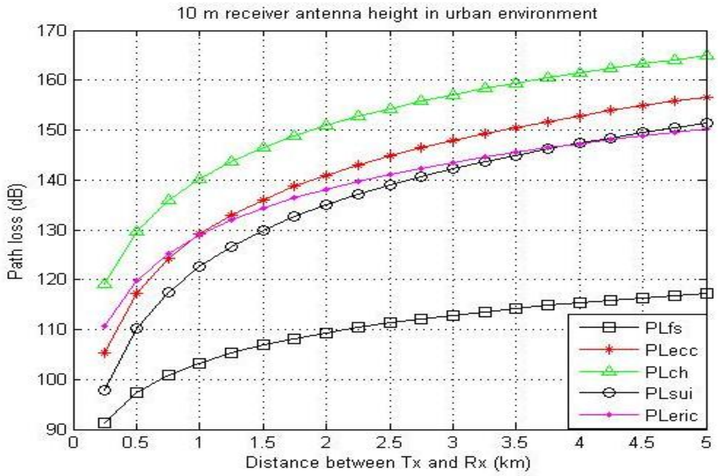

Fig III: Path loss in urban environment at 10 m receiver antenna height.

IV. CONCLUSION

Here we discussed different models and calculated path loss in three urban environment using MATLAB Software. The obtained path losses are graphically plotted for the better conclusion using the same software. By observing the graphical representation we concluded that ECC-33 and SUI models are giving the best results in urban are Okumara model is showing better results in urban environments.

REFERENCES

[1] T.S Rappaport, *Wireless communication* – Principles and practice, 2nd Edition, Prentice Hall, 2001.

[2] V.Erceg, K V S Hari, et al., "Channel models for fixed wireless applications," tech. rep., *IEEE 802.16 Broadband wireless access working group*, jan-2001

[3] V. Erceg, L. J. Greenstein, *et al.*, "An empirically based path loss model for wireless channels in suburban environments," *IEEE Journal on Selected Areas of Communications, vol. 17, pp. 1205–1211, July* 1999.

[4] V.S. Abhayawardhana, I.J. Wassell, D. Crosby, M.P. Sellars, M.G. Brown"Comparison of empirical propagation path loss models for fixed wireless access systems" *Vehicular Technology Conference, 2005. IEEE Date: 30 May-1 June 2005 Volume: 1, On page(s): 73-77 Vol. 1*

[5] T. Okumura, E. Ohmori, and K. Fukuda, "Field strength and its variability in VHF and UHF land mobile service," *Review Electrical Communication Laboratory, Vol. 16, No. 9-10, pp. 825–873*, Sept.-Oct. 1968.

[6] M. Hata, "Empirical formula for propagation loss in land mobile radio services," *IEEE Trans. Vehic. Technol., Vol VT-29, No. 3, pp. 317–325*, Aug. 1980.

[7] COST Action 231, "Digital mobile radio towards future generation systems, final report," tech. rep., *European Communities, EUR 18957*, 1999.

[8] H. R. Anderson, *Fixed Broadband Wireless System Design*. John Wiley & Co., 2003.

[9] Josip Milanovic, Rimac-Drlje S, Bejuk K, "Comparison of propagation model accuracy for WiMAX on 3.5GHz," *14th IEEE International conference on electronic circuits and systems*, Morocco, pp. 111-114. 2007.

[10] Simic I. lgor, Stanic I., and Zrnic B., "Minimax LS Algorithm for Automatic Propagation Model Tuning," *Proceeding of the 9th Telecommunications Forum (TELFOR 2001)*, Belgrade, Nov.2001.