© 2014 IJIRT | Volume 1 Issue 10 | ISSN: 2349-6002

Review of Path Loss models in different environments

Mandeep Kaur[1], Deepak Sharma[2]
[1]*Computer Scinece, Kurukshetra Institute of Technology and Management, Kurukshetra*
[2]*H.O.D. of CSE Deptt.*

***Abstract*— (WiMax) is a wireless broadband technology based on IEEE 802.16 standard. It offers fixed, nomadic, portable and mobile wireless broadband services. The Worldwide Interoperability of Microwave Access (WiMAX) technology becomes popular and receives growing acceptance as a Broadband Wireless Access (BWA) system. Path loss prediction models are essential tools in radio network planning for cellular transmission as they are used for received signal strength estimation, link budget design and analysis, cell size estimation, and interference optimization. Several models are available to estimate the path loss, such as: COST 231-Hata model, Hata model, Lee Model , Stanford University Interim model and Ericsson model.**

***Index Terms*- WiMax, PL,LOS,NLOS,BWA,OFDM and SUI.**

I. INTRODUCTION

World interoperability for microwave access (WiMax) is a wireless broadband technology based on IEEE 802.16 standard. This system is based on the Orthogonal Frequency Division Multiplexing (OFDM) and realized broadband data transmission by using a radio-frequency range of 2-11 GHz and 10-66 GHz. WiMax system is a telecommunication technology which enables wireless transmission of voice and data and provide wireless access in urban, suburban, and rural environments, and it has two potential access conditions; Line-of-Sight (LOS) condition, and Non-Line of Sight (NLOS) condition. There are two main classes of WiMax systems called fixed WiMax and mobile WiMax. Fixed WiMax is targeted for providing fixed and nomadic services, while mobile WiMax will also provide portable and mobile connectivity[1].

WiMax systems operating in the frequency range of 2-11 GHz are suitable for communication even in NLOS conditions, when direct visibility between the transmitting and receiving antenna does not exist [1]. To establish a WiMax network we have to face so many problems. Path loss calculation is one of the major factor that we have to estimate before installing the site.

Propagation models are used widely in network planning, mainly for conducting feasibility studies and during first deployment. Propagation models are used for calculation of electromagnetic field strength for the purpose of wireless network planning during preliminary deployment. It describes the signal attenuation from transmitter to receiver antenna as a function of distance, carrier frequency, antenna heights and other significant parameters like terrain profile (e.g. urban, suburban and rural). [2]

II. PATH LOSS

Path loss[3] ***(PL)*** is a measure of the average RF attenuation difference between transmitted signals when it arrives at the receiver, after traversing a path of several wavelengths. It is defined by

$$PL\ (db) = 10\ log \frac{P_t}{P_r} \qquad (1)$$

where P_t and P_r are the transmitted and received power. In free space, the power reaching the receiving antenna which is separated from the transmitting antenna by a distance d is given by the Friis free-space equation:

$$P_r = (d) \frac{P_t .G_t .G_r .\lambda^2}{(4\pi)^2 d^2 L} \qquad (2)$$

Where G_t and G_r, are gain of transmitting and receiving antenna, respectively. $\boldsymbol{L}$ is the system loss factor, not related to propagation. λ is the wavelength in meters.

III. PROPAGATION MECHANISM

There are some propagation mechanisms [3] that effect propagation. They are explained in this section.

- **Absorption**

Absorption is a loss that occurs if the signal passes through varying mediums or obstacles in which some of the transmitted signal is converted into another form of energy, usually thermal, and some of it continues to propagate. Any material or atmospheric condition that is non-transparent to electromagnetic signals will result in absorption of the transmitted signal. The conversion of energy occurs at the molecular level, resulting from the interaction of the energy of the radio wave and the material of the medium or obstacle.

- **Refraction**

Refraction occurs when a radio wave passes from one medium to another with different refractive indices resulting in a

change of velocity within an electromagnetic wave that results in a change of direction.

- **Reflection**

Reflection occurs when a propagating electromagnetic wave impinges upon an object that has very large dimensions compared to the wavelength of the propagating wave. Reflection occurs from the surface of the ground, from walls, and from furniture.

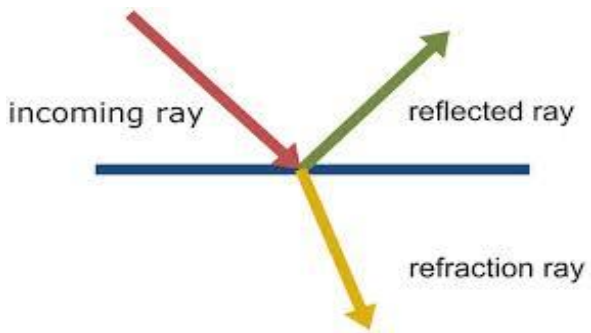

Fig.1. Reflection and Refraction

- **Diffraction**

Diffraction losses occur when there is an obstacle in the path of the radio wave transmission and the radio waves either bend around an object or spread as they pass through an opening. Diffraction can cause great levels of attenuation at high frequencies. However, at low frequencies, diffraction actually extends the range of the radio transmission.

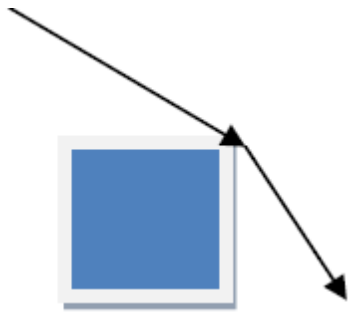

Fig.2.Diffraction

- **Scattering**

Scattering is a condition that occurs when a radio wave encounters small disturbances of a medium, which can alter the direction of the signal. Certain weather phenomena such as rain, snow, and hail can cause scattering of a transmitted radio wave. Scattering is difficult to predict because of the random nature of the medium or objects that cause it.

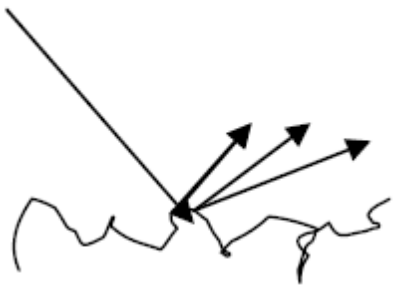

Fig.3.Scattering

IV. PATH LOSS MODELS

Path loss model describes the signal attenuation from transmitter to receiver antenna as a function of distance, carrier frequency, antenna heights and other significant parameters like terrain profile (urban, suburban and rural). In this section various path loss models are discussed.

1. COST 231 Hata Model

COST 231 project is the development of the outdoor propagation models for application in urban areas at higher frequencies. It has extended the earlier Hata-Okumura model to support frequencies ranging from 1500 MHz up to 2000 MHz . The main advantage is that it contains corrections for urban, suburban and rural (flat) environments.[2] Although the frequency ranges 2.5 GHz and 3.5 GHz is outside of its measurement range, its simplicity and correction factors still allowed to predict the path loss in this higher frequency range. The basic path loss equation for this COST-231 Hata Model can be expressed as [1,4]:

$$PL = 46.3 + 33.9\, log_{10}(f) - 13.82\, log_{10}(h_b) - ah_m + \left(44.9 - 6.55\, log_{10}(h_b)\right) log_{10}(d) + c_m \quad (3)$$

Where

d is the distance between transmitter and receiver (km)

f is the frequency (MHz)

h_b is the transmitter antenna height (m)

c_m the correction parameter has different values for different environments like 0 dB for suburban and open rural environments and 3 dB for urban areas

ah_m is defined in urban areas as

a$h_m = 3.20(log_{10}(11.75h_r))^2 - 4.79$,for f > 400 Mhz (4)

The value for ah_m in suburban and rural (flat) areas is given as:

$ah_m = (1.11\ log_{10}(f) - 0.7)h_r$ - $(1.5\ log_{10}(f) - 0.8)$ (5)

Where the $h_r$is the receiver antenna height in meter .

2. Stanford University Interim (SUI) Model

The 802.16 SUI is an empirical model recommended by 802.16 standardizing committee. The model is an extension of Hata model with correction for frequencies above 1900 MHz. The SUI model describes three types of terrain, they are terrain A, terrain B and terrain C. There is no affirmation about any particular environment. Terrain A can be used for hilly areas with sensible or very dense vegetation. This terrain presents the highest path loss. [2]The basic path loss expression of the SUI model with correction factors is presented as:

$$PL = A + 10\,\Upsilon\, log_{10}\left(\frac{d}{d_0}\right) + X_f + X_h + s \quad \text{,for d} > d_0 \qquad (6)$$

where
d is the distance between BS and receiving antenna (m)
d_0 is the reference distance 100 (m)
λ is the wavelength (m)
X_f is the frequency correction factor for frequency above 2 GHz
X_h is the correction factor for receiving antenna height (m)
S is the correction for shadowing (dB)
Υ is the path loss exponent
The random variables are taken through a statistical procedure as the path loss exponent Υ 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.
The parameter A is defined as [simulation]:

$$A = 20\ log_{10}(\frac{4\pi d_0}{\lambda}) \qquad (7)$$

and the path loss exponent Υ is given by

$$\Upsilon = a - b\ h_b + (\frac{c}{h_b}) \qquad (8)$$

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 1 [5].
The value of parameter $\Upsilon = 2$ for free space propagation in an urban area,$3 < \Upsilon < 5$ for urban NLOS environment, and $\Upsilon > 5$ for indoor propagation .

Table 1. 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	0.0050
C (m)	12.6	17.1	20.0
S	10.6	9.6	8.2

The frequency correction factor X_f and the correction for receiver antenna height X_h for the model are expressed in:

$$X_f = 6.0\ log_{10}\left(\frac{f}{2000}\right) \qquad (9)$$

For terrain type A and B

$$X_h = -10.8\ log_{10}(\frac{h_r}{2000}) \qquad (10.a)$$

for terrain type C

$$X_h = -20.0\ log_{10}(\frac{h_r}{2000}) \qquad (10.b)$$

Where
f is the operating frequency (MHz)
h_r is the receiver antenna height (m)

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.

3. Ericsson Model:

To predict the path loss, the network planning engineers are used a software provided by Ericsson company is called Ericsson model. 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 :

$$PL = a_0 + a_1\ log_{10}(d) + a_2\ log_{10}(h_b) + a_3 log_{10}(h_b) log_{10}(d) - g_1(h_r) + g_2(f) \qquad (11.a)$$

Where

$g_1(h_r) = 3.2(log_{10}(11.75h_r)^2)$ (11.b)

$g_2(f) = 44.49\ log_{10}(f) - 4.78(log_{10}(f))^2$ (11.c)

and parameters

f is the frequency (MHz)

h_b is the transmission antenna height (m)

h_r is the receiver antenna height (m)

The default values of the parameters (a_0 , a_1 , a_2 and a_3) for different terrain are given in Table 2 [simulation].

Table 2. Values of parameters for Ericsson model

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

4. Hata Propagation Model

The Hata model is an empirical formulation [7] of the graphical path-loss data provided by Okumura's model. The formula for the median path loss in urban areas is given by

$$PL = 69.55 + 26.16log_{10}(f_c) - 13.82log_{10}(h_b) - a(h_r) + \left(44.9 - 6.55log_{10}(h_b)\right)log_{10}(d) \quad (12)$$

Where

fc is the frequency (in MHz**),** which varies from 150 MHz to 1500MHz

h_b and h_r are the effective heights of the base station and the mobile antennas (in meters), respectively.

d is the distance from the base station to the mobile antenna,

$a(h_r)$ is the correction factor for the effective antenna height of the mobile unit, which is a function of the size of the area of coverage. For small- to medium-sized cities, the mobile-antenna correction factor is given by:

$$a(h_r) = (1.1log_{10}(f_c) - 0.7)h_r - (1.56log_{10}(f_c - 0.8) \quad (13)$$

path loss in suburban area

$$PL = PL(urban) - 2[log_{10}\left(\frac{f_c}{28}\right)]^2 - 5.4 \quad (15)$$

The path loss in open rural area as is expressed

$$PL = PL(urban) - 4.78(log_{10}(f_c))^2 - 18.33log_{10}(f_c) - 40.98 \quad (16)$$

These equation improved performance value of okumara model, this technique is good in urban and suburban area but in rural areas performance decreases because rural area prediction is depend on urban area . This model is quite suitable for large-cell mobile systems, but not for personal communications systems that cover a circular area of approximately 1 km in radius.

5. Lee Model

Lee's Model is used to predict the path loss in urban, suburban, rural and free space areas .

Scenario 1: Urban Path loss

PL = 123.77 + 30.5 log10 (d) +10 n log10 (f/900) - α0 (17)

Scenario 2: Suburban Path loss

PL = 99.86 +38.4 log10 (d) +10 n log10 (f/900) - α0 (18)

Scenario 3: Rural Path loss

PL = 86.12 +43.5 log10 (d) +10 n log10 (f/900) - α0 (19)

where n is an experiment value chosen to be 3 in our simulation, α0 is the correction factor which is given as follows:

α0 = α1 + α2 + α3 + α4 + α5

α1 = (hb/30.48) ^ 2

α2 = (hm/3) ^ k

α3 = (Pt/10) ^ 2

α4 = (Gb/4)

α5 = Gm

V. CONCLUSION

The major contribution of this work is the study of the different path loss model using MATLAB in order to evaluate the loss in signal strength in different environments. The system model has been developed to obtain numerical results.

FUTURE SCOPE

In the present work we have study the models in different environmnets. In next paper shown that which model gives the best result in different environment at different parameters. So that we can easily choose the model which is suitable for environment.

REFERENCES

[1] Nafaa M. Shebani, Abdulati E. Mohammed," Simulation and Analysis of Path Loss Models for WiMax Communication System " (2013).

[2] Gupreet Singh Bola, Gurpreet Singh Saini," Path Loss Measurement and Estimation Using Different Empirical Models For WiMax In Urban Area".(2013).

[3]Hemant kumar sharma, Sanjeev Sharma**,"** Survey of propagation Model in wireless Network" (2011).

[4]A.N. Jadhav, Sachin S. Kale," Suburban Area Path loss Propagation Prediction and Optimisation Using Hata Model at 2375MHz"(2014).

[5]Noman Shabbir, Muhammad T. Sadiq," Comparision of radio propagation models for long term evolution(LTE) network"(2011).

[6]B.O.H Akinwole, Esobinenwu C.S," Adjustment of Cost 231 Hata Path Model For Cellular Transmission in Rivers State "(2013).

[7]Hemant Kumar Sharma, Santosh Sahu,"Enhanced Cost231 W.I. Propagation Model in Wireless Network"(2011).

[8]Nakul R. Mehta,Prof. Rajesh Ishwar," Performance Evaluation and Analysis of Wi-MAX Technology and 802.16 OFDM Physical Layer (2014).