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RESEARCH ARTICLE

Design & Analysis of Propagation Models for WiMAX Communication System at 3.9 GHz

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ABSTRACT: Worldwide Interoperability for Microwave Access (WiMAX) is currently one of the hottest technologies in wireless; it's a standard-based on the IEEE 802.16 wireless technology that provides high throughput broadband connections over long distance. The Worldwide Interoperability of Microwave Access (WiMAX) technology becomes popular and receives growing acceptance as a Broadband Wireless Access (BWA) system. Estimation of path loss is very important in initial deployment of wireless network and cell planning. Before any transmission and receiving we have to be analyses the path loss and delay at the different frequency range in the different area. Numerous path loss (PL) models (e.g. Okumura Model, Hata Model) are available to predict the propagation loss, but they are inclined to be limited to the lower frequency bands (up to 2 GHz). In the paper we describe the different propagation models which are suitable for work with WIMAX i.e. (cost 231 HATA model, ECC 33 model, ERICSON model & cost 231 walfish-Ikegami model) in non-los environment. Our main concentration in this paper is to find out a suitable model for different environments to provide guidelines for cell planning of WiMAX at operating frequencies 3.9 GHz. There are few proposed models which focus on frequency range at 3.9 GHz out of which we base our analysis. In this paper, we compare and analyze path loss behavior of some proposed models at 3.9 GHz frequency band.

Keywords: WIMAX, Path loss, Propagation models, N-LOS

I. INTRODUCTION

The path loss propagation models have been an active area of research in recent years, In wireless communication systems, transfer of information between the transmitting antenna and the receiving antenna is achieved by means of electromagnetic waves. The interaction between the electromagnetic waves and the environment reduces the signal strength send from transmitter to receiver that causes path loss.

For wireless communication system, the system should have the ability to predict the accurateness of the radio propagation behavior. Thus it has become pivotal for such system design. The site measurements are expensive and costly. Propagation models have been developed as low cost, convenient alternative and suitable way. Different models are used to calculate the path loss.

Frequency band has a major consequence on the dimension and planning of the wireless network. The operator has to consider between the available frequency band and deploying area. To reach the optimal goal, we identified the following impairments of the transmission between transmitters to receiver.

1. Path loss
2. Co-channel and adjacent-channel interference
3. Fading
4. Doppler spread

Path loss (PL): Path loss occurs 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. In our paper we mainly focus on path loss issue. In general it is expressed as:

PL= *POWER TRANSMITTED / POWER RECEIVED* in dB.

Co-channel and adjacent-channel interference: Co-channel interference or crosstalk occurs when same frequency is used by two different transmitters. Adjacent-channel interference (ACI) arises when a signal gained redundant power in an adjacent channel. It is caused by many reasons like improper tuning, incomplete or inadequate filtering or low frequency.

Fading: Fading is a random process a signal may experience deviation of attenuation due to multipath propagation or shadowing in any obstacles in certain broadcast media.

Doppler spread: A mobile user causes a shift in the transmitted signal path by its velocity. This is known as Doppler shift. When signals travelled in different paths, thus may experience different Doppler shifts with different phase changes. Contributing a single fading channel with different Doppler shift is known as the Doppler spread.

II. TYPES OF PROPAGATION MODELS

It is necessary to estimate propagation characteristics of a system through a medium so that the signal parameters can be more accurate in mobile system. Propagation analysis is very important in evaluating the signal characteristics. For wireless communication system, the system should have the ability to predict the accurateness of the radio propagation behavior. Thus it has become pivotal for such system design. The site measurements are expensive and costly.

Propagation models have been developed as low cost, convenient alternative and suitable way. Channel modeling is essential for characterized the impulse response and to predict the path loss of a propagating channel. Path loss models are important to design base stations, that can be estimated us to radiate the transmitter for service of the certain region. Channel characterization deals with the fidelity of the received signal. The main thing of designing a receiver is to receive the transmitted signal that has been distorted due to the multipath and dispersion effects of the channel, and that will receive the transmitted signals. It is very important to have the knowledge about the electromagnetic environment where the system is operated, and the location of the transmitter and receiver.

Models for path loss can be categorized into three types

1. Empirical Models

2. Deterministic Models

3. Stochastic Models

1. Empirical Models: Sometimes it is impossible to explain a situation by a mathematical model. In that case, we use some data to predict the behavior approximately. By definition, an empirical model is based on data used to predict, not explain a system and are based on observations and measurements alone.

2. Deterministic Models: The modern systems of predicting radio signal coverage are Site Specific (SISP) propagation model and Graphical Information System (GIS) database. SISP model can be associated with indoor or outdoor propagation environment as a deterministic type. Wireless system designers are able to design actual presentation of buildings and terrain features by using the building databases.

3. Stochastic Models: This is used to model the environment as a series of random variables. Least information is required to draw this model but it accuracy is questionable. Prediction of propagation frequency band is mostly done by the use of both empirical and stochastic approaches.

III. PATH LOSS MODELS

In our paper, we describe different models which have been proposed by the researchers at the operating frequencies of 3.9 GHz. We also choose our parameters for best fitted to the Asian environments. In this chapter we consider free space path loss model which is most commonly used idealistic model. We take it as our reference model; so that it can be realized how much path loss occurred by the others proposed models.

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:

PL_{FSPL}= 32.45+20log(d)+20log(f) ….. (1)

Where,

d: Distance between transmitter and receiver in mts.

f: Frequency in MHz

2. ECC-33 Model

(Electronic Communication Committee**)** One of the most extensively used empirical propagation models is the Hata-Okumura model, which is based on the Okumura model. This model is a well-established model for the Ultra High Frequency (UHF) band. Recently, through the ITU-R Recommendation P.529, the International Telecommunication Union (ITU) encouraged this model for further extension up to 3.5 GHz. The original Okumura model does not provide any data greater than 3 GHz.

Based on prior knowledge of Okumura model, an extrapolated method is applied to predict the model for higher frequency greater than 3 GHz. The tentatively proposed propagation model of Hata-Okumura model with report is referred to as ECC-33 model. In this model path loss is given by:

$PL= A_{fs}+A_{bm}-G_b-G_r$ .... (2)

A_{fs}: Free space attenuation

$A_{bm:}$ Basic median path loss

G_b: Transmitter antenna height gain factor

G_r: Receiver antenna height gain factor

Above given factors can be separately described as:

$A_{fs}= 92.4+20\log_{10} (d) +20\log_{10} (f)$ … (3)

$A_{bm}=20.41+9.83\log_{10}(d)+7.894\log_{10}(f)+9.56[\log_{10}(f)]^2$ …….. (4)

$G_b=\log_{10} (h_b)\{13.953+5.8[\log_{10}(d)]^2\}$ …..(5)

When dealing with gain for medium cities, the Gr will be given as:

$G_r=[42.57+13.7\log_{10}(f)][\log_{10}(h_r)-0.585]$(6)

for large city G_r will be calculated as:

$G_r = 0.759\ h_r - 1.862$ ……………… (7)

Where,

d:Distance between Tx and Rx antenna [km]

f:Frequency [GHz]

hb: Transmitter antenna height [m]

hr: Receiver antenna height [m]

This model is the hierarchy of Okumura-Hata model. So the urban area is also subdivided into large city and medium sized city.

3. COST 231 Walfish-Ikegami (W-I) Model

(Co-operative for Scientific and Technical research**)**

This model is a combination of J. Walfish and F. Ikegami model. The COST 231(Co-operative for Scientific and Technical research) project further developed this model. Now it is known as a COST 231 Walfish-Ikegami (WI) model. This model is most suitable for flat suburban and urban areas that have uniform building height .Among other models like the Hata model, COST 231 W-I model gives a more precise path loss. This is as a result of the additional parameters introduced which characterized the different environments. It distinguishes different terrain with different proposed parameters. For LOS condition

PL_{LOS}= 42.6+20log(d)+20log(f) ………(8)

And for NLOS condition Path Loss will be given as:
$PL_{NLOS} = L_{FSL} + L_{rts} + L_{msd}$ ………… (9)
Where,
L_{FSL}= Free space loss
Lrts = Roof top to street diffraction
Lmsd = Multi-screen diffraction loss

4. 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:

$PL=a_0+a_1\log_{10}(d)+a_2\log_{10}(h_b)+a_3\log_{10}(h_b).\log_{10}-3.2(\log_{10}(11.57\ h_r)^2)+g(f)$....... (10)
Here,
$g(f)=44.49\log_{10}(f)+4.78(\log_{10}(f))^2$... (11)

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

Environment	a0	a1	a2	a3
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.

IV. METRICS OF THE PROPAGATION MODELS

In our computation the distance between transmitter antenna and receiver antenna is 5Km, transmitter antenna height is 30m and receiver antenna height is 10m. The path loss is observed at operating frequency 3.9 GHz for four propagation models in urban environment we exploited free space model as a reference model and NLOS condition in our comparisons. The following table 4.1 presents the parameters we applied in simulation.

Table 4.1: Simulation Parameters

Parameters	Values
Base station Tx power	43 dBm
Mobile transmitter power	30 dBm
Tx antenna height	30 m
Receiver antenna height	3,6&10m
Operating frequency	3.9 GHz
Distance between Tx-Rx	5 Km

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, graphs showing plots for 3m,6m,10m receiver antenna heights.

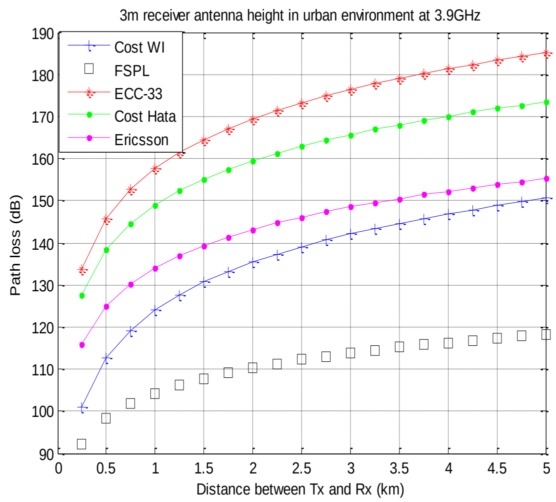

Fig. I: Path loss in urban environment at 3 m receiver antenna height at 3.9 GHz.

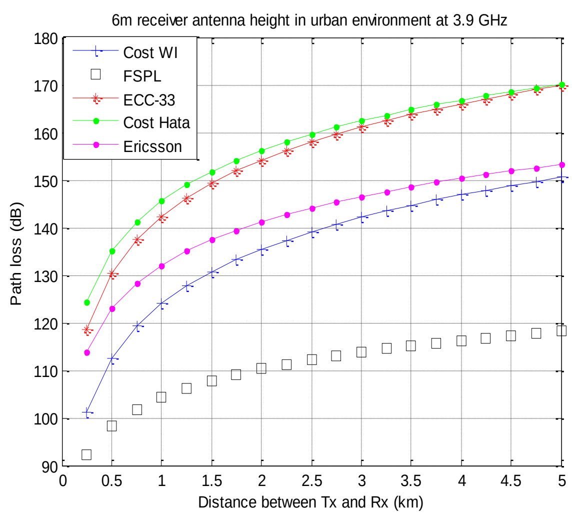

Fig. II: Path loss in urban environment at 6m receiver antenna height at 3.9 GHz

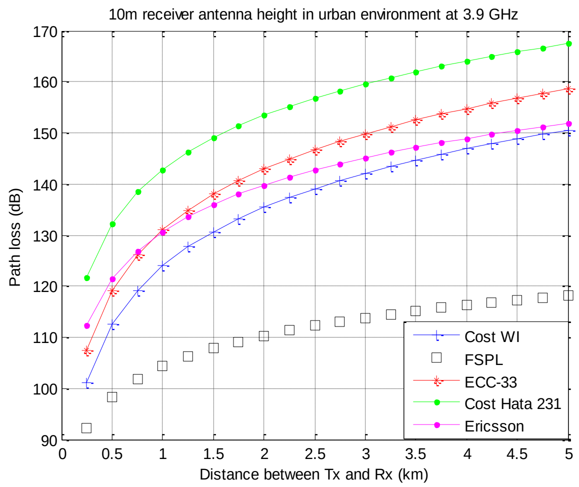

Fig. III: Path loss in urban environment at 10m receiver antenna height at 3.9 GHz

V. CONCLUSION & FUTURE WORK

Here we discussed different models and calculated path loss in three urban environment using MATLAB Software. By observing the graphical representation we concluded that ECC-33 model is giving the best results and Cost-WI model is giving less path loss but same result at different antenna heights in the urban areas. As the future works by selecting the different values of different parameters we will get better result.

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