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Propagation Model Analysis Of WiMAX Fixed Wireless Physical Layer Networks

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Abstract— **this work presents the analysis of WiMAX propagation model for wireless communication systems and allows us to estimate path loss on the channel. we developed a model using MATLAB® simulator and implemented it, which considers channel losses and reflects their effects on the physical layer. The implementation of the system involves different types of modulation techniques and coding rates defined in the IEEE 802.16 standard. The results of this model allows us to obtain the BER vs. Eb/No plots for different combinations of modulation types and coding rates as defined in the standard. The program allows us to calculate the path loss with increase in the distances between transmitter and receiver**

Keywords— ***WiMAX, IEEE 802.16, physical layer, BER, PATH LOSS***

I. INTRODUCTION

IEEE802.16 is a standard for Broadband Wireless Access (BWA) defined for Air Interface. It provides high data rates and high Quality Of Service(QOS) over large geographical areas. It has the maximum data rate of 70 Mbps and coverage area of 50 Km for fixed cases and varies from 5-15 Km for mobile cases.

The main objective of this paper is to analyse the performance of the WiMAX physical layer propogation model for different combinations of encoding techniques and modulation schemes. Several studies on IEEE 802.16-2009 standard is performed for obtaining the most stable propogation model. This paper focuses on study and analysis of WirelessMAN FIXED OFDM physical layer. Implementation of IEEE 802.16-2009 simulator was carried out based on the study made by Yon Soo Cho[4]. The propogation loss for different heights of transmitter and receiver antennas is calculated based on the same model.

II. KEY FEATURES OF IEEE 802.16-2009

In order to understand the fixed wireless physical layer design, it is important to describe the features of the main standard [5]

A. Modulation techniques

In IEEE 802.16-2009 standard, four modulation techniques is defined for fixed WiMAX model. BPSK, QPSK, 16QAM, 64QAM, where the information bits is equal to 1,2,4 and 6 respectively. The number of information bits are represented by 'M'

B. channel encoding

The channel encoding techniques used is Reed-Solomon (RS) and Convolutional encoding(CC). The channel encoder is formed by concatenation of RS encoder and Convolutional encoder. TABLE I. shows the combination of modulation schemes, coding rates of RS and CC encoders and the combined rates used in the design of wireless channel.

Modulation	**RS code**	**CC rate**	**Combined rate**
BPSK	(12,12,0)	1/2	1/2
QPSK	(32,24,4)	2/3	1/2
QPSK	(40,36,2)	5/6	3/4
16-QAM	(64,48,8)	2/3	1/2
16-QAM	(80,72,4)	5/6	3/4
64-QAM	(108,96,6)	3/4	2/3
64-QAM	(120,108,6)	5/6	3/4

C. OFDM signal parameters

The standard defines the elements that characterize the signal being sent through the wireless channel.

1. Primitive parameters definitions

parameters	***Description***
F_s	Sampling frequency
Tsam	Sampling time
N_{FFT}	Size of FFT
N_{used}	Number of subcarriers used
N_{cp}	Length of cyclic prefix
Tb	Useful symbol time
Tg	CP time
Δf	Subcarrier spacing
Tsym	OFDM symbol time
BW	Channel bandwidth
n	Sampling factor
CP	Cyclic prefix
G	Ratio of cyclic prefix(CP)

III. DESIGN

A. Propagation model

The proposed model is based on the study of Yon Soo Cho model. It is based on the studies of a log-normal channel measurement with shadowing, since three types of terrain is defined as shown in TABLE III.

TABLE III. TERRAIN TYPES

Type	Description
A	For hilly terrain with moderate-to-heavy obstacles Densities
B	For intermediate path loss conditions. Medium density of obstacles.
C	For flat terrain with light obstacles densities

To estimate the losses of the channel, it is necessary to calculate all the parameters described below.

1) *Correlation coefficient*

$$C_f = 6\log_{10}(fc/2000) \quad (1)$$

2) *Correlation coefficient for receiver*

$$C_{RX} = -10.8\log_{10}(h_{Rx}/2) \quad \text{for Type A and B} \quad (2)$$

$$C_{RX} = -20\log_{10}(h_{Rx}/2) \quad \text{for Type C} \quad (3)$$

3) *Terrain Factor*

The terrain factor in mathematical model is described as

$$\gamma = a - bh_{tx} + (c/h_{tx}) \quad (4)$$

4) *Modified reference*

$$d_0' = d_0 10^{-(Cf+CRX)/10\gamma} \quad (5)$$

By using (1), (2), (3), (4), and (5), we can calculate the propagation loss of the wireless channel as shown in (6) and (7).

$$PL[db] = 20\log_{10}(4\pi d/\lambda) \quad \text{for } d<=d_0' \quad (6)$$

$$PL[db] = 20\log_{10}(4\pi d/\lambda)+10\gamma(d/d_0)+C_f+C_{RX} \text{ for } d>d_0' \quad (7)$$

B. WiMAX transmitter

In Fig. 2, it is showed the block diagram of WiMAX transmitter, which is done in MATLAB® Simulink and is also programmed as established by the IEEE 802.16-2009 standard.

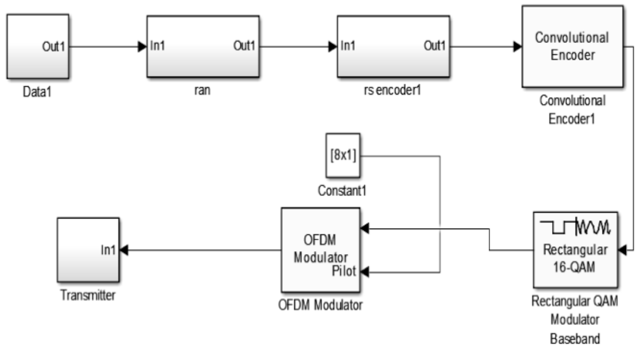

Fig. 1 WiMAX Transmitter

Channel coding is done by concatenation of Reed-Solomon and Convolution encoder followed by modulating using QAM and using OFDM modulation technique to transmit the signal through the transmitter.

C. Wireless Channel Implementation

In Fig. 2, the wireless channel implementation is shown, this helps in generating AWGN noise for each OFDM symbol

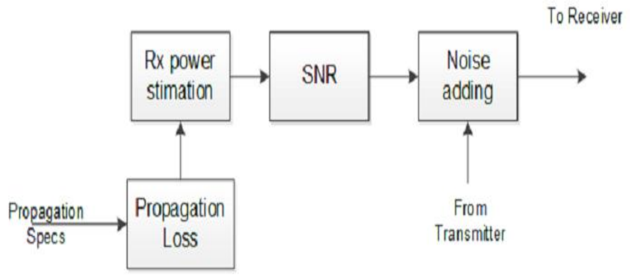

Fig. 2 Wireless channel

The Path loss, Received power and SNR are calculated based on the model proposed by Yon Soo Cho.

D. WiMAX receiver

Similar to that of the transmitter, WiMAX receiver is done using MATLAB® Simulink and model is prepared using the standard.

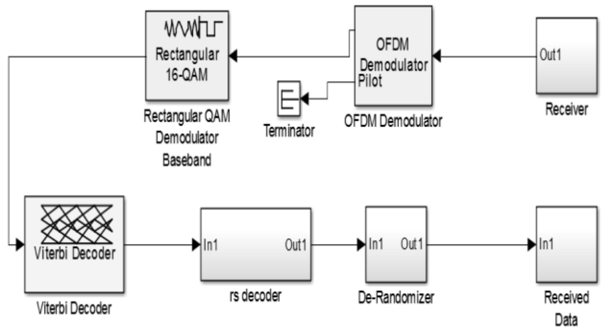

Fig. 3 WiMAX Receiver

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OFDM demodulation is done by removing cyclic prefix added at the transmitter followed by FFT and QAM demodulation. Viterbi decoder is used to decode the convolutional encoded signal and RS decoder is used followed by the De-randomizer to obtain the original signal.

IV. RESULTS

A. BER calculation

The Bit Error Rate is calculated by comparing the original signal with the received signal with the help of the Error Rate Calculation block in simulink for different SNR values the MATLAB programming is done to obtain the same as shown in the Fig. 4 and Fig. 4.

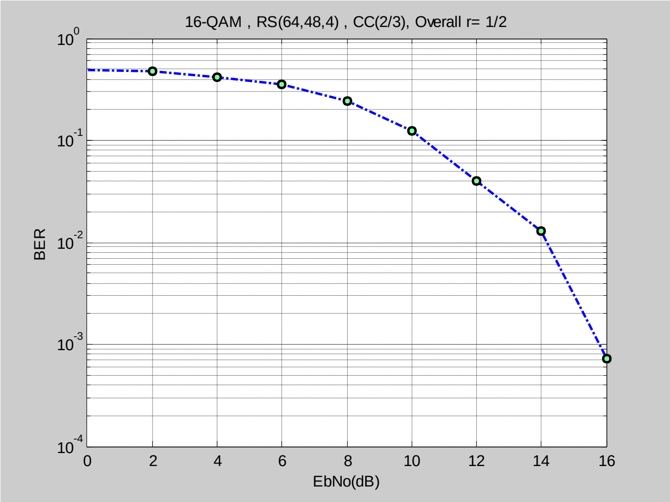

Fig. 4 BER Vs. Eb/No for r =1/2

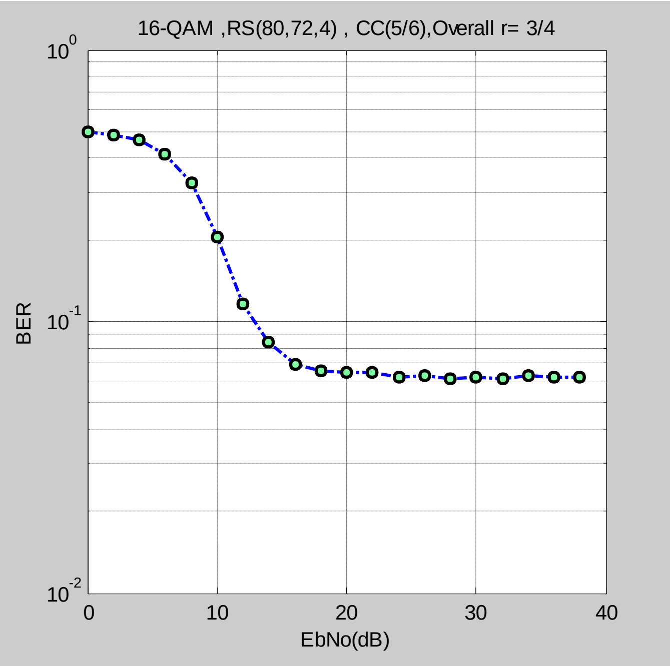

Fig. 5 BER Vs. Eb/No for r =3/4

B. Wireless channel losses

The path loss for sampling frequency of 3.5 GHz with transmitter height of 20m and receiver height of 10m with the most critical case of obstructions using the terrain A is shown in Fig. 6. The reference distance d0' is fixed as 100m for calculation of the new reference distance.

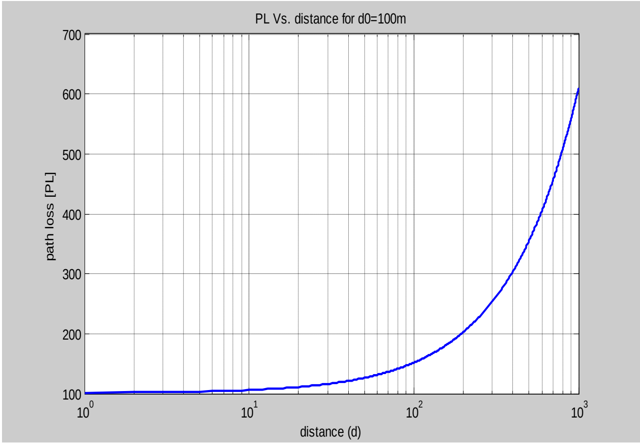

Fig. 6 PL Vs. distance(d)

C. Spectrum analysis

Fig. 7 shows the transmitted signal that is generated after OFDM modulation with FFT size of 256.

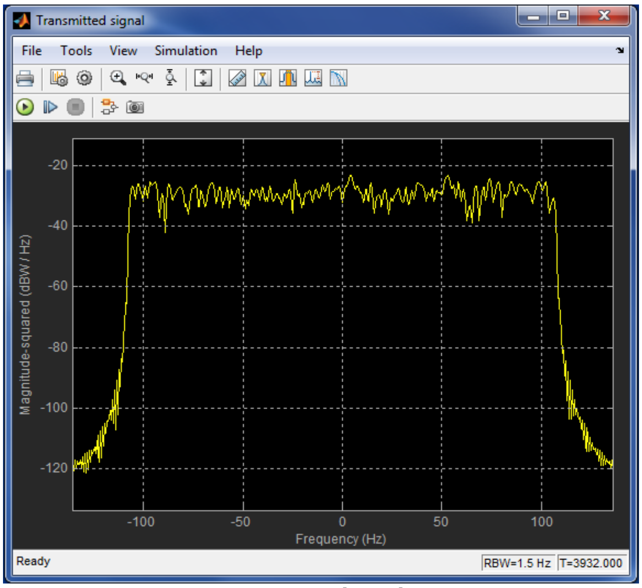

Fig. 7 Transmitted signal

This transmitted signal is sent through the channel for analysis of propagation loss and noise generated in the air interface

The path loss for distance of 5Km is calculated and the spectrum is shown in Fig. 8. It shows the predominant reduction in the magnitude level. The obtained signal is then

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transmitted through the AWGN channel to obtain the spectrum of the noise affected signal as shown in Fig. 9.

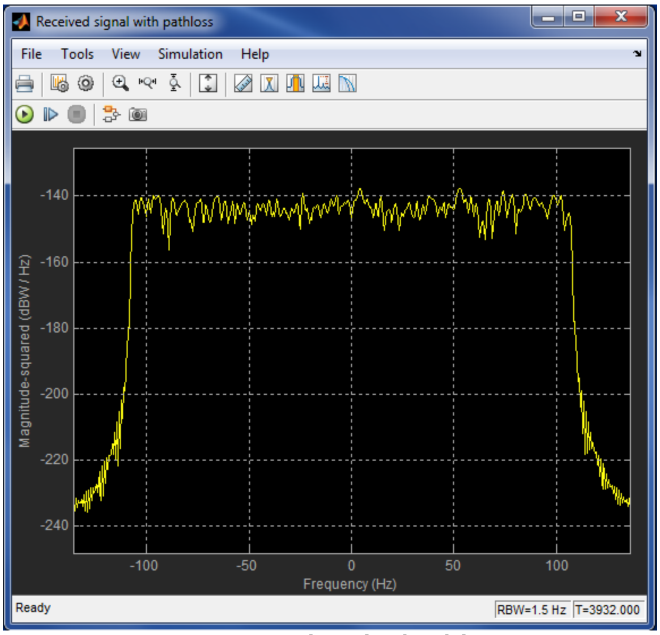

Fig. 8 Received signal with path loss

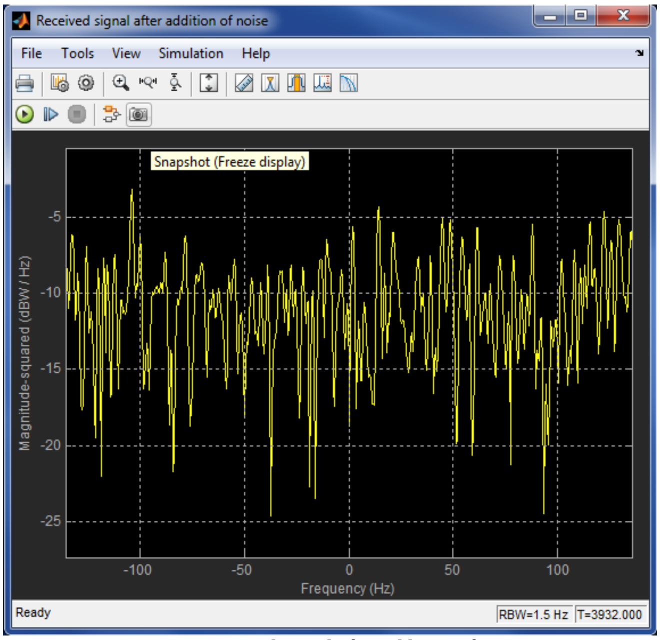

Fig. 9 Received signal after addition of noise

V. References

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