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Simulation of Wimax 802.16E Physical Layermodel

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Abstract: *The needs of high speed broadband wireless access at lower cost and easy deployment to meet the modern mobile services leads in the emergence of an another IEEE standard called Worldwide Interoperability for Microwave Access (WiMAX). The limitations of conventional Broadband wireless access have been overcomewith the scalable features of WiMAX. The main purpose of this paper is to evaluate, analyze and compare the performance of a WiMAX under different data rate and coding techniques. For this purpose a simulation model of WiMAX PHY layer transmitter and Receiver has been designed using MATLAB. The model was implemented at the Physical Layer using ConvolutionalEncoding Rate of 3/416-QAM modulations and transmitted with 256 OFDM symbols in both the AWGN and Rayleigh fading channels. In this thesis, the performance analysis is being done by studying the bit loss and Packet losses that occurred during transmission over channel. It is found that the performance of transmitted data not only depends on parameters like Signal to noise ratio (SNR) and Signal power but also on the effect of transmission channel.*
Keywords: *WiMAX-IEEE802.16,Physical Layer,QAM, SNR, Signal Power, Bit Loss, AWGN, Rayleigh*

I. Introduction

WiMAX, the IEEE 802.16e standard has brought a revolution in wireless broadband technology. Fixed Broadband Wireless Access (FBWA) systems that are capable to transmit higher data rates over larger geographical areas are not fulfilling the QOS needs. WiMAX is a substitute to wired DSL technology for last-mile solutions for providing backhaul services, thus increasing the data rate for large area. IEEE standard 802.16e provides fixed, nomadic,and mobile wireless broadband connectivity without the need for direct line-of-sight with the base station. This makes user to get all new and emerging services such as Video on Demand (VoD), Internet Protocol Television (IPTV) etc at the required place. This paper analyses the Bit Error Rate (BER) and throughput performance of WiMAX as a function of signal-to-noise-ratio (SNR) for AWGN and Rayleigh fading channel.The model implemented in this thesishas the following characteristics:

The paper is organized as follows: a description of WiMAX simulation model is described in section II and Section III presents the performance analysis in terms of BitLoss and SNR.

II. WiMAXPhysical Layer Simulation Model

The WiMAX simulator presented in this paper had been implemented in MATLAB. The functional stages had been mainly designed by using in MATLAB 2009b version. The WiMAX PHY layer model mainly consists ofthree major parts: Transmitter, Channel and Receiver as represented in figure 1 and characteristics of the WiMAX simulation model is shown in Table 1.

Table 1: Characteristics of WiMAX Simulation Model

Standard	802.16e
Data rate	18 Mbps or 36 Mbps
Carrier Frequency	10 GHz
Bandwidth size	1.5MHz to 20 MHz
Topology	Mesh
Modulation	16-QAM
Radio Technology	OFDM

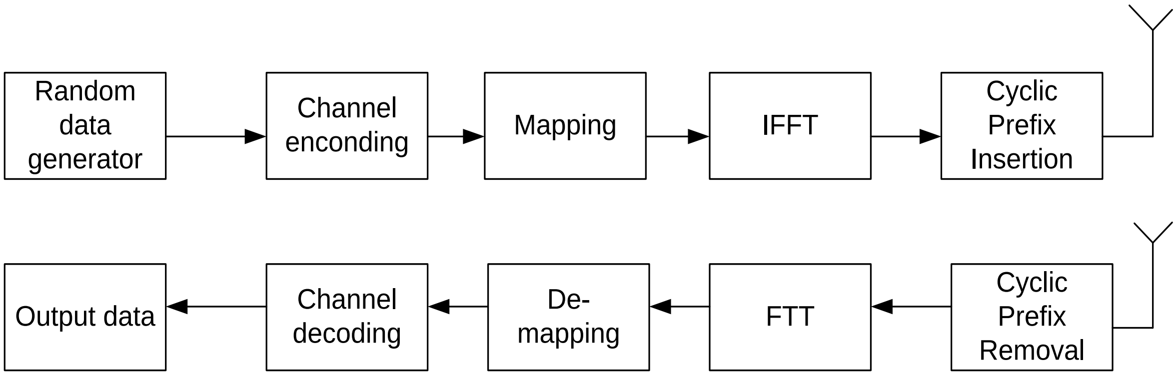
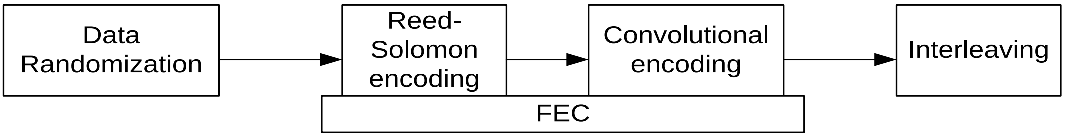


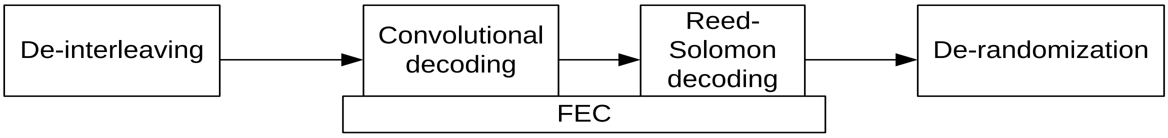
Fig 1: Simulation Setup

A. WiMAX Transmitter Section

The PHY layer transmitter section consists of Channel encoderand Modulator. Channel encoding stage includes Randomization, acombination of inner Reed Solomon code and outer convolutionalcode and puncturing to produce higher code rate as shown in figure 2. To reduce theimpact of burst error a block interleaver is used to interleavethe encoded bits onto separated subcarriers. The data is then modulated using 16-QAM modulation techniques, the modulateddata is mapped by segmenting the sequence of modulated symbolsinto a sequence of slots and then mapping these slots into a dataregion. After mapping the modulation symbols are assigned totheir corresponding logical subcarriers. The modulation parameters used are as in Table 2.



Channel Encoding Setup



Channel Decoding Setup

Fig. 2 : Channel Encoding and Decoding Setup

Table 2: Modulation Parameters

Modulation	Overall coding rate	RS code	CC code rate
16-QAM	¾	(80,72,4)	2/3

In WiMAX, each OFDM symbol consists of 256 subcarriers. Out of which 192 sub-carriers are used to convey data, 8 Pilot carriers,52 null subcarriers and a guard interval are also inserted at this point. The main purpose to use guard band to prevent Inter Symbol Interference (ISI). The OFDM parameters used are listed in Table 2. The final stage is to convert the data into a time-domain form for use by IFFT algorithm. The data is then transmitted throughchannel.

Table 2: OFDMSymbol Parameters

Parameters	Value
Nominal Channel Bandwidth, BW	10 MHz
Number of Used Subcarrier, N_{used}	200
Correction Factor, n	144/125
Ratio of Guard time to useful symbol time, G	1/16

N_{FFT}	256
Sampling Frequency, F_s	Floor(n.BW/8000) x 8000
Subcarrier Spacing, Δf	F_s/N_{FFT}
Useful Symbol Time, T_b	$1/\Delta f$
CP Time, T_g	$G.T_b$
OFDM Symbol Time, T_s	T_b+T_g

B. WiMAX Channel Section

The Stanford University Interim (SUI) channel model is used for our simulation to model our Rayleigh fading. In this model a set of sixchannels can be selected to address three different terrain types that are typical of the continental US [10]. This model can be used for simulations,design, development and testing of technologies suitable for fixed broadband wireless applications [9]. The parameters for the model were selected based upon some statistical models. The tables below depict the parametric view of the six SUI channels.

Table 3:Terrain type for SUI channel

Terrain Type	**SUI Channels**
C (Mostly flat terrain with light tree densities)	SUI-1,SUI-2
B (Hilly terrain with light tree density or flat terrain with moderate to heavy tree density)	SUI-3, SUI-4
A (Hilly terrain with moderate to heavy tree density)	SUI-5, SUI-6

C. WiMAX Receiver Section

At the Receiver section, the data received is first goes through PHY layer. In PHY layer the reveres process of transmitter occurs. The received data coming from channel is fed into the OFDM demodulation, which consist of removal of CP, Fast Fourier Transform (256 FFT) and disassemble OFDM frame. To convert received data from time domain to frequency domain, the FFT is used. It is needed because the decoding processes arework on frequency domain based signal. Guard band which is added at the transmitter side is also removed at this point. Then, the data is performed by de-mapper to convert the waveforms created at the modulation mapper to the original transformed bits and afterwards the demapped data enter the channel decoder. Channel decoder consists of de-interleaver, depuncture, Viterbi decoder and finally RS decoder. The deinterleaver consists of two blocks, a general block deinterleaver and a matrix deinterleaver. The general block deinterleaver rearranges the elements of its input according to an index vector. The matrix deinterleaver performs block deinterleaving by filling a matrix with the input symbols column by column, and then, sending its contents to the output row by row. Depuncturing the reverse process of puncturing. Zeros are used to fill the corresponding hollows of the stream in order to getthe same code rate as before performing the puncturing process. This depunctured bit stream is decoded by Viterbi algorithm and finally derandomized.

III. Results and Discussion

The test was carried out on the WiMAX Simulation model. Each block of the simulation model was tested by a test vector. These vectors were generated in MATLAB. The performance was evaluated by transmitting the output OFDM symbols through the AWGN and Rayleigh fading (modeled using SUI-1) channels. 50 samples of 16-QAM signals were transmitted in each case according to Modulation and OFDM parameters as listed in Tables 1 and 2. The performance is displayed in in terms of the Bit Loss versus SNR.

Figures 3 and 4 show the Bit Loss versus SNR at various constant signal power for 16QAMin AWGN and Rayleigh fading channels. It can be observed that the bit loss becomes zero at SNR =11dB, 13dB, 13dB,15dB and 15dB respectively at a constant signal power of 0.4, 0.6,0.8,1.0 and 1.2 watts in AWGN while in Rayleigh fading bit loss of zero was achieved at SNR=11dB, 13dB, 15dB,15dB and 15dB respectively at a constant signal power of 0.4, 0.6,0.8,1.0 and 1.2 watt. The Bit Loss at 0.4,0.6,1.0and 1.2 watt maintain almost the same SNR requirement for zero bit loss in Rayleigh channel as in AWGN channel except the bit loss at 0.8 watt which requires additional SNR of 2dB in Rayleigh channel.

Figures 5 and 6 represent the Bit Loss versus Signal Power at various SNR respectively in AWGN and Rayleigh channels. It was observed that for a fixed SNR the Bit Loss generally increases as the signal power increases. This is expected as the noise will increase correspondingly. However, in AWGN channel SNR=16dB achieves practically zero bit loss. For a range of signal power 0.4 watt to 1.2 watt. The SNR=14dB achieves zero bit loss in range of 0.4 watt to 0.8 watt only, while at SNR=12dB zero bit loss was possible only in the range of

0.4dB to 0.5dB. Zero bit loss was not possible for SNR=8dB and SNR=4dB at 0.4 watt. In Rayleigh channel zero bit loss was achievable for both SNR=14dB and SNR=16dB in the range up to 0.8 watts only. It is interesting to note also that SNR curves show increase in slope for SNR=12,14,16dB curvesbut decrease in slope for SNR=4 ,8dB curves all at signal power 0.8 wattwhether in the AWGN channel or Rayleigh channel.

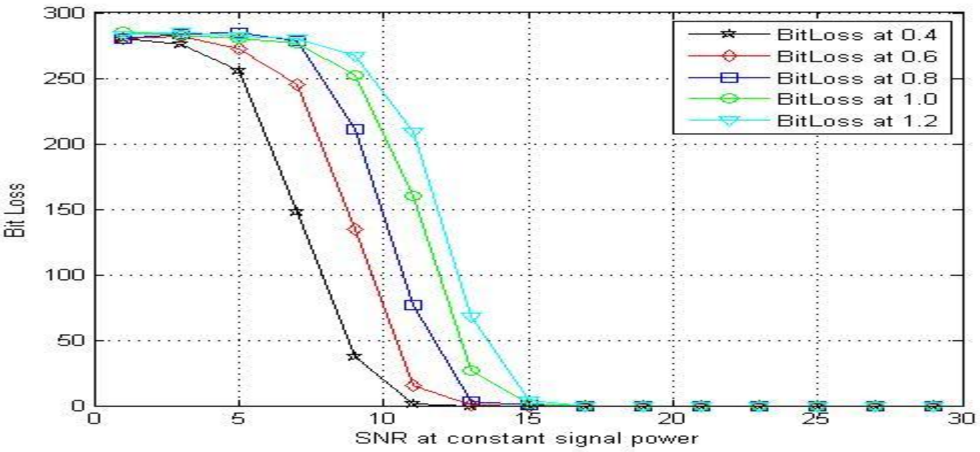


Fig. 3: Bit Loss versus SNR with 16QAM in AWGN channel

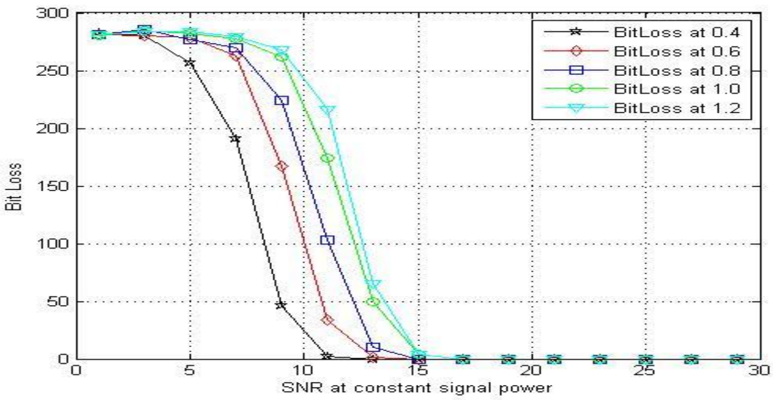


Fig. 4: Bit Loss versus SNR with 16QAM in Rayleigh fading channel

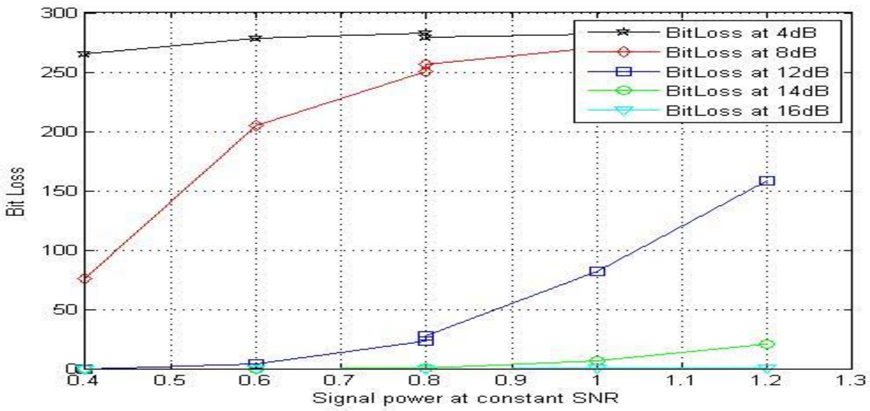


Fig. 5: Bit Loss versus Signal Power with 16-QAM in AWGN channel

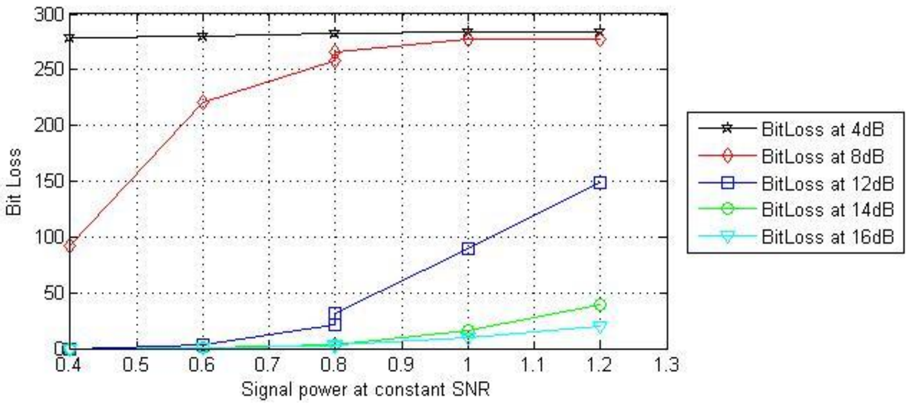


Fig. 6: Bit Loss versus Signal Power with 16-QAM in Rayleigh channel

IV. Conclusion

From the experimental results, figures and plots, it can be concluded that for a constant value of SNR, if we are decreasing the signal power then it implies that noise is also decreasing & therefore bit loss & packet losses are also reduced. These losses are almost zero for a very low value of signal power such as 0.4 watt & SNR greater than 15dB, but transmission will not be faithful practically with this much low power signals. Signal power at 0.8 watts appears to indicate a limit beyond which zero bit loss cannot be guaranteed. So we try to find the appropriate combination of SNR & signal power for which losses are zero & the packets are practically received with full authenticity. SNR =13dB & signal power = 0.6watt fulfill these needs, hence we can use this combination

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