Performance Analysis Of Wimax 802.16e Physical Layer Using Digital Modulation Techniques And Code Rates

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Abstract

WiMAX (Worldwide Interoperability for Microwave Access) is a new broadband wireless communication technologies that provide very high speed data over long distance and the core technique for fourth-generation (4G) wireless mobile communication. It is big advantage over other technology like free to use, high data rate, long range communication and cost effective. for these reasons, WiMAX has attracted so much interest from researchers in the past few years. WiMAX technology is actually based on the standards that making the possibility to delivery last mile broadband access as a substitute to conventional cable and DSL lines.

This paper mainly based WiMAX physical layer to understand the effect of various Modulation techniques, Coding rates, cyclic prefix factors and OFDM symbol on the system performance. Reed-Solomon encoding and convolution coding is used for improving system performance .Performance analysis of bit error rate vs. signal to noise ratio study the Bit Error Rate (BER) performance of this model.

Keywords- *Worldwide Interoperability for Microwaves Access (WiMAX), Orthogonal Frequency Division Multiplexing (OFDM), Physical Layer (PHY). Coding data rate, Additive White Gaussian Noise (AWGN), Bit Error Rate (BER), Interleaving, Modulation.*

I. INTRODUCTION

Worldwide Interoperability for Microwave Access (WiMAX) is currently one of the best technologies in wireless. The Institute of Electrical and Electronics Engineers (IEEE) 802 committee, which sets networking standards such as Ethernet (802.3) and Wi-Fi (802.11), has published a set of standards that define WiMAX. IEEE 802.16-2004 (also known as Revision D) was published in 2004 for fixed applications; 802.16 Revision E (which adds mobility) is publicized in July 2005. The WiMAX Forum is an industry body formed to promote the IEEE 802.16 standard and perform interoperability testing. The WiMAX Forum has adopted certain profiles based on the 802.16 standards for interoperability testing and "WiMAX certification". These operate in the 2.5GHz, 3.5GHz and 5.8GHz frequency bands, which typically are licensed by various government authorities. WiMAX, is based on an RF technology called Orthogonal Frequency Division Multiplexing (OFDM), which is a very effective means of transferring data when carriers of width of 5MHz or greater can be used. Below 5MHz carrier width, current CDMA based 3G systems is comparable to OFDM in terms of performance. WiMAX is a standard-based wireless technology that provides high throughput broadband connections over long distance. WiMAX can be used for a number of applications, including "last mile" broadband connections, hotspots and high-speed connectivity for business customers. It provides wireless metropolitan area network (MAN) connectivity at speeds up to 70 Mbps and the WiMAX base station on the average can cover between 5 to 10 km. In this paper a model implementation is MATLAB on which BER calculation for various digital modulation schemes like BPSK, QPSK, 8-QAM, and 16-PSK. The convolution coding and interleaving is applied to improve BER performance of signal is transmitted over the AWGN channel for various signal to noise ratio (SNR) value. To evaluate the performance, for each SNR level, the received signal was demodulation and the received data was compared to the original information. The result of the plot of the bit error rate versus signal to noise ratio which provide information about the systems performance. For the performance analysis of this network following parameters are chosen:

1) Various modulation techniques,
2) Various Coding rates,
3) Various cyclic prefix factors,
4) Various FFT sizes

Model for the system has been developed for various modulation schemes and different coding rates like BPSK ½ , QPSK ½ , QPSK ¾ , 16QAM ½, 16QAM ¾, 64QAM ½, 64QAM ¾. And simulated on MATLAB Simulink R2009. The Model itself consists of three main components namely Transmitter, Receiver and Channel. Transmitter and receiver have taken care of channel coding and modulation process, whereas channel is modelled as standard AWGN channel.

II. WiMAX SIMULATION MODEL

The WiMAX simulation presented in this paper had been implemented in MATLAB. The functional stages had been mainly design by using simulink in MATLAB 7.8.0 (R2009a) version, simulink 7 and communications block set 3 running on windows XP SP2.

Matlab simulink includes all the mandatory function blocks as specified by the standard documents. The WiMAX PHY in the transmitter, binary input data sequence is taken forward error correction (FEC), and interleaving is done to provide frequency diversity. The sequence is encoded by a convolution encoder. Then interleaving is applied to randomize the occurrence of bit errors pair to increase performance. After interleaving, the (0, 1) binary values are converted to symbol value, on which digital modulation scheme is applied. Previously, multi-carrier systems were implemented through the use of separate local oscillator. This was both inefficient and costly with the advent of cheap powerful processors; the sub-carriers can now be implemented by the FFT which keep tones to orthogonal with each other.

III. WIMAX PHYSICAL LAYER

The role of the PHY layer is to encode the binary digits that represent MAC frames into signals and to transmit and receive these signals across the communication media. The WiMAX PHY layer is based on OFDM; which is used to enable high-speed data, video, and multimedia communications and is used by a variety of commercial broadband systems. The PHY layer; shown in Fig.1, in WiMAX includes various functional stages: (i) forward error correction (FEC): including; randomizing, channel encoding, rate matching, interleaving, and symbol mapping; (ii) OFDM symbol in frequency domain, and (iii) conversion of the OFDM symbol from the frequency domain to the time domain .

B. Randomizer

Randomization process is used to minimize the possibility of transmissions of non–modulated subcarriers. The process of randomization is performed on each burst of data on the downlink and uplink. This is implemented with a Pseudo Random Binary Sequence (PRBS) generator which uses a 15-stage shift register with a generator polynomial of $1+ x^{14} + x^{15}$ with XOR gates in feedback configuration as shown in Fig.2.

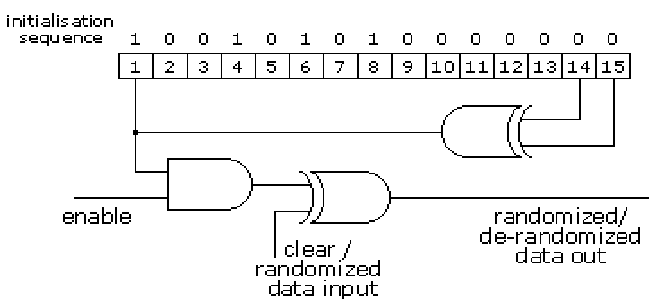

Fig 2: Randomizer

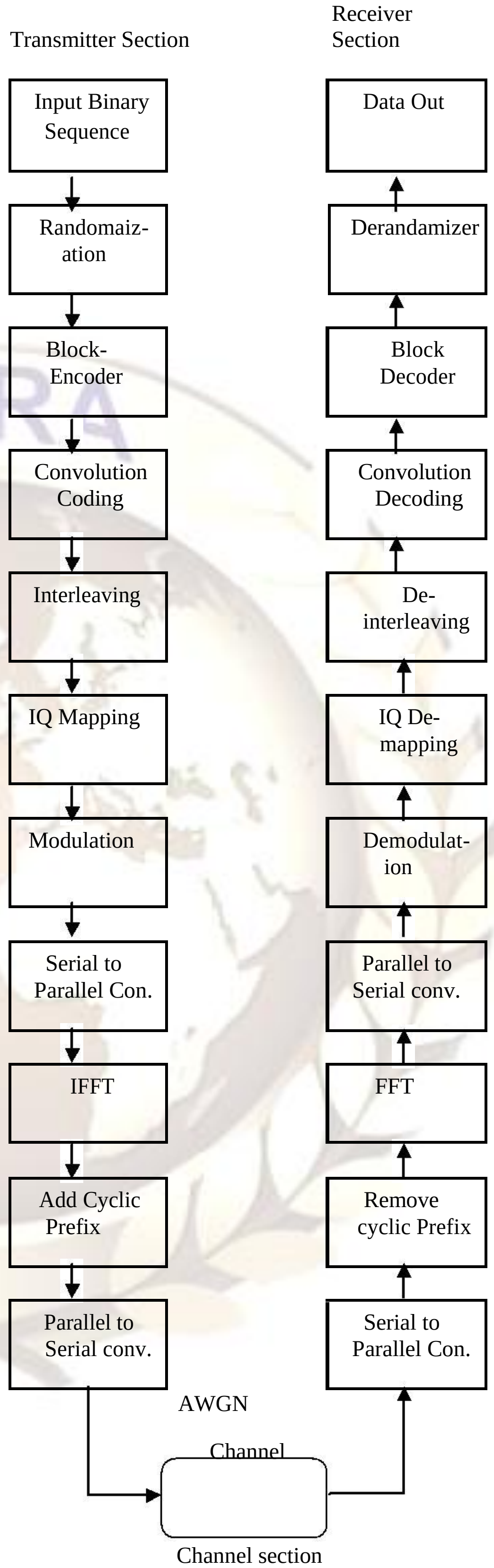

Fig 1: Block diagram of Wimax model

C. Reed-Solomon (RS) Encoder

The encoding process for RS encoder is based on Galois Field Computations to do the calculations of the redundant bits. Galois Field is widely used to represent data in error control coding and is denoted by GF .WIMAX uses a fixed RS Encoding technique based on GF(28) which is denoted as RS(N = 255, K =239, T = 8)

Where:

N = Number of Byte

K = Data Bytes

T = Number of bytes corrected

Eight tail bits are added to the data just before it is presented to the Reed Solomon Encoder stage. This stage requires two polynomials for its operation called code generator polynomial g(x) and field generator polynomial p(x). The code generator polynomial is used for generating the Galois Field Array whereas the field generator polynomial is used to calculate the redundant information bits which are appended at the start of the output data. These polynomials are defined by the standard as below:

Code Generator Polynomial:

p(x)=x^8+x^4+x^3+x^2+1

Field Generator Polynomial:

$g(x) = (x +\lambda.0) (x +\lambda.1) (x +\lambda.2) (x +\lambda.3)$

The properties of Reed-Solomon codes make them suitable to applications where errors occur in bursts. Reed-Solomon error correction is a coding scheme which works by first constructing a polynomial from the data symbols to be transmitted, and then sending an oversampled version of the polynomial instead of the original symbols themselves. A Reed-Solomon code is specified as RS (n, k ,t) with l-bit symbols. This means that the encoder takes k data symbols of l bits each and adds 2t parity symbols to construct an n- symbol codeword. Thus, n, k and t can be defined as: n: number of bytes after encoding; k: number of data bytes before encoding, and t: number of data bytes that can be corrected. The error correction ability of any RS code is determined by (n − k), the measure of redundancy in the block.

D. Convolution Encoder (CC)

After the RS encoding process, data bits are further encoded by a binary CC, which has a native rate of 1/2 and a constraint length of 7; Fig.3 The generator polynomials used to derive its two output code bits, denoted X and Y, are specified in the following expressions: *G1 = 171 OCT for X*, and *G2 = 133 OCT for Y.*

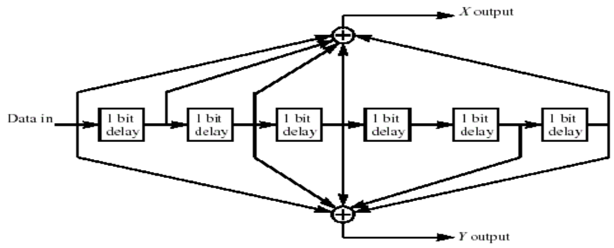

Fig 3: Convolution Encoder (CC)

E. Interleaving

Interleaving in its most basic form can be described as a randomizer but it is quite different from the randomizer in the sense that it does not change the state of the bits but it works on the position of bits. The block interleaver interleaves all encoded data bits with a block size corresponding to the number of coded bits per OFDM symbol. The number of coded bits depends on the modulation technique used in the physical layer. Wimax 802.16e supports 4 modulation techniques and is adaptive in the selection of a particular technique based on the channel condition and data rate. WiMAX 802.16e defines two permutations for the interleaver.

The first permutation is defined by the formula:

mk = (Ncbps/12) * mod(k,12) + floor(k/12).

The second permutation is defined by the formula:

S = ceil (Ncpc/2)

Jk = s × floor (mk/s) + (mk + Ncbps – floor (12×mk/Ncbps)) mod(s)

Where:

K = Index of coded bit before first permutation

mk = Index of coded bit after first permutation

jk = Index of coded bit after second permutation

Ncpc = Number of coded bits per carrier

Ncbps = Number of coded bits per symbol.

Index of bits represented by jk is used during the modulation process.

F. Adaptive Modulation

All wireless communication systems use a modulation scheme to map coded bits to a form that can be effectively transmitted over the communication channel. WiMAX supports a variety of modulation and coding schemes and allows for the scheme to change on a burst-by-burst basis per link, depending on channel and interference conditions.

G. OFDM Modulation

OFDM is a multicarrier modulation technique, which provides high bandwidth efficiency because the carriers are orthogonal to each other and multiple carriers share the data among themselves. The main advantage of this transmission Technique is their robustness to channel fading. The serial to parallel converter receive the *M* serial bits to

be transmitted, and those bits are divided into *sub* blocks of *mn* bits each sub block. Those *N* sub blocks will be mapped by the constellation modulator using Gray codification, this way *an* + *jbn* values are obtained nth constellation of the modulator. The modulation scheme converts input data into complex valued constellation points, according to a given constellation, 4-QAM, 16-QAM, and 32- QAM and so on. The Inverse Fast Fourier Transform (IFFT) transforms the signals from the frequency domain to the time domain. The cyclic prefix (CP) is a copy of the last *N* samples from the IFFT, which are placed at the beginning of the OFDM frame;
usually used to combat the inter-symbol interference (ISI) and inter-channel-interference (ICI) introduced by the multipath channel through which the signal is propagated.

Four different duration of cyclic prefix are available in the standard. Being G the ratio of CP time to OFDM symbol time, this ratio can be equal to 1/32, 1/6, 1/8 and 1/4 the receiver blocks are basically the inverse of the transmitter blocks. When communicating over a wireless radio channel the received signal cannot be simply modelled as a copy of the transmitted signal corrupted by noise. At the receiving side, a reverse process (including deinterleaving and decoding) is executed to obtain the original data bits. As the deinterleaving process only changes the order of received data, the error probability is intact. When passing through the CC decoder and the RS-decoder, some errors may be corrected, which results in lower error rates.

H. AWGN (Additive white Gaussian noise) Channel

The AWGN channel block adds white Gaussian noise to real or complex input signal. When the input signal is real, this block add real Gaussian noise and produces a real output signal. Additive white Gaussian noise is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral density (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The AWGN channel is a good model for many satellite and deep space communication links. If the average received power is P'[w] and the noise power spectral density is No [W/Hz], the AWGN channel capacity is following equation
Cawgn = W log2 (1+P'/NoW) bits/Hz
Where P'/NoW is received signal-to-noise ratio (SNR)

IV. SIMULATION RESULTS

The performance analysis of WiMAX 802.26e physical layer model, simulation is performed by considering the standard test vectors specified in the WIMAX standard. The following subsection presents the simulation results using the model in fig. 3, 4, 5, 6, 7, 8 and 9 for AWGN channel. BER Verses SNR. BER is the number of error bits occurs within one second in transmitted signal. BER define mathematically as follow.

$$BER = \frac{\text{Numbare of bit with error}}{\text{total number of bit transmitted}}$$

When the transmitter and receiver's medium are good in a particular time and Signal-to-Noise Ratio is high, and then Bit Error rate is very low. In our thesis simulation we generated random signal when noise occurs after that we got the value of Bit error rate.
SNR= Signal Power/Noise Power

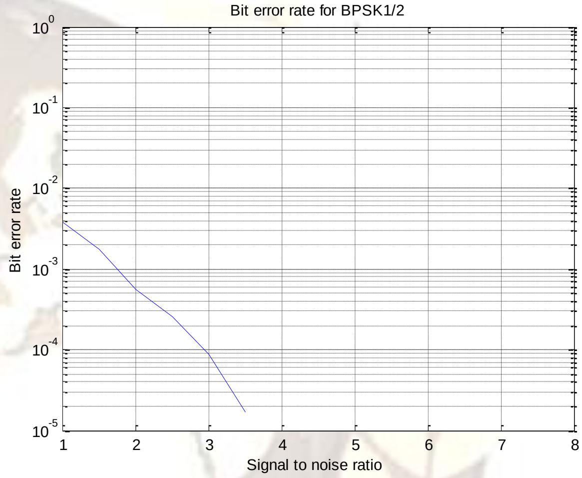

Fig.3. The BER results versus SNR using BPSK modulation schemes and ½ coding rates

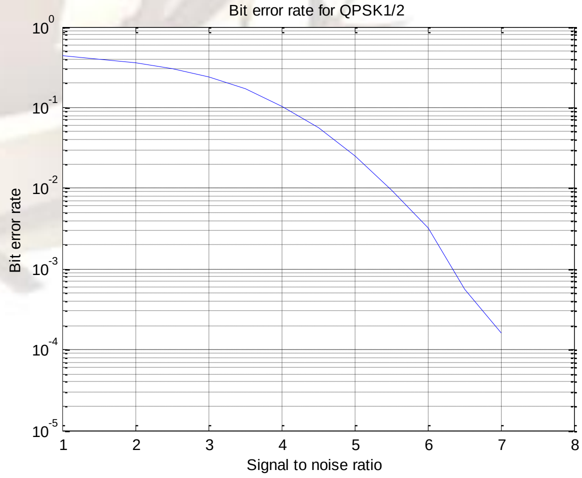

Fig. 4. The BER results versus SNR using QPSK modulation schemes and ½ coding rates

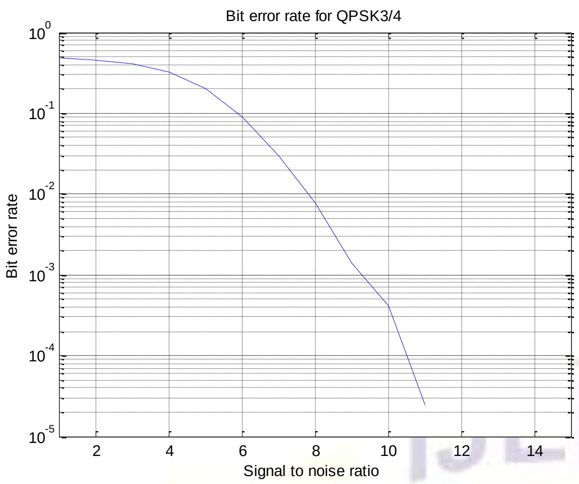

Fig. 5. The BER results versus SNR using QPSK modulation schemes and ¾ coding rates

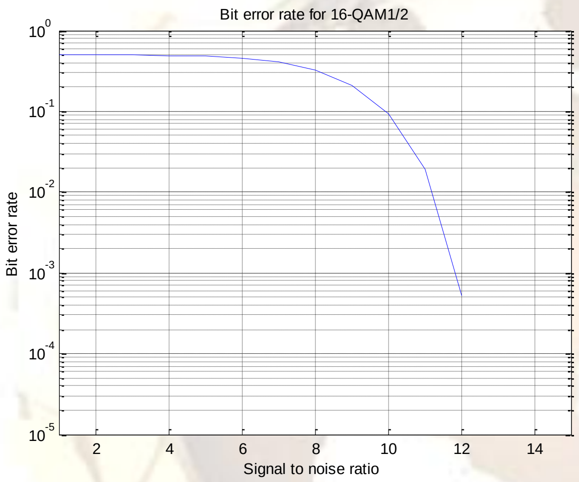

Fig. 6. The BER results versus SNR using 16-QAM modulation schemes and ½ coding rates

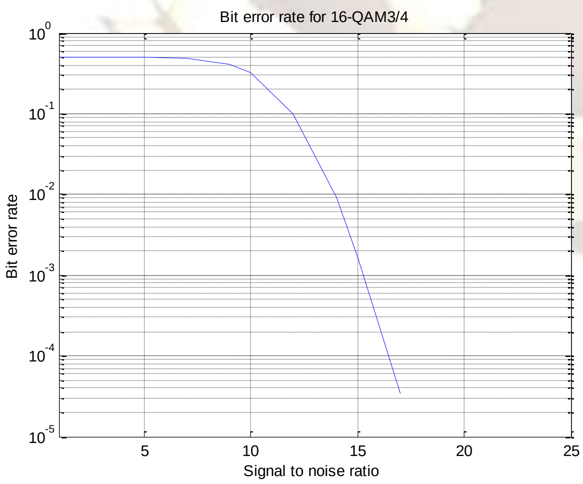

Fig. 7. The BER results versus SNR using 16-QAM modulation schemes and ¾ coding rates

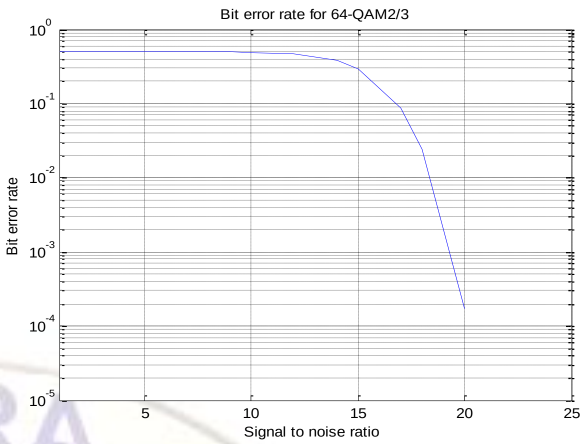

Fig.8. The BER results versus SNR using 64-QAM modulation schemes and 2/3 coding rates

Fig. 9. The BER results versus SNR using 64-QAM modulation schemes and ¾ coding rates

V. CONCLUSION AND FUTURE WORKS

In this paper, we have presented the WiMAX PHY layer model using simulink of the different modulation technique and coding rate gives an impression about the transmission power required for different modulation technique in the WiMAX system for BER of 10^-5 the BPSK 1/2system can be utilized after 3.49db SNR value. Where the QPSK 1/2 system can be used for SNR about 7db, the power increase of transmission by 3.51db .In QPSK ¾ the SNR 11.2db, 16-QAM ½ SNR 12db, 16-QAM ¾ SNR 17.46db, 64-QAM ¾ SNR value is 22.63db This analysis can be used further initial analysis of other modulation techniques, variable coding rate and different types of channel condition used . The results performance is displayed in the figure in terms of the BER versus E_s/N_o, db.

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