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Performance Evalution of WiMAxx OFDM System Over Multi Path Fading Channel

Karan Jeet Kaur
Department of ECE
PTU, Jalandhar
India
karanjit2009@gmail.com

Abstract **–** Wimax is a wireless technology which offers high data rate transmission in broadband. In this paper, the architecture of the Wimax physical layer simulator is presented. The main blocks are implemented with the aid of the Matlab and the bit error rate (BER) curves are presented in this paper are: the bit error rate (BER) versus the ratio of bit energy to noise power spectral density (Eb/No). The system parameters used in this paper are based on IEEE 802.16 standards. The simulation model built for this research work, demonstrates that Doppler shift 10 and QPSK modulation has better performance than other value Doppler shift and 8PSK modulation over the Rayleigh and Rician fading channels.

Keywords - Wimax , convolution coding(CC), Rayleigh channel., Rician channel

I. INTRODUCTION

Worldwide Interoperability for Microwave Access (Wimax) is an emerging global broadband wireless system based on IEEE 802.16 standard. Wimax is a new OFDM based technology and promises to combine high data rate services with wide area coverage[1,2] Wimax provides specifications for both fixed Line of sight (10-66GHz) 802.16c, and fixed, portable, Non- LOS communication (2-11GHz) 802.16a & 802.16d. In addition, Wimax defines wireless communication for mobiles, moving at a speed of 125 KMPH, in the range of 2-6 GHz[6,7].Wimax support both Time division duplex TDD and Frequency division duplex FDD. The basic two layers in Wimax are the MAC layer and the physical layers. The MAC layer supports Quality of service (QoS) ,adaptive modulation ,security and encryption[5] .Wimax 802.16 physical layer considers two types of transmission techniques OFDM /OFDMA orthogonal frequency division multiplexing /multiple access. Both of these techniques have frequency band below 11GHz and use TDD and FDD as its duplexing technology. The physical layer design to support Multiple – In Multiple-Out (MIMO) antennas in order to provide good NLOS characteristics. The MAC layer in turn provides a medium independent interface to the physical layer as the standard medium access.[3,4] Wimax standard only supplied for fixed and nomadic services. The Wimax technology have nomadic service in point-to point and point to multipoint connections.[8,9,10]. The implementation of OFDM physical layer is different for two types of Wimax. For fixed Wimax, FFT size is fixed for OFDM-PHY and it is 256 but for mobile Wimax, the FFT size for OFDMA-PHY can be 128, 512, 1024 and 2048 bits to support channel bandwidths of 1.25 MHz, 5 MHz, 10 MHz, and 20 MHz respectively.[11,12]. In such wireless systems involving slow time-frequency hopping, the frequency nonselective fading channel model seems to be feasible in real time .Typically, for such frequency nonselective channels, a viterbi decoder is selected usually to decode the information sequence at the receiver for better BER. Further, In order to reduce the inter-symbol interference (ISI) and inter-carrier interference (ICI) generated due to selective fading channels cyclic prefix (CP), is inserted to the beginning of OFDM symbol. This helps in improving the performance and simplification of receiver structure .[15 16]. BER performance of OFDM system in flat fading channel using BPSK modulation and in AWGN channel using different adaptive modulation techniques are studied.[16,17] In this paper performance of Wimax OFDM system is evaluated using MATLAB and BER is calculated for various digital modulation schemes like QPSK and 8-PSK . The convolution coding and interleaving is applied to improve BER performance of signal which is transmitted over the Rayleigh fading and Rician fading 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 was observed 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 Doppler shift

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II. WIMAX SIMULINK MODEL

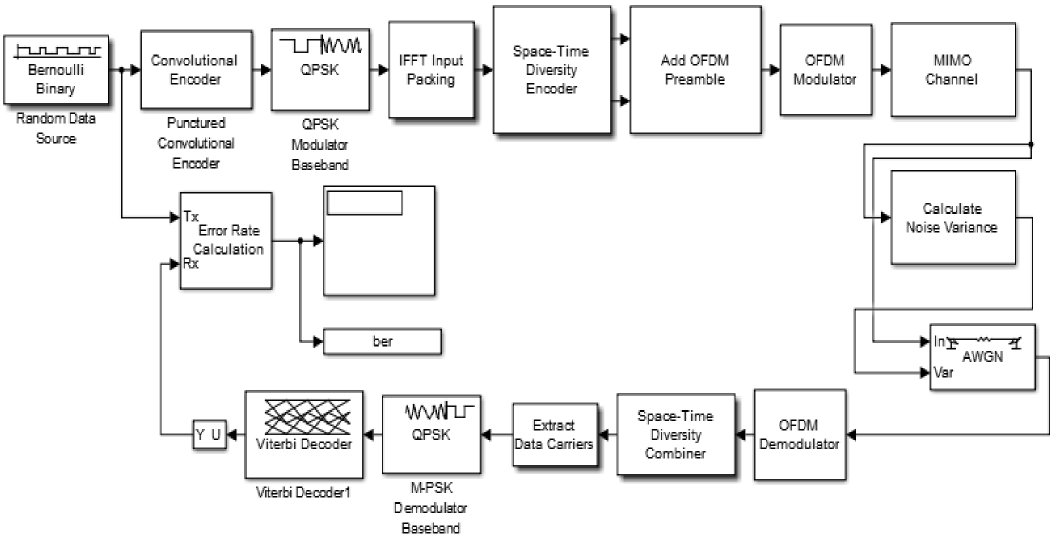

Figure1:Block Diagram Of Wimax Simulink Model

The transmitter and receiver sections of the Wimax Physical layer are shown in the block diagram of Figure-a. This structure corresponds to the physical layer of the Wimax air interface. In this setup, we have just implemented the mandatory features of the specification, while leaving the implementation of optional features for future work. The channel coding part is composed of coding techniques of the Convolution Code and space time diversity coding . The complementary operations are applied in the reverse order at channel decoding in the receiver end. We do not explain each block in details. Here we only give the emphasis on communication channel i.e Fading channels (Rayleigh and Rician) and space time diversity code and Convolution Code (CC) coding techniques.

A Convolution encoder consists of a shift register which provides temporary storage and a shifting operation for the input bits and exclusive-OR logic circuits which generate the coded output from the bits currently held in the shift register. In general, k data bits may be shifted into the register at once, and n code bits generated. In practice, it is often the case that k=1 and n=2, giving rise to a rate 1/2 code. space time coding involves the transmission of multiple copies of data .this helps to compensate for the channel problems such as fading and thermal noise. The space time encoder used Alamuti code which are simple space time block code . the Alamuti space time coding offers a simple method for achieving spatial diversity with two transmit antennas . Alamuti code used a matrix the each row of matrix represents a time slot and each column represent one antenna transmission. [14] Multipath fading results in fluctuations of the signal amplitude because of the addition of signals arriving with different phases. This phase difference is caused due to the fact that signals have traveled different distances by traveling along different paths. Because the phases of the arriving paths are changing rapidly, the received signal amplitude undergoes rapid fluctuation that is often modeled as a random variable with a particular distribution. The most commonly used distribution for multipath fast fading is the Rayleigh distribution, whose probability density function (pdf) is given by

$$f_{ray}(r) = \frac{r}{\sigma^2}\exp\left(-\frac{r^2}{2\sigma^2}\right), \quad r \geq 0$$

Here, it is assumed that all signals suffer nearly the same attenuation, but arrive with different phases. The random variable corresponding to the signal amplitude is r. Here σ2 is the variance of the in-phase and quadrature components. Theoretical considerations indicate that the sum of such signals will result in the amplitude having the Rayleigh distribution of the above equation . This is also supported by measurements at various frequencies. The phase of the complex envelope of the received signal is normally assumed to be uniformly distributed in [0,2π]. When strong LOS signal components also exist, the distribution is found to be Rician, the pdf of such function is

given by:

$$f_{ric}(r) = \frac{r}{\sigma^2}\exp\left(\frac{-\left(r^2+A^2\right)}{2\sigma^2}\right)I_0\left(\frac{Ar}{\sigma^2}\right), \quad r \geq 0, A \geq 0$$

Where σ2 is the variance of the in-phase and quadrature components. A is the amplitude of the signal of the dominant path and I0 is the zero-order modified Bessel function of the first kind. Normally the dominant path significantly reduces the depth of

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fading, and in terms of BER Ricean fading provides superior performance to Rayleigh fading. The probability of having line-of-sight (LOS) component depends on the size of the cell. The smaller the cell the higher the probability of having LOS path. If there is no dominant path then the Rician pdf reduces to Rayleigh pdf. When A is large compared with σ, the distribution is approximately Gaussian. Thus, since Rician distribution covers also Gaussian and Rayleigh distribution, mathematically the Rician fading channel can be considered to be general case.

The procedures that we have followed to develop the Wimax physical layer simulator is briefly stated as follows: At the transmission section:

At first we have generated a random data stream of length 378 bit as our input binary data using Matlab 14. Then randomization process has been carried out to using bernuoli theorem order to convert long sequences of 0's or 1's in a random sequence to improve the coding performance. Secondly we have performed 1/2 rated convolutional encoding . The encoding section was completed by interleaving the encoded data. Then various digital modulation techniques, as specified in Wimax Physical layer namely QPSK, and 8-PSK are used to modulate the encoded data. The modulated data in the frequency domain is then converted into time domain data by performing IFFT on it. For reducing inter-symbol interference (ISI) cyclic prefix has been added with the time domain data. Finally the modulated parallel data were converted into serial data stream and transmitted through different communication channels. Using Matlab BER TOOL using MONTE CARLO method .we have generated Rayleigh and Rician channels respectively.

III. Simulation Description And Result Discussion

A whole system model is implemented in MATLAB according to the above described system for different modulation techniques and Doppler Shift . The BER vs Eb/No is calculated. In table1(a)-1(b) it has been shown that different simulated modulation techniques such as QPSK and 8PSK show improved results at varied values of Eb/No over Rayleigh channel and Rician fading channel for different Doppler shift. In QPSK and 8PSK modulation the result upto 29 db Eb/No is obtained and it shows improvement in the Rayleigh fading channel and Rician fading channel with Doppler shift of 10,20,and 30 but in case of Rayleigh fading, Doppler shift of 10 gives best result as it has the lowest value of BER being 0.0020 and 0.0040 for QPSK and 8 PSK respectively and in case of Rician fading BER values being 0.0013 and 2.03E-4 at Doppler shift of 10 for QPSK and 8PSK respectively. it is also observed that with increase in Doppler shift the value of BER is constant as shown in fig 2(a)-2(f). It is also clear that OFDM with QPSK modulation technique shows better BER as compare to 8 PSK simulated modulation techniques over both the simulated channels.

Table1(a): Rayleigh fading channel with OFDM+QPSK & OFDM+8PSK modulation for different values of Doppler Shift

Sr. No	Eb/No	Rayleigh fading channel with OFDM+ QPSK modulation			Rayleigh Fading channel with OFDM+8 PSK modulation		
		BER with Doppler Shift10	BER with Doppler Shift20	BER with Doppler Shift30	BER with Doppler Shift10	BER with Doppler Shift20	BER with Doppler Shift30
1	1	0.4523	0.4417	0.5105	0.5368	0.5403	0.4456
2	5	0.0811	0.2235	0.3201	0.3315	0.4	0.3982
3	9	0.0032	0.0363	0.0667	0.0649	0.0964	0.2736
4	13	0.0020	0.0160	0.0899	0.0086	0.0465	0.2114
5	17	0.0015	0.0141	0.0798	0.0050	0.0292	0.1605
6	21	0.0017	0.0131	0.0857	0.0037	0.0231	0.1122
7	25	0.0021	0.0046	0.0867	0.0040	0.0218	0.1043
8	29	0.0020	0.0109	0.0777	0.0040	0.0147	0.1192

Table1(a): Rician fading channel with OFDM+QPSK and OFDM+8PSK modulation for different values of Doppler Shift

Sr.No	Eb/No	Rician fading with OFDM+8PSK modulation			Rician fading with OFDM+QPSK modulation		
		BER with Doppler Shift 10	BER with Doppler Shift 20	BER with Doppler Shift30	BER with Doppler shift 10	BER with Doppler Shift 20	BER with Doppler Shift 30
1	1	0.5087	0.4982	0.5228	0.4312	0.4523	0.3994
2	5	0.4105	0.4684	0.3614	0.0696	0.1128	0.3095
3	9	0.0365	0.1532	0.2631	3.92E-4	0.0060	0.0426
4	13	0.0015	0.0513	0.2052	1.76E-4	0.0037	0.0329
5	17	0.0016	0.0030	0.1359	1.76E-4	0.0056	0.0061
6	21	0.0013	0.0052	0.0964	1.67E-4	0.0044	0.0060
7	25	0.0013	0.0057	0.1359	1.94E-4	0.0037	0.0098
8	29	0.0013	0.0050	0.1201	2.03E-4	0.0037	0.0094

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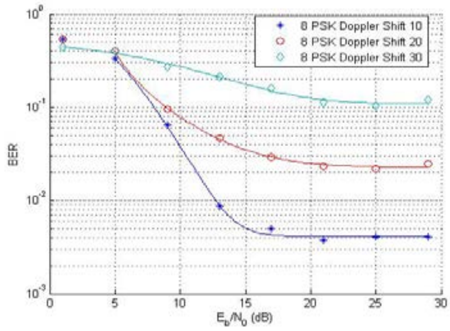

Figure2(a):Rayleigh Fading Channel With Different Doppler Shift For 8 PSK Modulation

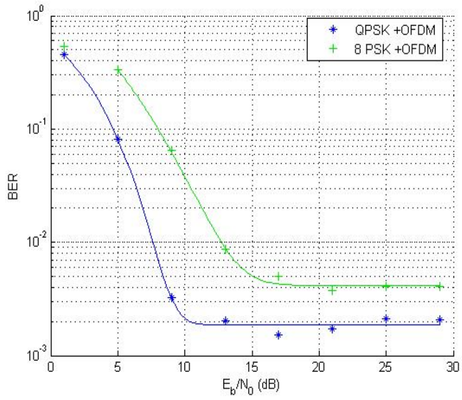

Figure2(b): Rayleigh Fading Channel With Different Modulation Techniques (QPSK,8 PSK)

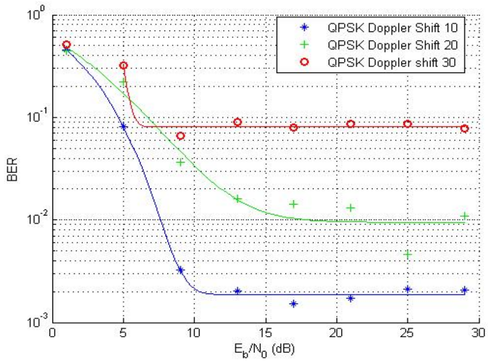

Figure2(c): Rayleigh Fading Channel With Different Doppler Shift For QPSK Modulation

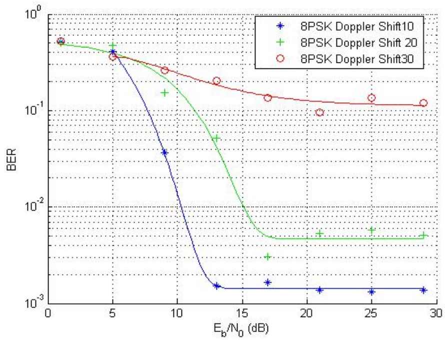

Figure2(d): Rician Fading Channel With Different Doppler Shift For 8 PSK Modulation

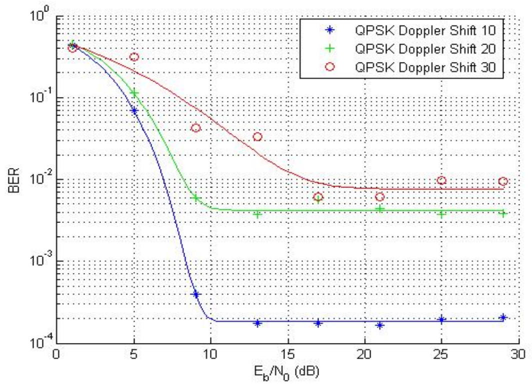

Figure2(e):Rician Fading Channel With Different Doppler Shift For QPSK Modulation

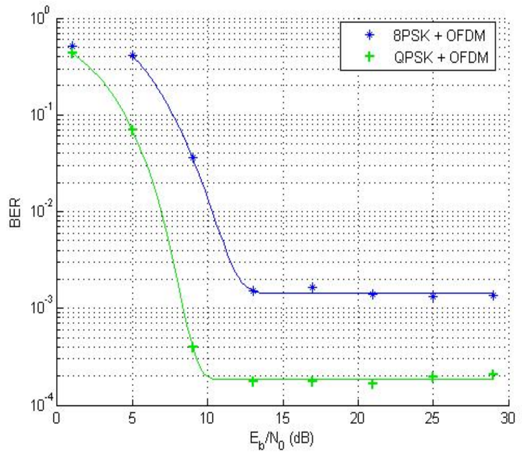

Figure2(f):Rician fading channel for different modulation techniques(8PSK,QPSK)

CONCLUSIONS

From above discussion, it is concluded that for Rayleigh channel and Rician channel under all channel conditions QPSK is best modulation technique to be used along with OFDM technology . It has been also observed that Doppler shift 10 is best with Rayleigh and Rician fading channel .

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