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Performance Analysis of MIMO-Mobile WiMAX System using Space Time Block Codes under Different Channels

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Abstract: ***The mobile Worldwide Interoperability for Microwave Access (WiMAX) is based on IEEE 802.16e standard used for wireless Metropolitan Area Network (MAN). The IEEE 802.16e standard supports high data rate and high capacity in mobile Broadband Wireless Access (BWA). The inclusion of Multiple Input Multiple Output (MIMO)in mobile WiMAX system provides a robust platform for space, time and frequency selective fading conditions and increases both data rate and system performance. In this paper, the MIMO-mobile WiMAX using Space Time Block Codes (STBC) technique is developed for both adaptive modulation and constant modulation schemes (BPSK,QPSK,QAM) with the consideration of 1/2, 3/4 code rate to determine and analyse Bit Error Rate (BER) performance under AWGN, Rayleigh and Rician channels. The simulation of MIMO-mobile WiMAX model is done by using MATLAB.***

Index Terms— ***BER, MIMO, STBC, WiMAX Systems.***

I. INTRODUCTION

The first WiMAX system is based on the IEEE 802.16-2004 standard [1]. The features to support mobile applications were added in December, 2005 to introduce 802.16e-2005. The resulting standard is referred to as mobile WiMAX. The mobile WiMAX system provides a large number of flexibility in terms of deployment options and potential applications. IEEE 802.16e is a promising technology for ensuring broadband access for the last mile connectivity. It provides a wireless backhaul network that enables high speed Internet access to residential, small and medium business customers, as well as Internet at a cost-effective, rapidly deployable solution access for WiFi hot spots and cellular base stations [2]. PHY layer of mobile WiMAX has scalable FFT size from 128 to 2048 point FFT and the range is from 1.6 to 5 Km at 5MHz.

Further, MIMO wireless systems help to achieve the goals of the future generation wireless communication system in terms of high data rate, high performance and optimum utilization of the bandwidth [3]. The application of MIMO in wireless systems also embraces many other scenarios such as wireline digital subscriber line (DSL) systems and single antenna frequency-selective channels [4]. The incorporation of MIMO in mobile WiMAX significantly improves the system coverage, quality of the signal and reliability against fading conditions [5].

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In this paper, an attempt has been made to develop MIMO-mobile WiMAX system using space time block codes to analyse the BER performance for adaptive and constant modulation schemes under different channels. The rest of the paper is organized as follows. The MIMO systems are described in section II. In section III, the MIMO-mobile WiMAX model and its different blocks are discussed. The simulation results are described in section IV. This paper concludes with section V.

II. MIMO SYSTEMS

MIMO based wireless systems equipped with multiple antennas at both transmitting and receiving ends have promised enormous capacity gains [6] over Single-Input Single-Output (SISO) based wireless systems. MIMO integration into real life wireless applications can be considered to be still in its infancy level. MIMO systems are considered to be suitable technology because they have the ability to exploit non line-of sight (NLoS) channels, and hence they can increase spectral efficiency compared to SISO systems. The MIMO wireless system is shown in Figure 1.

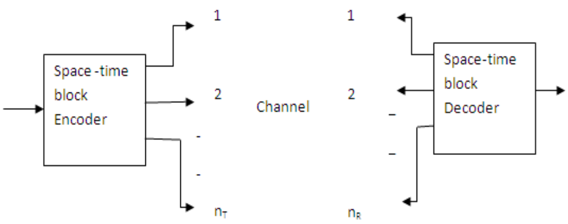

Figure 1. MIMO wireless model

There are three types of MIMO techniques that are suitable for mobile WiMAX because it supports a full range of smart antenna technologies [7]. The three types of MIMO techniques are STBC [8], [9], Spatial Multiplexing (SM), and beamforming techniques [10]. Further, Multi-antenna [11] systems can be classified into three main categories. Multiple antennas at the transmitter side are usually applicable for beam forming purposes. Frequency and space diversity schemes are realized by using multiple antennas [12] at the transmitter or receiver side constitutes second type. The third class includes systems with multiple transmitter and receiver antennas realizing spatial multiplexing [13] (often referred as MIMO by itself). For such MIMO channels, several optimum space time codes have been designed. Generally, a single point-to-point MIMO system is considered with arrays of n_T transmit and n_R receive antennas.

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In this case, focus on a complex base band linear system model is described in discrete time. The general modeling of a channel as an abstract MIMO channel allows for a unified treatment using a compact convenient vector–matrix notation. The advantages of MIMO system include diversity gains, multiplexing gains, interference suppression, and array gains.

III. MIMO- MOBILE WIMAX SYSTEM

The mobile WiMAX standard builds on the principles of Orthogonal Frequency Division Multiplexing (OFDM) by adopting a scalable OFDMA-based PHY layer. Then the MIMO model is incorporated in the mobile WiMAX system to develop the MIMO-mobile WiMAX model which is shown in Figure 2.

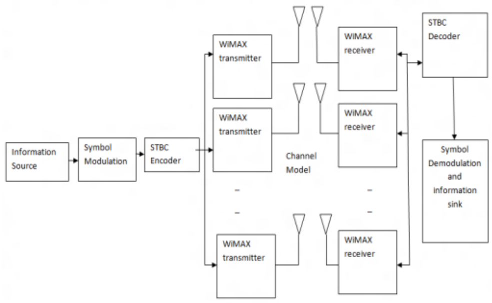

Figure 2. MIMO-mobile WiMAX model

A. *Information Source*

The Bernoulli binary generator block generates random binary numbers using a Bernoulli distribution. The Bernoulli distribution with parameter p produces zero with probability p and one with probability 1-p. The Bernoulli distribution has mean value 1-p and variance p (1-p). The probability of a zero parameter specifies p, and can be any real number between zero and one. The output signal can be a frame-based matrix, a sample-based row or column vector, or a sample-based one-dimensional array. These attributes are controlled by the Frame-based outputs, Samples per frame, and Interpret vector parameters as one dimensional parameter. The Signal Attribute Parameters is given for Random Sources in Communications Blockset.

B. *Symbol Modulation*

This block uses a rate adaptive modulation scheme depending on the SNR value of channel for adaptive modulation among BPSK QPSK, 16-QAM and 64-QAM.For constant modulation only one modulation scheme is selected at a time.

C. *STBC Encoder*

This block is used for space time diversity coding which is used to reduce the effect of noise and increase the bandwidth by reducing the Bit Error Rate. Alamouti [6] STBC is one of most important technique to achieve diversity using MIMO systems, and secure mean of exchange information. It is usually design under certain assumption and consideration of having knowledge about response of channel i.e. perfect channel state information (CSI) at

a. Transmitter site only
b. Receiver site only
c. The both site

D. *WiMAX Transmitter*

The block then transmits the encoded symbol by a space-time block code to spread each of the N-transmit antennas according to the type of coding technique used.

E. *Additive White Gaussian Noise(AWGN)*

AWGN 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 model does not account for fading, frequency selectivity, interference, nonlinearity or dispersion. In the study of communication systems, the classical (ideal) AWGN channel, with statistically independent Gaussian noise samples corrupting data samples free of inter-symbol interference (ISI), is the usual starting point for understanding basic performance relationships. An AWGN channel adds white Gaussian noise in the signal that passes through it.

F. *Rayleigh Fading Channel*

Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal such as that used by wireless devices. It assumes that the power of a signal that has passed through such a transmission medium (also called a communications channels) will vary randomly or fade according to a Raleigh distribution, the radial component of the sum of two uncorrelated Gaussian random variables. It is reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built up urban environment on radio signals. Raleigh fading is most applicable when there is no line of sight between the transmitter and receiver. In a multipath propagation environment, the received signal is sometimes weakened or intensified. The signal level of the received wave changes from moment to moment. Multipath fading raises the error rate of the received data.

G. *Rician Fading Channel*

Rician fading is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself the signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others.

IV. SIMULATION RESULTS

The MIMO-WiMAX model is simulated for different digital modulation schemes (BPSK, QPSK, QAM) with the consideration of ½, ¾ code rates of convolutional codes under AWGN, Rayleigh and Rician channels with the help of MATLAB package. The performance parameter in terms of BER of MIMO-WIMAX systems is determined and compared for adaptive modulation and various constant modulations. The simulation is carried out at 5 MHz channel bandwidth for the physical layer of MIMO-WIMAX at both the transmitter and the receiver. The simulation parameters used for simulation is given in Table 1.

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Table 1. Simulations Parameters

STANDARD	802.16e
CHANNEL MODEL	AWGN,Rayleigh,Rician
MODULATION SCHEME	BPSK,QPSK,16 & 64-QAM
CONVOLUTION CODE RATE	1/2,3/4
CYCLIC PREFIX	1/8
BANDWIDTH	5 MHz
FFT SIZE	512

A. BER of MIMO-WiMAX system with Adaptive Modulation Schemes under Different Channels.

It is inferred from figure 3 under AWGN channel, the BER has a value near 10^{-5} at Eb/No of 21dB. While in Rician channel, the MIMO-WiMAX model achieves BER performance of about 10^{-3} at Eb/No of 21dB. This BER is worse in Rayleigh channel when compared to AWGN and Rician channels because of non line of sight condition. For Rayleigh channel, the BER has value about 10^{-2} at Eb/No of 21dB.

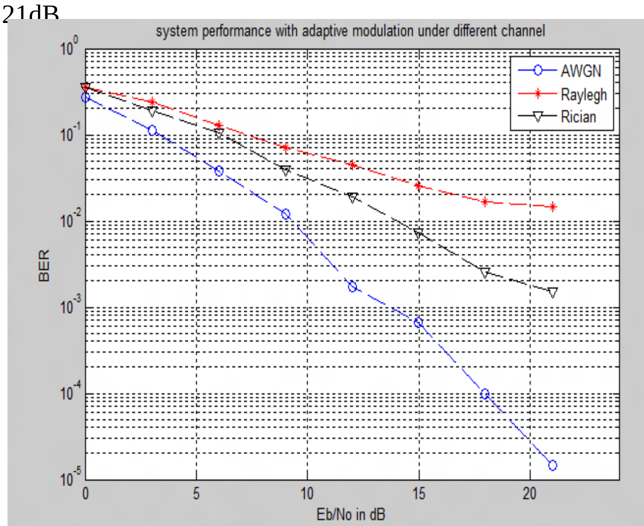

Figure 3. BER of MIMO-WiMAX System with adaptive modulation with ½ and ¾ code rate under different channels.

B. BER of MIMO-WiMAX System with Constant Modulation Scheme under AWGN Channel.

BER vs. Eb/No performance of MIMO-WiMAX with constant modulation schemes (BPSK, QPSK, and 64-QAM) using ½ convolution code rate under AWGN channel is shown in Figure 4. The BER performance in case of 64-QAM modulation is 10^{-5} at Eb/No of 21dB where as the same BER value is achieved at Eb/No of 18 dB for BPSK and Eb/No of 20 dB for QPSK modulation.

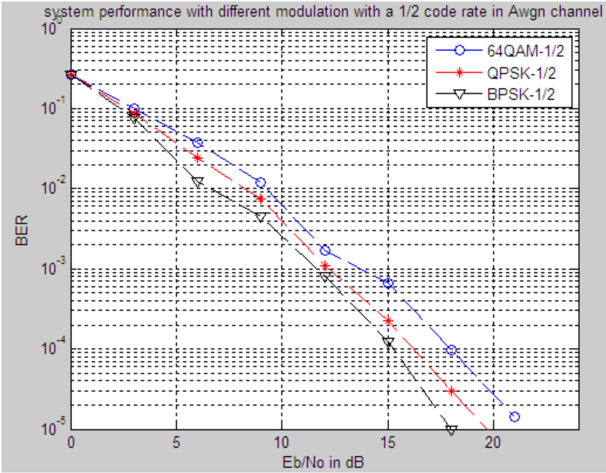

Figure 4. BER of MIMO-WiMAX system for different modulation with ½ code rate under AWGN channel.

C. *BER of MIMO-WiMAX System with Constant Modulation Scheme under Rayleigh Channel.*

It is observed through the simulation result shown in figure 5 that BER vs. Eb/No performance using BPSK modulation with ½ convolutional code rate is better than all other modulation schemes(QPSK and 64-QAM) under Rayleigh channel.

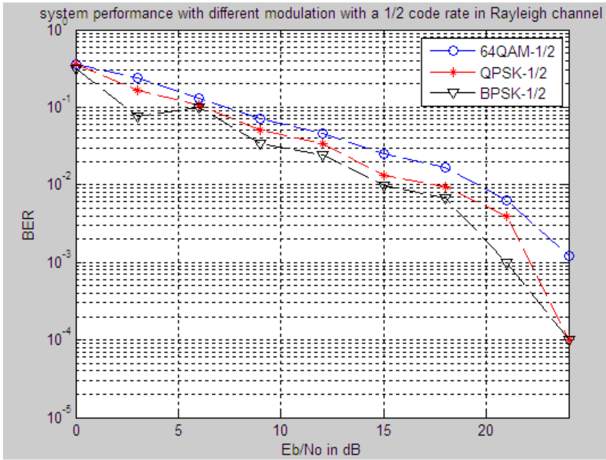

Figure 5. BER of MIMO-WiMAX system for different modulation with ½ code rate under Rayleigh channel.

D.BER of MIMO-WiMAX System with Constant Modulation Scheme under Rician Channel.

It is inferred through the simulation result shown in figure 6 that BER vs. Eb/No performance of ½ convolutional code rate using BPSK modulation technique is better than all other modulation techniques(QPSK and 64-QAM modulation techniques).There is a little difference exists in BER performance of MIMO-WiMAX system between QPSK and BPSK modulation schemes.

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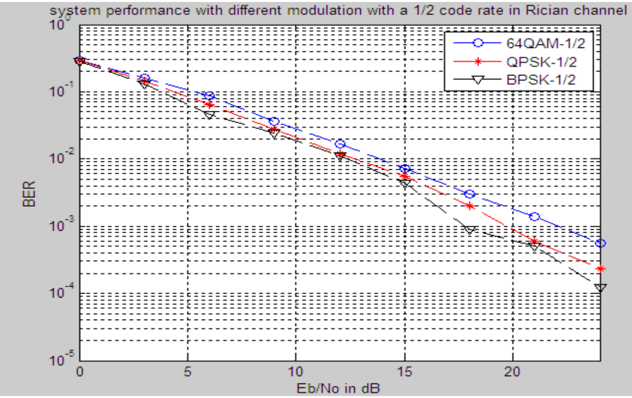

Figure 6. BER of MIMO-WiMAX system for different modulation with ½ Code Rate under rician channel.

V. CONCLUSION

Broadband Wireless Access (BWA) has emerged as a promising solution for providing last mile internet access technology to provide high speed internet access to the users in the residential as well as in the small and medium sized enterprise sectors. IEEE 802.16e is one of the most promising and attractive candidate among the emerging technologies for broadband wireless access. The emergence of WIMAX protocol has attracted various interests from almost all the fields of wireless communications. MIMO systems which are created according to the IEEE 802.16-2005 standard (WIMAX) under different fading channels can be implemented to get the benefits of both the MIMO and WIMAX technologies. In this paper, the MIMO-mobile WiMAX system is simulated for adaptive and constant modulation schemes with ½ and ¾ code rate of convolutional code to evaluate and analyse BER performance under AWGN, Rayleigh and Rician channels with the help of MATLAB. Simulation results have shown that MIMO-mobile WiMAX system with various modulation schemes is able to achieve better BER performance at different values of Eb/No under different channels. Hence, different Be/No values can be used as a threshold value in designing adaptive modulation systems commercially to achieve acceptable BER performance for MIMO-mobile WiMAX systems.

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