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Performance Analysis of MIMO-OFDM Using Zigzag Code over Different Modulation Techniques

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ABSTRACT: The Wi-MAX is an acronym for Worldwide Interoperability for Microwaves Access is an efficient and an upcoming technology which can deliver high quality audio, pictures and videos at tremendously higher data rates and high transmission reliability. The improvement of 802.16 standards for BWA (Broadband Wireless Access) technologies was promoted by the quickly growing requirement for higher data rates, universally and lucrative access. The base stations of WiMAX can offer vast wireless coverage of about 5 miles, with LOS (line of sight) transmission within the bandwidth of up to 70 Mbps. In this paper we are compared the performance of IEEE 802.16 Wireless MAN network with various modulation techniques as well as other methodologies which intrinsically advance the performance of Wi-MAX System. In this paper, we evaluated that the combination of Zigzag Coded Modulation and MIMO presents a stronger error correcting capability as compared to the Reed Solomon with Convolution code and hence enhances the BER performance and spectral efficiency which include performance analysis based on bit-error-rate versus signal-to-noise-ratio plots and spectral efficiency of different modulation and coding schemes according to the IEEE 802.16 general standard.

KEYWORDS: WiMAX, OFDM, Zigzag codes, MIMO, OFDM, FEC, MAN, BER

I. INTRODUCTION

Wireless technologies are bringing revolution in telecommunication industries and thus can be called as spectrum of opportunities. The IEEE 802.16 standard is based on the Wireless Metropolitan Area Network. It carries several frequency allocations from 10-66GHz. Broadband Wireless Access (BWA) has come out as a promising solution for last mile access technology to endow with high speed access to internet not only in the residential but also in small and medium sized enterprise sectors. Cable and digital subscriber line (DSL) technologies are also serving broadband services. But as many urban and suburban locations face practical problems it may not be served by DSL connectivity as it can only reach about four miles from the central office switch. On Broadband Wireless Access it can be speedy to deploy, easier to scale and more flexible, so giving it the potential to provide clients not served or not satisfied by their wired broadband substitutes. IEEE 802.16 standard for BWA and its associated industry consortium, Worldwide Interoperability for Microwave Access (WiMAX) forum assure to offer high data rate over wide region to a massive amount of users where broadband is absent.

It sustains data rates between 1.5 and 75 Mbps per channel. Mobile WiMAX is a modification to Fixed WiMAX and adds innovative chief specifications i.e. full mobility at vehicular speed and increased QoS.

Formerly military, satellite and cellular technologies are now commercially driven by ever more demanding consumers. In order to meet the hastily ever-increasing demand for multimedia purposes OFDM is utilized. Orthogonal Frequency

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Division Multiplexing (OFDM) is a prevalent and most promising modulation process to attain high spectral efficiency, robustness, low computational intricacy, frequency selective fading and simple in implementation using IFFT/FFT and equalization schemes. In OFDM the frequency time and dissimilarity in the organization of the carriers is chosen in such a way that the carriers are orthogonal so that they don't cause interference to one another. The name "OFDM" is originated from the fact that the digital data is sent via numerous carriers, each of a diverse reduction is fall in power signal when broadcasting from one point to another which is caused due to shadowing /slow fading and it can be avoided by splitting the signal into numerous small frequency band carriers like OFDM does. This results in small loss in carrier rather than complete loss.

It has been observed that diversity gain and system capacity can be enhanced with OFDM in combination with a MIMO transceiver system, named MIMO OFDM system on a time-varying multipath fading channel [8]. MIMO as the name signifies; used multiple inputs at both the access point and mobile terminal which is beneficial rather than a single transceiver (SISO-Single input Single output) systems. MIMO wireless systems are encouraged by two essential objectives: high data rate and better performance.

Generally in OFDM, fading is regarded as a trouble in wireless set-up but MIMO channels make use of the fading to boost the capacity of the whole communication arrangement. MIMO-OFDM technology has been considered as the infrastructure for the next generation wireless/ multimedia networks. Taking the advantage of OFDM technique the physical layer is able to provide robust broadband service in hostile wireless channel. The OFDM based physical layer of the IEEE802.16 standard has been standardized in close cooperation with the European Telecommunications Standards Institute (ETSI) High Performance Metropolitan Area Network (HiperMAN).

This paper will answer to all the questions concerning uncertainty in preferring the best modulation technique to use, not only to get improved utilization of available frequency band but also how to lessen the BER. WI-MAX at base level make use of OFDM and our research started with convenient model of OFDM and uses that model in WI-MAX to get better result.

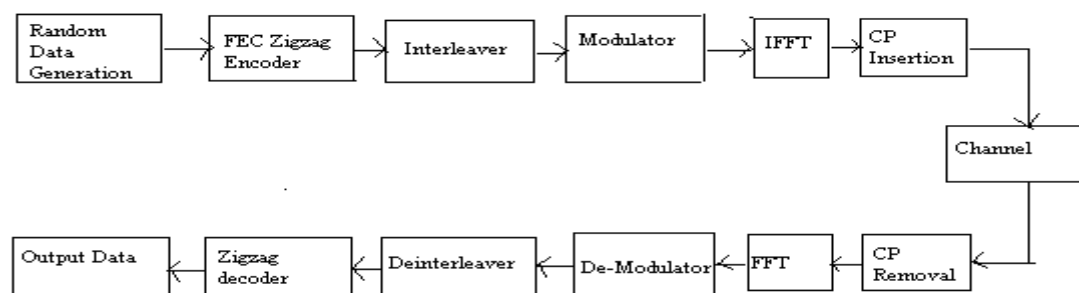


Fig. 1 WiMAX (IEEE 802.16) Model

II. MIMO

MIMO technique is mainly divided into Space time codes (STC) and Spatial Multiplexing (SMX). In STC, two or more antennas are used at the transmitter and one antenna at the receiver. To improve the reception of STC transmitted signals, multiple receiver antennas can be used. SMX uses multiple antennas at transmitter for beam forming functions as well as at receiver for recognizing different (frequency, space) diversity schemes and that is why its BER performance is better than STC codes. In SMX [7], this mode sends out one data bit from the first antenna, and another bit from the second antenna simultaneously, per symbol, instead of transmitting the same bit over two antennas. As long as the receiver has more than one antenna and the signal is of adequate quality, the receiver can separate the two

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incoming signals. Although SMX increases implementation cost but data can be transmitted twice as fast as compared systems using Space Time Codes [7].

MIMO presents considerable data throughput enhancement and link range without additional bandwidth or transmission power. Since MIMO is acting better in terms of channel capacity in a rich scatter multipath environment than in case of environment with LOS. This fact is shown in Figure 2.

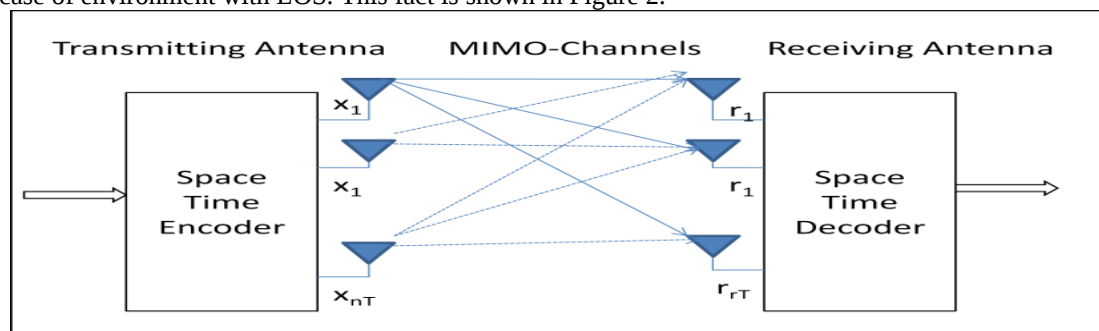


Fig.2 MIMO System

III. OFDM

OFDM is a multi-carrier transmission technique in which data symbols modulate a parallel collection of equally spaced sub-carriers. Minimum frequency separation is required to maintain orthogonally of sub-carriers corresponding to time domain waveforms, however the signal spectra corresponding to the dissimilar sub-carriers overlap in frequency. The spectral overlap results in a waveform that uses the available bandwidth with very high bandwidth efficiency.

In wireless architecture, OFDM based structure grants greater resistance to multipath fading and impulse noise, and reduces the need of equalizers, while efficient hardware implementation can be realized using FFT techniques [9]. OFDM is simple to use on Frequency selective channels that exhibit time delay spread or channel coherence bandwidth which measures the channel de-correlation in frequency. The coherence bandwidth and the root-mean-square (rms) delay spread are inversely proportional.

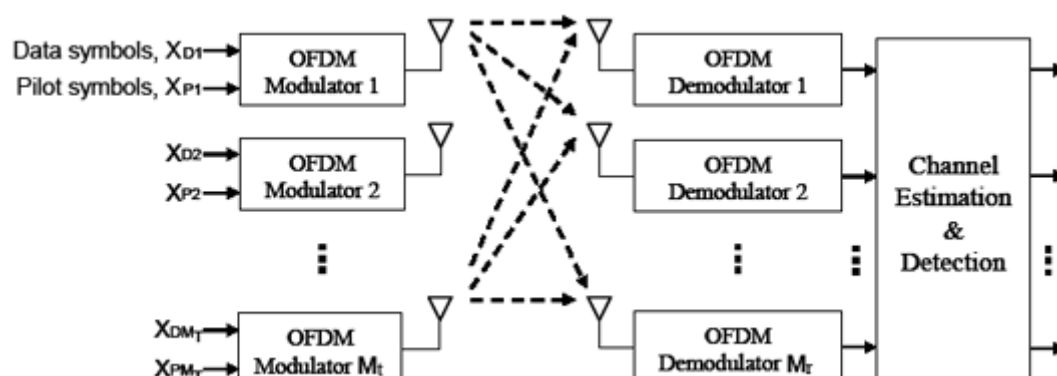


Fig.3 Block diagram of OFDM

IV. CHANNEL CODING

To minimize the error probability in decoding, redundant bits are added systematically with the data. This represents source information over the channel and called Channel Coding [3]. It is important for wireless channel as it minimizes the bit error rate at the receiver. Therefore reception quality of information improves. Usually channel

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coding can be performed by error detecting and correcting codes. Coding methods are based on logical or mathematical operations [2]. Zigzag code has a big benefit, in that it can choose a higher code rate. Modulation used here is of the M-QAM as well as M-PSK modulation type, and possesses such advantages as small radiation outside the band and higher bandwidth efficiency.

A coded modulation scheme is used for ultra-high speed transmission. A zigzag code is a type of linear error-correcting code [1]. In this coding the input data is partitioned into segments of fixed size and the sequence of check bits to data is added, where each check bit is the exclusive OR of the bits in a single segment and of the previous check bit in the sequence. This paper deals with bit-error-rate (BER) performance of WiMAX systems that uses the various coding and modulation schemes [3].

A. (I, J)-zigzag codes

The structure of zigzag code is shown in Fig. 4.2.2, where node represents the modulo-2 summation. An (I, J)-zigzag code is a systematic code with I parity bits in the form of a column vector p, and I.J information bits in the form of an I×J matrix D, where P and D are given by,

$$D = \begin{bmatrix} d(1,1) & d(1,2) & \dots & d(1,J) \\ \vdots & \vdots & \dots & \vdots \\ d(I,1) & d(I,2) & \dots & d(I,J) \end{bmatrix}_{I \times J} \quad \text{and} \quad \begin{bmatrix} p(1) \\ \vdots \\ p(I) \end{bmatrix}_{I \times 1}$$

The parity check bits are generated according to

$$P(i) = (p(i-1) + \sum_{j=1}^J d(i,j)) \bmod 2, \quad 1 \leq i \leq I,$$

With the initial value $p(0) = 0$

B. Concatenated (I, J) Zigzag Codes

If we concatenate several component zigzag codes then a stronger code can be obtained. The first constituent code encodes the original data D and the remaining K-1 constituent codes encode K-1 different interleaved versions of D using K-1 random interleaves. The k^{th} constituent code generates a parity check vector and the parity check matrix is denoted by [3]

$$P = \begin{bmatrix} p1(1) & \dots & pk(1) \\ \vdots & \ddots & \vdots \\ P1(I) & \dots & pk(I) \end{bmatrix}_{I \times K}$$

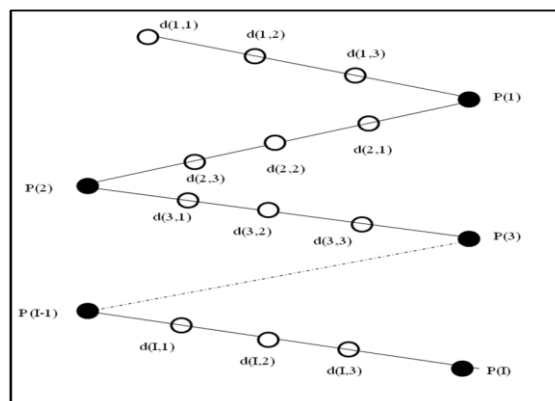


Fig. 4 The structure of zigzag codes

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V. RESULT

The results of the simulation that are done in MATLAB R2012a are presented in this segment. During simulation some constraints are set like CP length, coding rate, code length, modulation and range of SNR values. Random input is being generated. We have plotted the BER to SNR figures for different modulation and zigzag coding.

The Simulation is done in with FFT size 512 for mobile WiMAX system. The code rate is always taken as $\frac{1}{2}$ in comparing PSK different modulation order. All the results are represented in Rayleigh fading environment. Spatial Multiplexing technique is used at the MIMO.

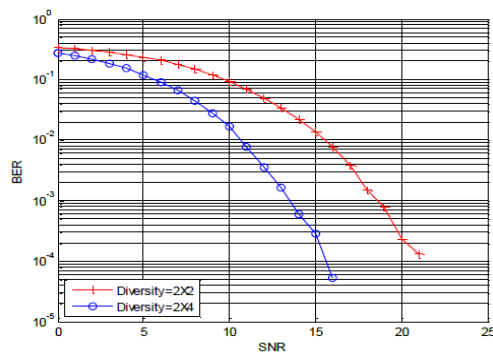


Fig. 5 BER Performance comparison of MIMO with Zigzag coded For 16PSK Modulation

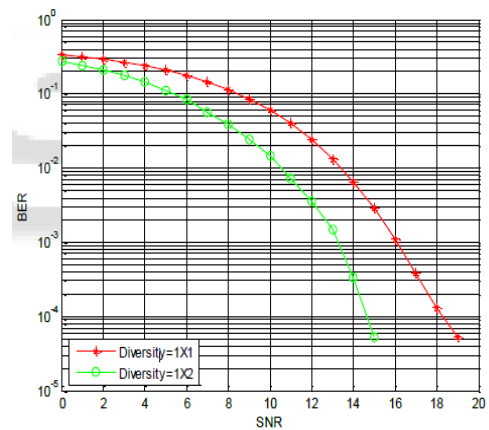


Fig. 6 BER Performance comparison of SISO and SIMO for 16 PSK Modulation

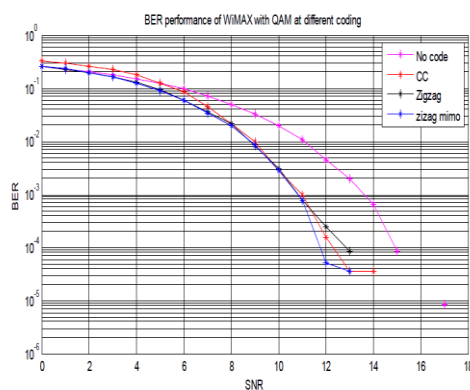


Fig. 7 BER performance evaluation of different code and QAM modulation for WiMAX

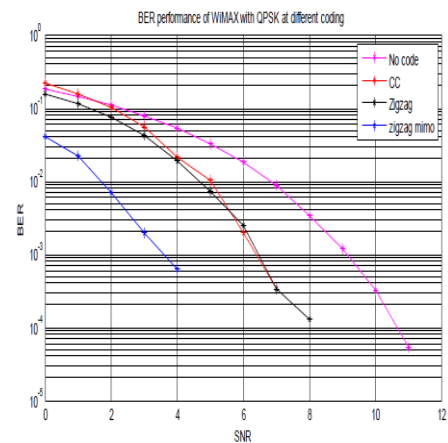


Fig. 8 BER performance evaluation of different code and modulation for WiMAX

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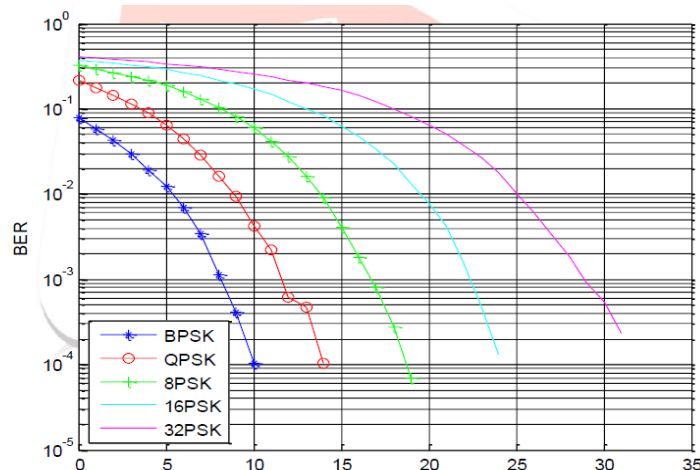


Fig. 9 Performance comparison of Zigzag coded PSK with different Modulation order

VI. CONCLUSION

In this paper, performance improvement of WiMAX system is done with MIMO. BER for different adaptive modulation techniques are estimated in slow frequency selective fading channel. In frequency selective fading, channel is affected by more ISI and noise then in flat fading.

The BER vs. SNR plots are drawn by using different combinations of numerous antennas used in the mobile WiMAX. It is observed that SIMO performs better than SISO and the performance can be further improved by using multiple antennas at the receiving end. It is viewed that Antenna order of 2×4 performs better than 2×2 .

The BER Performance of Zigzag code using PSK modulation is compared for different modulation order and it is concluded from the results that the performance is better for lesser value of modulation order. So BPSK gives better results than QPSK and QPSK performs better than 16PSK.

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