Performance Analysis of MIMO-OFDM using Zigzag Code over QAM Modulation

Rajat Pant[1] Madhvi Jangalwa[2]
[1]P.G. Scholar [2]Assistant Professor
[1,2]Department of Electronics & Telecommunication Engineering
[1,2]IET-DAVV, Indore (MP) India

Abstract— With the development and advancement of Internet, the demand of Wideband High data rate communication services is increasing. This triggered the demand of WiMAX as it supports high data rate and high capacity in mobile Broadband wireless access (BWA). IEEE 802.16e (mobile WiMAX) is better than IEEE 802.16d (fixed WiMAX) as it gives full mobility at vehicular speeds and better performance. The performance of mobile WiMAX is further enhanced by the use of FEC (Forward Error Correction Codes) and the MIMO-OFDM (Multiple input, multiple output-orthogonal frequency division multiplexing) techniques. The combination of FEC and MIMO reduces the possibility of errors and fading and hence enhances the BER performance and spectral efficiency. Further, Rayleigh channel is generally preferred for non line of sight propagation and in environment where multipath fading is more probable. In this paper a comparison is made between the diversity gains of MIMO systems (Spatial Multiplexing) and different modulation order in terms of BER for Zigzag coded QAM modulation scheme.

Key words: MIMO-OFDM, QAM Modulation

I. INTRODUCTION

WiMAX is an acronym for Wireless interoperability for microwave access, is a type of WMAN and is based on IEEE 802.16 standard. It provides high data rate services with wide area coverage in frequency range of 10 – 66 GHz (Line of sight) and 2 -11 GHz (Non Line of Sight).WiMAX standard is classified into IEEE 802.16d(Fixed user) and IEEE 802.16e(Mobile user) standard. It can provide BWA up to 50 km for fixed station and 5 to 15 km for mobile stations .It supports data rates between 1.5 and 75 Mbps per channel .Mobile WiMAX is an amendment to Fixed WiMAX and adds new major specifications i.e. full mobility at vehicular speed and increased QoS. The performance of mobile WiMAX is further increased by using channel coding and MIMO techniques. Channel coding technique is used for providing reliable information through the transmission level to users. It reduces noise and interference in channel [1]. MIMO based wireless systems equipped with multiple antennas at both transmitting and receiving ends provides very high capacity gains over SISO (Single-Input Single-Output) based wireless systems. MIMO is considered suitable technology for WiMAX because it can exploit non-line-of sight channels.

II. CHANNEL CODING

Channel coding represents the source information over the channel in such a manner that minimizes the error probability in decoding by adding the redundant bits systematically with the data. Channel coding is important for wireless channel because it reduces the bit error rate at the receiver. Hence in this way the reception quality improves. In general channel 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 advantage, in that it can choose a higher code rate. Modulation used here is of the QAM modulation type and it is robustly applicable in practical communication systems. FEC codes add redundancy to the transmission information using an algorithm. Bits are sent multiple times. Each character is sent two to three times and receiver checks instances for each character. It is accepted on conformity. If no conformity, then character is rejected and '_' or blank is displayed. It is called forward error correction code because the receiver can correct error without needing reverse channel for request to retransmission. Reverse channel is absent but requires high forward channel Band-width [1]. It is of two categories ie. block codes and convolution codes. In block codes fixed sized packets of bits called blocks are decoded.eg. Zigzag code codes. In convolution codes packets are of arbitrary length and are decoded using Viterbi algorithm.

III. ZIGZAG CODES

This paper introduces a family of error-correcting codes called zigzag codes. The zigzag code is described by a highly structured zigzag graph. A zigzag code is a type of linear error-correcting code. In this coding the input data is partitioned into segments of fixed size and the sequence of check bits to data is added, in 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 QAM modulation scheme [2].

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

The parity check bits are generated according to

$$P(i) = \left(p(i-1) + \sum_{j=1}^{J} d(i,j) \right) \bmod 2, \qquad 1 \le I \le I$$

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

If we concatenate several component zigzag codes then a stronger code can be obtained. The first constituent code encodes the original data $\Pi 1(D) = D$, the remaining K-1 constituent codes encode K-1 different interleaved versions of D using K-1 length (I×J) random interleaves. The k^{th} constituent code generates a parity check vector $pk = [pk(1), \dots, pk(I)]T$ and the parity check matrix is denoted by

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

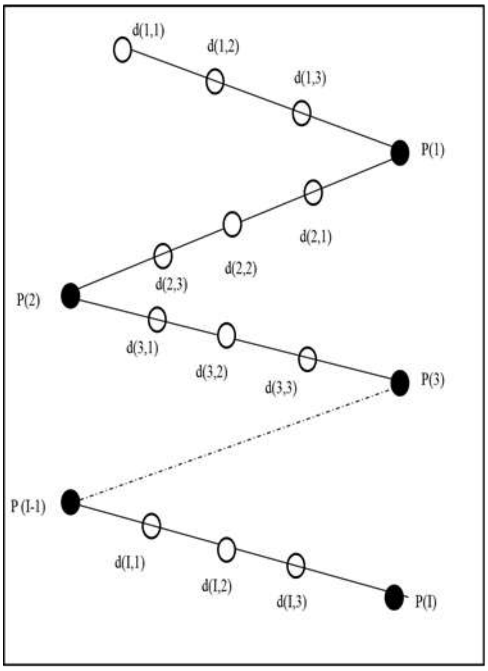

Fig. 1: The structure of zigzag codes

IV. MIMO SYSTEM

In MIMO Multiple antennas are used at Transmitter and Receiver sides. MIMO technique is broadly divided into STC (Space time codes) and SMX (Spatial Multiplexing). In STC, two or more antennas are employed at the transmitter and one antenna at the receiver. The use of multiple receive antennas can further improve the reception of STC transmitted signals. SMX uses multiple antennas at transmitter as well as receiver so its BER performance is better than STC codes. In SMX, instead of transmitting the same bit over two antennas, this method transmits one data bit from the first antenna, and another bit from the second antenna simultaneously, per symbol [4]. As long as the receiver has more than one antenna and the signal is of sufficient quality, the receiver can separate the signals.

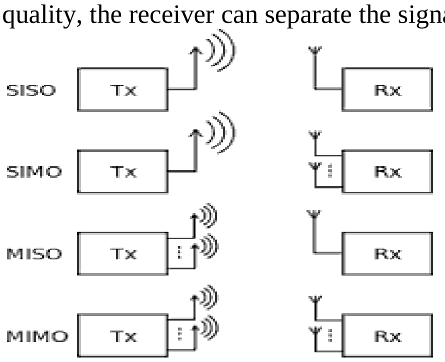

Fig 2: MIMO System

SMX increases complexity and cost at both the transmitter and receiver. But with two transmit antennas and two receive antennas, data can be transmitted twice as fast as compared systems using Space Time Codes with only one receive antenna. One specific use of Spatial Multiplexing is to apply it to users who have the best signal quality, so that less time is spent transmitting to them [4]. Users whose signal quality is too low to allow the spatially multiplexed signals to be resolved stay with conventional transmission. This allows an operator to offer higher data rates to some users and to serve more users.

V. RESULTS

A. System Description

The system description for the simulation is given in fig 5. The image data are transmitted through the MIMO WiMAX system with zigzag coding.

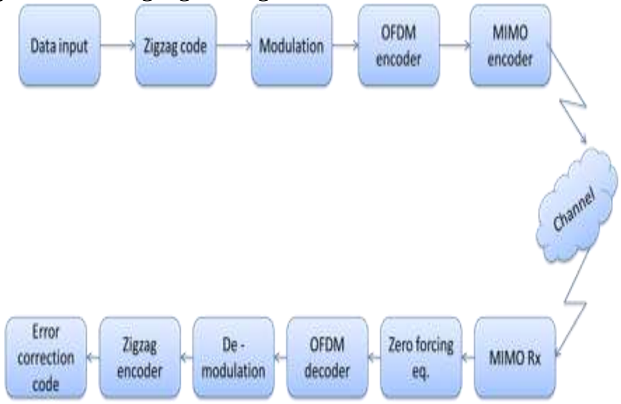

Fig. 3: System block diagram

The Simulation is done in MATLAB R2012a with FFT size 512 for mobile WiMAX system. The code rate is always taken as ½ and Antenna order as 2×2 MIMO is used in comparing PSK different modulation order. The Input is generated randomly. All the results are drawn in Rayleigh fading environment. Spatial Multiplexing technique is used at the MIMO.

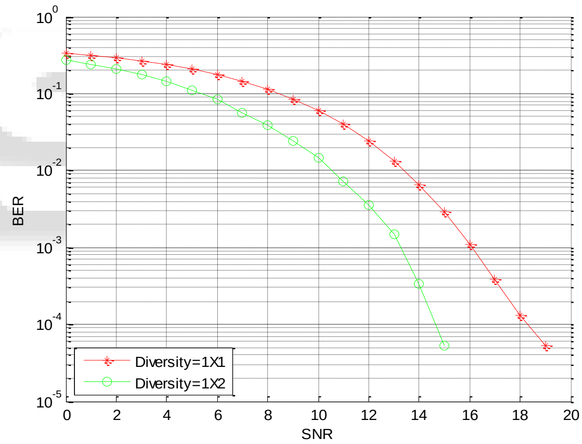

Fig 4: BER Performance comparison of SISO and SIMO for 16PSK.

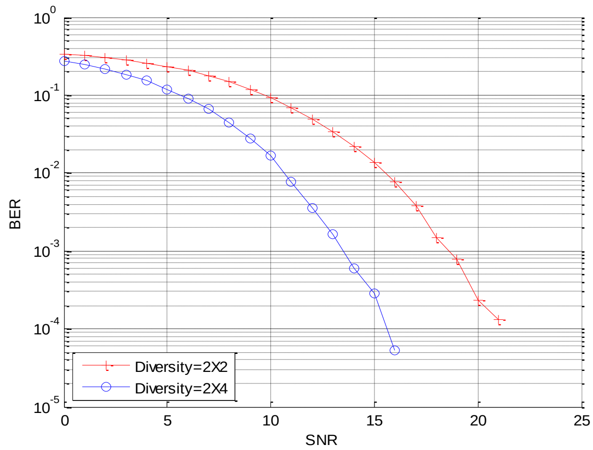

Fig 5: BER Performance comparison of MIMO with Zigzag coded 16PSK Modulation.

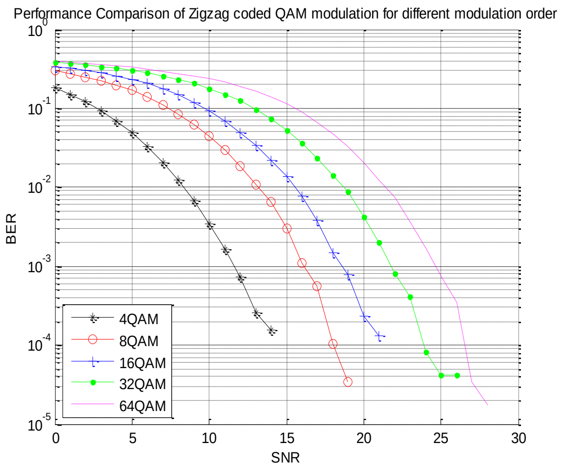

Fig 6: Performance comparison of Zigzag coded QAM with different Modulation order.

VI. CONCLUSION

The BER Vs. SNR plots are drawn by using different combinations of number of transmitting and receiving antennas used in the mobile WiMAX. It is seen that SIMO performs better than SISO and the performance is better for more number of Antennas at the receiving end. It is observed that Antenna order of 2×4 performs better than 2×2.

The BER Performance of Zigzag code using QAM 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 4QAM gives better results than 16QAM.

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