PERFORMANCE ANALYSIS OF DOWNLINK MIMO IN 2X2 MOBILE WIMAX SYSTEM

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Abstract

In this paper, we analyze the error rate performance of downlink coded multiple-input multiple-output orthogonal frequency division multiple access (MIMO OFDMA) systems under frequency selective fading channel conditions. The IEEE 802.16 standard, commonly known as WiMAX, is the latest technology that has promised to offer broadband wireless access over long distance. Since 2001 WiMAX has evolved from 802.16 to 802.16d for fixed wireless access and to the new IEEE 802.16e standard with mobility support. In WiMAX, multiple input multiple-output (MIMO) antenna technologies play an essential role in meeting the 4G requirements. The application of MIMO technologies is one of the most crucial distinctions between 3G and 4G. A large family of MIMO techniques has been developed for various links and with various amounts of available channel state information in IEEE 802.16e/m. In this paper, the performance of downlink STC (Space Time Coding) PUSC with Matrix B under ITU OIP-B outdoor-to-indoor pedestrian channels with the velocity of 3Km/h for various modulation systems. The outputs have been generated averaging over 1000 frames on MIMO channel.

Keywords: MIMO, OFDMA, WiMAX

1. Introduction

WiMAX stands for the Worldwide Interoperability for Microwave Access and is also known as the IEEE 802.16 wireless metropolitan area network. WiMAX (Worldwide Interoperability for Microwave Access) is central to a number of new market and technology opportunities. The standard offers a range of broadband wireless technologies that are capable of delivering differentiated and optimized service models. WiMAX promises to combine high capacity services with wide area coverage. However, issues such as power and spectral efficiency still need to be resolved. In 2004, the IEEE 802.16d standard [1] was published for Fixed Wireless Access (FWA) applications. In December 2005 the IEEE ratified the 802.16e [2] amendment, which aimed to support Mobile Wireless Access (MWA) with seamless network coverage. This standard is now receiving considerable industrial attention.

The IEEE 802.16e air interface based on Orthogonal Frequency Division Multiple Access (OFDMA) which main aim is to give better performance in non-line-of-sight environments. IEEE 802.16e introduced scalable channel bandwidth up to 20 MHz, Multiple Input Multiple Output (MIMO) and AMC enabled 802.16e technology to support peak Downlink (DL) data rates up to 63 Mbps in a 20 MHz channel through Scalable OFDMA (S-OFDMA) system [3].

WiMAX uses Orthogonal Frequency Division Multiple Access (OFDMA) to assign sub-carriers to different users. OFDMA is coming forth as the favored downlink transmission scheme for these systems because it is highly adaptive and robust in frequency selective radio channels and also provides good system flexibility [4] [5].The number of sub-carriers available for assignment in the UL and DL are a function of the channel bandwidth, the frame size, and the UL/DL transmit ratio.

In mobile WiMAX, the smallest unit of frequency-time allocation available is a slot which contains 48 data sub-carriers. The sub-carriers comprising a slot can be made up of adjacent sub-carriers or can be allocated in a distributed fashion throughout the available carrier space. Mobile WiMAX systems adopt orthogonal frequency division multiplexing (OFDM) and orthogonal frequency division multiple access (OFDMA) [6] technology. Most of these systems are expected to provide broadband services for mobile users. As such, it is expected that receivers will suffer from time-varying frequency-selective propagation effects. The quality of channel estimation, in such case, can significantly impact the overall system performance.

2. IEEE 802.16 PHY Layer: OFDMA

The Wireless MAN - OFDMA air interface is based on OFDMA which is a multiple access/multiplexing scheme that provides multiplexing operation of data streams like OFDM. Both technologies differ of resource management. In OFDMA, sub-carriers are grouped into sub-channels which can be allocated to each user for the UL. The resource management then relates to which sub-carriers and time slots should be allocated to each user. Each sub-channel coding and modulation is then set separately based on channel conditions which give more flexibility in managing the bandwidth and transmission power. This then leads to a more efficient use of the network resources than in OFDM-based systems. More specifically, it has been shown that OFDMA-based systems deliver better delay characteristics than their OFDM counterparts [7] with a significantly lower delay variation due to the finer granularity offered by OFDMA. Further flexibility to efficiently use the system resources is introduced with Scalable OFDMA (SOFDMA). It allows smaller FFT sizes to further improve performance and reduce the cost for lower bandwidth channels.

In OFDMA WiMAX systems, the mapping of all the DL bursts allocated into the frame must be rectangular. With such rectangular mapping, some resources are wasted. More specifically, two types of waste can be distinguished -one in which more resources are allocated than required and one in which consecutive slots are too small to be allocated to any user. The issue then is to maximise the frame resource utilisation while keeping the signalling overhead from the DL-MAP relatively low. Different proposals trying to tackle the issues with the bursts mapping in OFDMA WiMAX systems can be found in [8]-[10]. Based on the burst sizes, the algorithms proposed in these papers are aiming to define (i) the shape and (ii) the position of the bursts that fit into the DL sub-frame without overlapping in time or frequency.

3. Multi Input Multi Output (MIMO) Systems

The MIMO technology is one of the key benefits of the Mobile WiMAX systems. It is based generally on multiple-antennas configuration both at the transmitter and at the receiver end. It can be used to

- Increase the system reliability (decrease the bit and packet error rate)
- Increase the achievable data rate and hence the overall system capacity
- Increase the coverage area
- Decrease the required transmit power

MIMO is an antenna technology for wireless communications in which multiple antennas are used at both the source (transmitter) and the destination (receiver). The antennas at each end of the communications circuit are combined to minimize errors and optimize data speed. In MIMO Diversity techniques can be implemented into different ways in order to improve the bit error rate of the system.

The IEEE 802.16-2009 standard [11] offers a variety of tools for MIMO processing including Space-Time Coding (STC), spatial multiplexing, and beamforming. The support for MIMO techniques is provided in IEEE 802.16-2009 by dividing the transmission frame into several parts, referred to as zones. The first zone is used for single antenna transmission while the latter zones can be used for spatially processed signaling. The latter zones can also be used for some other transmission schemes, such as optional PUSC, optional Full Usage of Subchannels (FUSC), or Adaptive Modulation and Coding (AMC), and some of them also have the possibility for processing in spatial domain. The standard supports the use of two, three, or four antennas at the BS, and two antennas at the MS. Also, for the UL, two single antenna MSs can perform collaborative spatial multiplexing onto the same subcarrier. The very basic DL STC transmission scheme for two transmitter antennas is based on the Alamouti coding, which uses the transmission matrix

$$\begin{vmatrix} S_1 & -S_2^* \\ S_2 & S_1^* \end{vmatrix}$$

where S_1 and S_2 depict symbols, and can be used both in PUSC and FUSC permutations. Basically, this technique is similar to Alamouti coding, but the OFDMA symbol index is replaced by the subcarrier index, leading to diversity coding in frequency and space. For the optional zones in the DL, spatial multiplexing is supported as well. In PUSC mode, the number of pilot subcarriers is doubled in a cluster compared to the single antenna mode, in a way that half of the pilots are dedicated to antenna 0 and the other half is dedicated to antenna 1. In FUSC mode, pilots are divided between transmitter antennas. The MIMO midamble can be switched on by BS in the DL MAP in STC DL Zone information element. Basically, the MIMO midamble is an OFDMA symbol filled with pilot symbols from different transmitter antennas that can be used for estimation purposes at the MS. The MIMO midamble can be boosted by 3 dB using midamble boosting if the STC DL Zone information element in DL MAP is switched on. The Alamouti STC used in our Mobile WiMAX measurements is a rate one transmit diversity code. That is, it does not increase or decrease data throughput as spatial multiplexing or conventional error-correction codes would do, but it increases the reliability of the received signal by transmitting via two independently fading spatial subchannels and allows a simple but optimal combination of the signals at the receiver.

4. WiMAX-MIMO Systems

MIMO systems 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. Main aim of combining both WiMAX and Spatial multiplexing MIMO technique is to achieve higher data rates by lowering the BER and improving the SNR of the whole system. The proposed block diagram of WiMAX-MIMO systems is given in Fig 1.

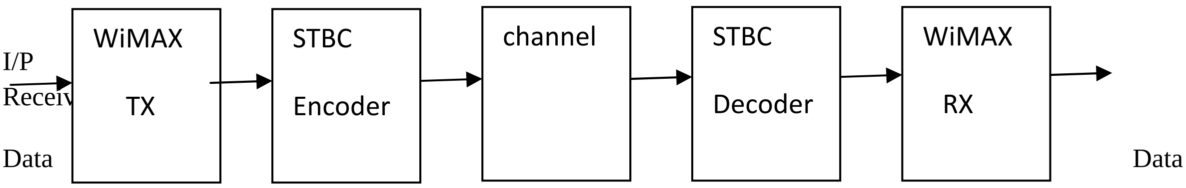

Fig 1: WiMAX MIMO System

The use of WiMAX technology with the MIMO technology provides an attractive solution for future broadband wireless systems that require reliable, efficient and high-rate data transmission. Employing MIMO systems in WiMAX [12] yields better BER performance compared to simple WiMAX protocol. Spatial multiplexing technique of MIMO systems provides spatial multiplexing gain that has a major impact on the introduction of MIMO technology in wireless systems thus improving the capacity of the system. Combining of both the systems involves employing STBC encoder and decoder at the transmitter and receiver side of WiMAX Physical Layer respectively. This paper analyze the WiMAX protocol as well as the spatial multiplexing technique of MIMO systems in order to achieve higher data rates by lowering the Bit Error Rate and improving the SNR value of the system to achieve better performance and results. Spatial multiplexing (SM) is a recently developed transmission technique that uses multiple antennas and helps in achieving the capacity gain.

5. Simulation Results

In this section Downlink BER & PER on 2x2 WiMAX MIMO channel results are presented using the Mobile WiMAX simulator and channel model. In this paper the performance of downlink STC PUSC with Matrix B under ITU OIP-B outdoor-to-indoor pedestrian channels with the velocity of 3Km/h for various modulation systems. The outputs have been generated averaging over 1000 frames on MIMO channel. On the DL a 3-sector BS is assumed. This transmits data simultaneously to 3 MS, with each sharing a common OFDMA symbol. Perfect channel estimation and synchronisation is assumed. The downlink BER & PER on 2x2 WiMAX MIMO channel results are shown in fig 2 & fig 3 respectively.

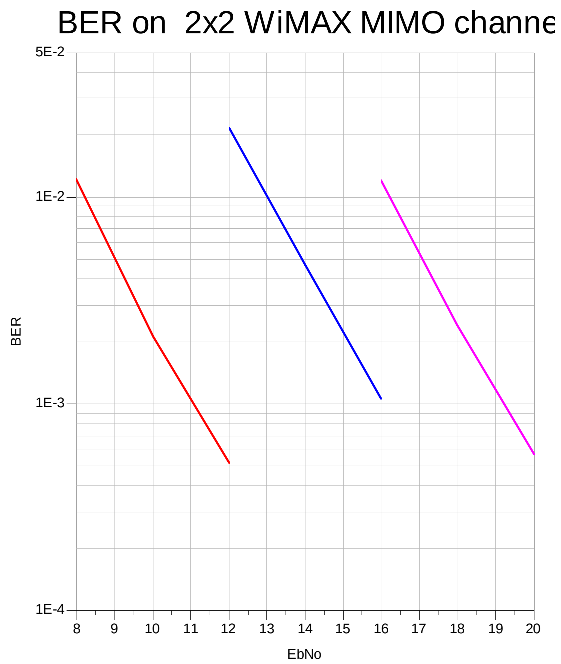

Fig 2: Downlink BER on 2x2 WiMAX MIMO channel

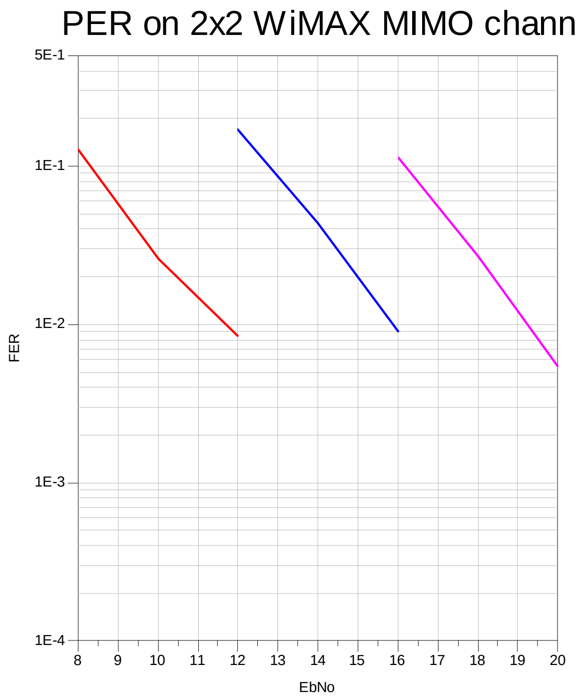

Fig 3: Downlink PER on 2x2 WiMAX MIMO channel

6. Conclusions

In this paper effect of employing spatial multiplexing technique of Downlink BER & PER on 2x2 MIMO system in WiMAX 802.16e PHY layer has been simulated through ADS. This technique of MIMO systems provides spatial multiplexing gain that has a major impact on the introduction of MIMO technology in wireless systems. Rayleigh channel has been taken into account for the analysis purpose. Simulations are based upon using different modulations with different convolutional code rates and show that there is improvement in the SNR value as well as capacity improvement can also be seen by employing spatial multiplexing technique of MIMO system in WiMAX protocol. Results are presented in the form of BER vs SNR value & PER vs SNR value and show that BER reduces when we employ MIMO system in WiMAX in comparison to simple WiMAX. Main aim is to reduce the BER of the system for lower value of SNR hence providing higher data rates for the transmission purpose such that originality of the input signal is retained.

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