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Performance Evaluation of MIMO Wi MAX Network

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Abstract: ***In wireless communication system the transmitted signals from mobile station are reflected and scattered by the surrounding objects. This causes the signals to travel with multiple paths, so it arrived to the base station with different lengths and attenuations. This is known as multipath propagation. Fading problems are consequences of multipath propagation, which leads to decrease the data rate in Broadband Wireless Access (BWA) systems. The multipath fading problem can be solved using antenna diversity techniques. Multiple-Input Multiple-Output (MIMO) techniques are important to provide significant performance improvements for BWA systems such as the IEEE 802.16e, which known as mobile WiMAX systems. WiMAX systems define the physical (PHY) layer and Medium Access Control (MAC) layer for mobile and portable BWA systems. In this paper, the performances of MIMO based WiMAX system have been investigated with comparing to other two techniques , namely, Single-Input Single-Output (SISO), Multiple-Input Single-Output (MISO) . The simulation results show that the system performances, in terms of Bit Error Rate (BER) of WiMAX system can be improved using MIMO technique.***

Keywords: Wimax, MIMO, MISO, SISO, Space-Time Coding, BER

1. Introduction

WiMAX (Worldwide interoperability for micro wave access technology) is the most recent technology to establish wireless access network. It acts as broad band access solutions for wireless communications. WIMAX has been regarded as a promising alternative for constructing the next broadband wireless metropolitan area networks (WMAN). There are two types of the WIMAX, fixed WIMAX and mobile WIMAX, Fixed WIMAX is based on IEEE-802.16d standard for fixed application form its base stations. Mobile WIMAX targets mobile application allows mobile nodes to move from one place to other. OFDM is widely used in WLAN and WMAN. The original frequency carrier is divided into group of sub carriers that are orthogonal to each other. In OFDM each sub-channel is accessed to only one user at a given time slot. IEEE 802.16e WIMAX air interface uses orthogonal frequency division multiple access (OFDMA) for improved multi-path performance in non-Loss of sight (NLOS). The radio link MS is named as the access link, but the link between BS and RS is called relay link. Theses access link and relay link can be used for uplink and downlink data transmission. This standard defines the physical and the MAC layer specifications. The MAC layer supports functions such as network entry, bandwidth request, connection management and Hand over. The PHY layer adopts orthogonal frequency division multiple access (OFDMA) as the primary channel access mechanism for non-line of sight (NLOS) communications in the frequency band less than 11 GHz. It supports point to multipoint (PMP) network topology[1].

2. Related Works

Author in [4] presented the performance of a wireless architecture that provides ultra-broadband wireless transmission. The architecture was used to system with multiple antenna elements on the transmitter and the receiver (MIMO) using a Spatial Multiplexing technique conforming to the 802.16 (WiMAX) standard. The results show that the significant superiority of the proposed LoS-optimised array architecture compared with standard antenna arrays of inter-element spacing of one-wavelength.

Author in [7] presented that Wireless digital communication system, like WiMAX, has an advantage of implementing intelligent antennas and with the use of OFDM and Space-Time Block Code (STBC). Also multiple antenna technology is implemented on both of the base station and user terminal with appropriate coding technique. A comparison between .Alamouti scheme using MIMO and multiple antennas was done. The results show that Bit Error Rate (BER) is being reduced. And gains maximum diversity gained when we increase the number of antennas on either side. This allows considerable error free transmission in wireless transmission environment for MIMO.

Author in [11] discussed the use of multiple-antenna techniques in mobile WiMAX systems. And presented antenna array techniques, which primarily reduce interference and enhance the useful signal power. Also a general description of multi-input multi-output (MIMO) systems was given, which can be used for different purposes including diversity, spatial multiplexing and interference reduction. They focused in multi-antenna profiles adopted for WiMAX systems and discussed their relative merits. The results show that SEQUANS Communications has devised and patented a receiver algorithm and architecture, which substantially reduces the receiver complexity and makes the optimum receiver implementable in practice.

3. MIMO System

MIMO based wireless systems equipped with multiple antennas at both transmitting and receiving ends it provides high capacity gains over (SISO), (SIMO) and (MISO) based wireless systems. MIMO systems are considered to be convenient technology for their ability to exploit non line-of sight (NLoS) channels, furthermore they have the ability to increase spectral efficiency compared to SISO and other systems. The MIMO wireless system is shown in Fig 1.

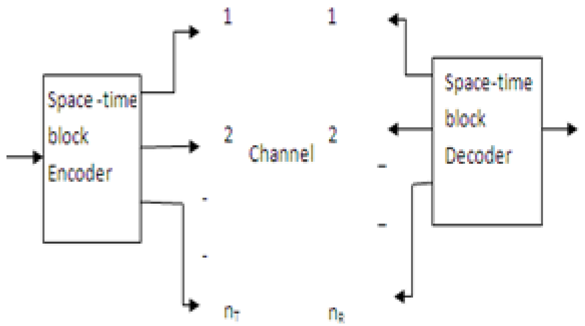

Figure 1: MIMO wireless model.

There are three types of MIMO techniques that are suitable for WiMAX because it supports a full range of smart antenna technologies . The three types of MIMO techniques are STBC, Spatial Multiplexing (SM), and beam forming techniques. Multiple antennas at the transmitter side are usually applicable for beam forming purposes. Frequency and space diversity schemes are realized by using multiple antennas at the transmitter or receiver side constitutes second type. The third class includes systems with multiple transmitter and receiver antennas realizing spatial multiplexing (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 nT transmit and nR receive antennas. In this case, focus on a complex base band linear system model is described in discrete time The advantages of MIMO system include diversity gains, multiplexing gains, interference suppression, and array gains.

4. Multiple Antenna Technologies

A. MIMO Matrix A (STBC)

With MIMO Matrix A, a single data stream is replicated and transmitted over multiple antennas. The redundant data streams are each encoded using a mathematical algorithm known as Space Time Block Codes. With such coding, each transmitted signal is orthogonal to the rest reducing self-interference and improving the capability of the receiver to distinguish between the multiple signals. With the multiple transmissions of the coded data stream, there is increased opportunity for the receiver to identify a strong signal that is less adversely affected by the physical path. The receiver additionally can use Maximal-Ratio Combining (MRC) techniques to combine the multiple signals for more robust reception as shown in Fig 2. MIMO Matrix A is fundamentally used to enhance system coverage.

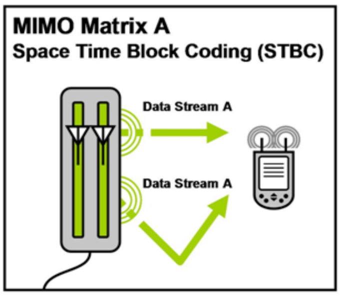

Figure 2: MIMO Matrix A.

B. MIMO Matrix B (SM-MIMO)

With MIMO Matrix B, the signal to be transmitted is split into multiple data streams and each data stream is transmitted from a different base station transmit antenna operating in the same time-frequency resource allocated for the receiver. In the presence of a multipath environment, the multiple signals will arrive at the receiver antenna array with sufficiently different spatial signatures allowing the receiver to readily discern the multiple data streams as explained in Fig 3. Spatial multiplexing provides a very capable means for increasing the channel capacity.

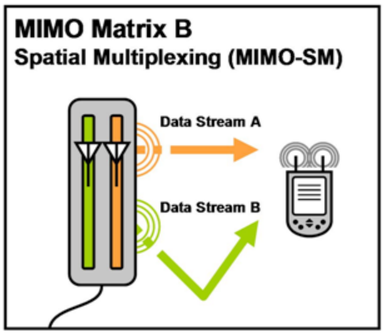

Figure 3: MIMO Matrix B.

C. Beamforming

WiMAX systems that use beamforming as a means to further increase system coverage and capacity can surpass the capabilities of MIMO techniques. Beamforming techniques such as Statistical Eigen Beamforming (EBF) and Maximum Ratio Transmission (MRT) are optional features in the 802.16e WiMAX standard, but leading vendors are taking advantage of its strong performance characteristics. Beamforming techniques leverage arrays of transmit and receive antennas to control the directionality and shape of the radiation pattern. The antenna elements have spatial separation dictated by the wavelength of transmission and are supported by sophisticated signal processing as shown in Fig 4.

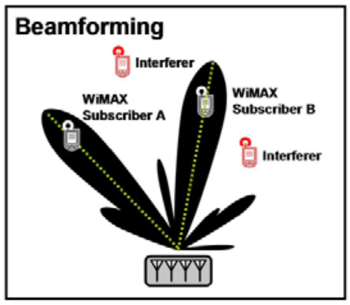

Figure 4: Beamforming.

5. WI-MAX MIMO System

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 5.

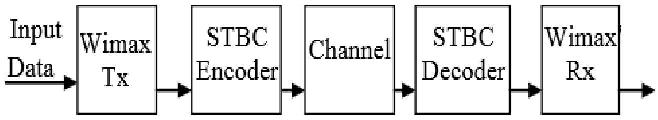

Figure 5: WiMAX MIMO System.

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 [5] 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 systemsthus 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.

SISO communication systems are vulnerable to environments characterized by problems caused by multipath effects. On the other hand, the MISO transmission strategy maximizes the received SNR by adding up the received signal from all transmit antennas in-phase and by allocating more power to the transmit antennas. MISO wireless communication system exhibits transmitter diversity. Some of the transmitter diversity techniques include frequency weighting, antenna hopping, delay diversity and channel coding . The MIMO system exhibits both transmitter diversity and receiver diversity. While the transmitter diversity techniques have already been discussed, some of the receiver diversity techniques include selection diversity, antenna diversity, maximal ratio combining and equal gain combining. The advantages of using MIMO systems are increased spectral efficiency, throughput, coverage, capacity, better BER.

6. System Model And Simulation Results

The SISO –WiMAX model was simulated using Matlab simulator for different fading modes including frequency selective fading and when there is no fading. with the consideration of several parameters like Cyclic prefix such as (1/4, 1/8, 1/16 and 1/32) . The simulation is carried out at 3.5 MHz channel bandwidth and using adaptive modulation as a modulating technique.
MISO Wimax was also simulated using the same parameters except for fading which multipath Rician fading was used.

Furthermore a comparison between (MIMO-MISO-SISO) Wimax was done using bpsk as modulation technique. The performance parameter in terms of BER of all techniques is determined and compared to each other.

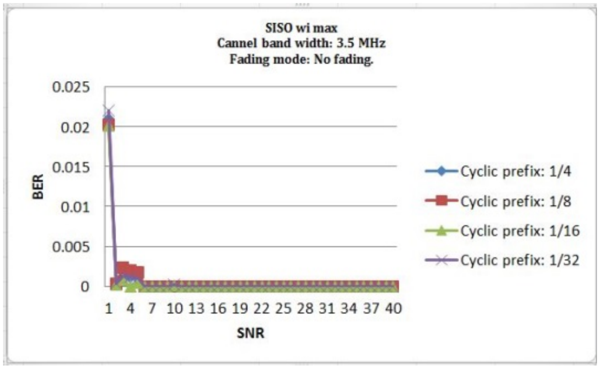

Figure 6: BER Vs SNR for SISO (No fading).

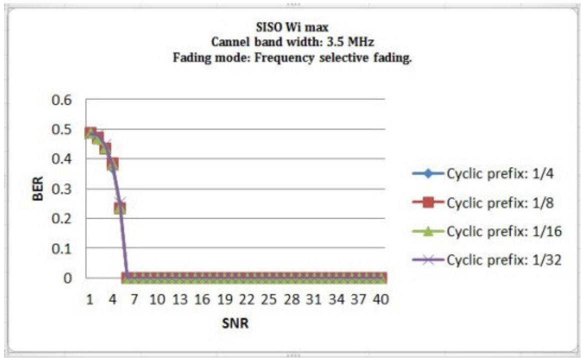

Figure 7: BER Vs SNR for SISO (Frequency selective fading).

The results in terms of BER as a function of the received SNR are presented when there is no fading. The maximum value of BER was obtained at (0.0221) when cyclic prefix was 1/32. The BER values are sharply start to decrease when the SNR increased to (2dB) as shown in Fig 6.

The results in Fig 7 show that the BER cross SNR when frequency selective fading is used for several cyclic prefix values. It is clear that the highest value of BER is obtained at (0.04882) for cyclic prefix (1/16), this values start to decrease when the SNR reach (7dB).

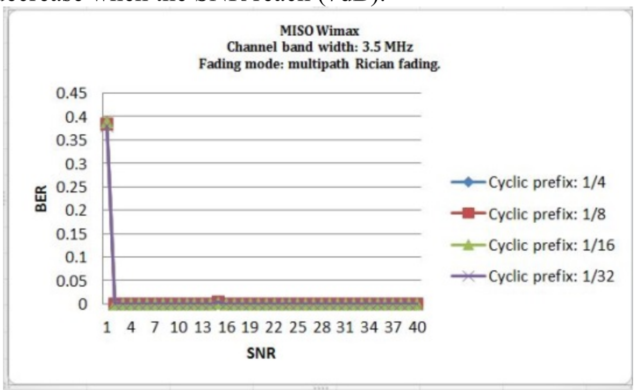

Figure 8: BER Vs SNR for SISO (Multipath Rician fading)

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In MISO Wimax when multipath Rician fading is used, it shown that the greatest BER is obtained at (0.389) for the cyclic prefix of (1/16), and it decreases when SNR is (5dB) as shown in Fig 8.

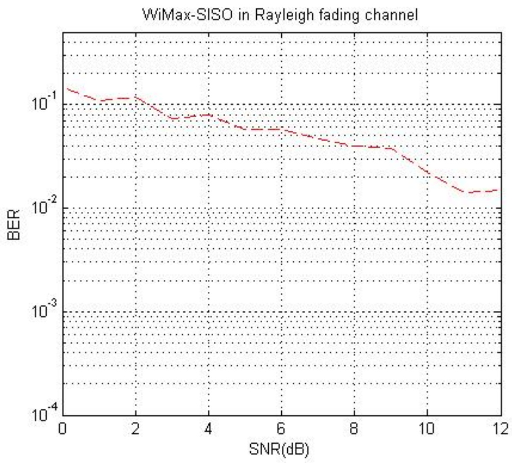

Figure 8: SISO Wimax in Rayleigh fading.

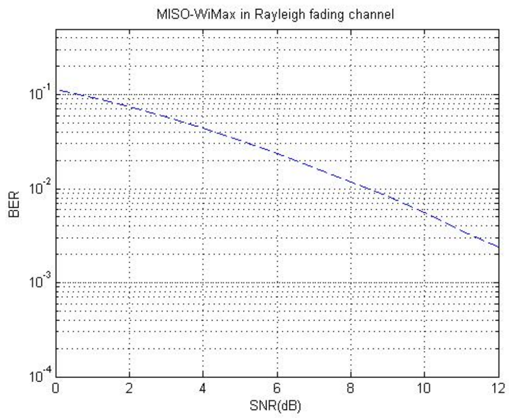

Figure 9: MISO Wimax in Rayleigh fading.

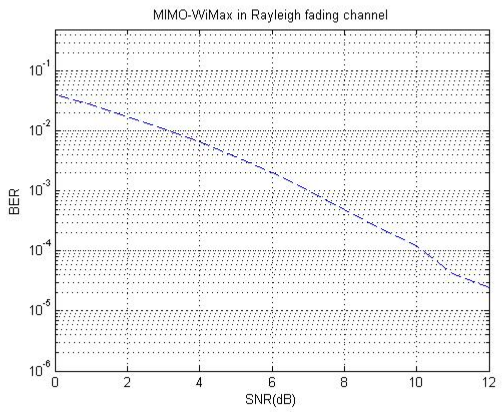

Figure 10: MIMO Wimax in Rayleigh fading.

From (SISO-MISO-MIMO) Wimax graphs using Rayleigh fading, it is clear that In MIMO channel, when the number of transmission and reception antenna increased, the performance enhances. The highest BER value obtained in SISO technique, medium value obtained at MISO (2X1) technique and the lowest value of BER was obtained when the multiple antenna technique (MIMO-Wimax 2X2) is used This shown in Fig 8, Fig 9 and Fig 10 respectively.

7. Conclusion

This paper shows that the performance of WiMAX sytem can be improved using MIMO techniques. Therefore multiple antenna techniques offer diversity gain and it can be used to increase system coverage with low bit error rate. A comparison between three techniques included SISO, MISO and MIMO was done. The performance in term of BER was obtained and the results showed that for SISO WiMax the best BER values were taking when there are no fading channels. For MISO Wimax from the results it was clear that it enhances the BER comparing to SISO technique. The results showed by MIMO Wimax technique offer the best values of BER. Therefor increasing in the number of antennas at the both transmitting side and receiving side would help to increase capacity and provide low BER.

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