Analysis of BER for Multiple Antenna Technology Using STBC

Muhammad Hassan, MS Electrical Engineering (Telecommunication)

Abstract— Attaining Quality of Service (QoS) and high speed data rate on mobile Worldwide Interoperability for Microwave Access (WiMAX) for very well spreading of internet technology and multimedia services is optimum. Multiple Antenna technology both at the receiver as well as at the transmitter can be used to achieve that using MIMO-OFDM (multiple input multiple output orthogonal frequency-division multiplexing) techniques. Wireless digital communication system, like WiMAX, has an advantage of implementing intelligent antennas and with the use OFDM and Space-Time Block Code (STBC) this paper presents a scheme to achieve high bit error rate. Multiple antenna technology is implemented on both of the base station and user terminal with appropriate coding technique. Alamouti scheme using MIMO has also been compared with multiple antennas. The results show that Bit Error Rate (BER) is being reduced. Furthermore, it also gains maximum diversity when we increase the number of antennas on either side. This allows considerable error free transmission in wireless transmission environment for MIMO.

Index Terms— WiMAX, MIMO systems, OFDM, Space-time block code.

1 Introduction

NOW a day's people are more prone to mobile devices and QoS is an important asset while selecting proper wireless access. Many techniques have been used so far to improve the quality of services and reduce Bit Error Rate for devices which work on WiMAX technology. To overcome this problem and improve the quality QoS for mobile devices, normal modulation techniques were used in the beginning. This helped to improve the quality of service to an extent but still faces some issues like "fading" and it does not support 3G/4G technology. To overcome this problem and improve QoS, OFDM (Orthogonal Frequency Division Multiplexing) was introduced which is an efficient technique but works only in combination with other schemes like MIMO (Multiple Input Multiple Output), SISO (Single Input Single Output) etc. 1X1 SISO system with OFDM came into existence which supports 3G technology but still have some issues like "fading" and it transmits only one symbol per two symbol times, which does waste one symbol time.

Keeping all these things in mind and a study about OFDM, this paper implements OFDM-MIMO with STBC (Almouti scheme). Since Almouti scheme have many advantages over other schemes as it helps to improve quality of service for mobile devices and sends two symbols per two symbol time.

2 Review of the State of Art

MIMO-OFDM is a multiplexing technique which is reproductive and famous for services of wireless broad band access. Current application of MIMO-OFDM is IEEE 802.16 (WiMAX) which is highly popular.

• *Muhammad Hassan has completed his masters program in Electrical Engineering (Telecommunication) from Blekinge Institute of Technology, Sweden. E-mail:m_hassan786@yahoo.com*

The effect of channel estimation errors in OFDM-MIMO and the performance of BER are determined by using single antenna systems (SISO), with ½ rate convolution coding QPSK modulation [1]. The performance of Alamouti code is compared with system in a Rayleigh Fading Channel using BPSK modulation in the reference [3], where the performance of BER with two transmitters and a single receiver found to be better when compared to (SISO).

3 Problem Statement and Main Contribution

Our research question was 'How can be BER improved in WiMAX?' A hypothesis was put forward that this can be attained by implementing multiple antenna technology with Alamouti scheme (space time block code) to operate with MIMO.

Alamouti scheme with MIMO produce high order of diversity and considerable improvement in BER as number of antennas increased. The main aim of this paper is to improve BER which will be useful for future applications based on WiMAX.

4 Problem Solution

In order for a better QoS in the 4G technology, we need to know how to improve the BER. There were different proposed techniques that were used to improve BER for WiMAX technology. In this paper we discuss the Alamouti scheme (Space time block code) for improving BER. The Alamouti space time block code is used for multiple antenna technology. The code works orthogonally and doesn't work if the number of transmitting antennas increases from two.

Suppose there are 2 transmitter and one receiver as shown in figure 1, and let transmitted signals are s_1, s_2 and its conjugates $-s_1^*$, s_2^* ,described by matrix representing symbols, S .

$$S = \begin{bmatrix} s_1 & s_2^* \\ s_2 & -s_1^* \end{bmatrix} \quad (1)$$

In the first symbol interval the signals s_1 and s_2 are transmitted, where as its conjugates $-s_1^*$, s_2^* are transmitted in the next symbol interval. The interval time between the two symbol channels is assumed to be static.

Channel,

$$h = [h1 \quad h2] \tag{2}$$

where, h1 and h2 are received signal at receiver.

Then the received signal is multiplied with hermitian transpose of symbol matrix.

$$RS^H = h.S.S^H$$

$$= [h_1 \quad h_2] \ (|s_1|^2 + |s_2|^2)$$

Where, $S = \begin{bmatrix} s_1 & s_2^* \\ s_2 & -s_1^* \end{bmatrix}$

Therefore,

$$R = h \cdot S$$

$$R = [h_1 \ h_2] \cdot \begin{bmatrix} s_1 & s_2^* \\ s_2 & -s_1^* \end{bmatrix}$$

$$= [h_1 s_1 + h_2 s_2 \quad h_1 s_2^* - h_2 s_1^*] \tag{3}$$

Effective matrix (H), multiplying with second element of received matrix with negative complex conjugate i.e.

$$\begin{bmatrix} h_1 & h_2 \\ h_2^* & h_1^* \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} = \begin{bmatrix} h_1 s_1 + h_2 s_2 \\ h_2^* s_1 - h_1^* s_2 \end{bmatrix} = \begin{bmatrix} R(1) \\ -\text{conj}(R(2)) \end{bmatrix}$$

$$H = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix}$$

Now they inverse of effective channel matrix is multiplied and the symbols s_1 and s_2 are retireved.

H with received matrix:

$$\begin{bmatrix} R(1) \\ -\text{conj}(R(2)) \end{bmatrix}$$

Finally s_1 and s_2, which were transmitted from the transmitter are received shown in the figure as y.

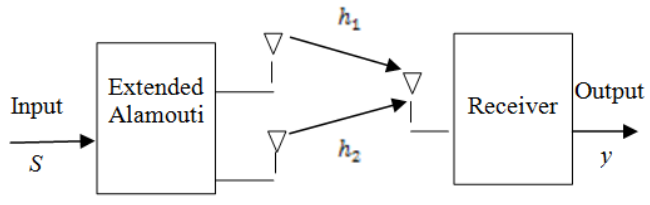

Fig. 1 2x1 system for extended alamouti scheme

The process was implemented with MATLAB R2007b version for different systems like 2x1 MIMO, 2x2 MIMO and 2x3 MIMO and bit error performance was compared.. Fig. 2 shows the comparison of all the simulated results of MIMO systems, which shows that, the BER performance of 2x3 systems is much better than 2x1 and 2x2 MIMO systems. Since higher number of receiver antennas can receive multiple copies of transmitted information results in higher diversity order. So the result shows that, as the number of antenna is increased on receiver`s side, BER improves proportionally.

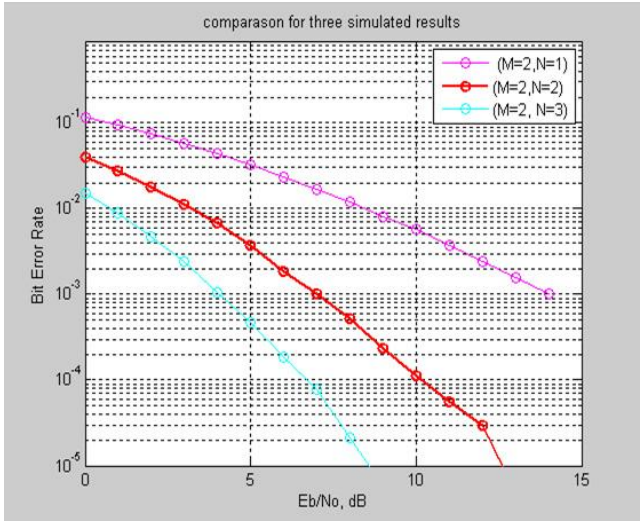

Fig. 2 Comparison of 3 simulated result

4 Conclusion

The performance of Alamouti scheme (space time block code) using MIMO systems for WiMAX technology using multiple antennas was compared. The comparison simulation result shows the improvement of BER as the number of receiving antenna increases.

Future work can be done on this system, by combining OFDM and STBC for MIMO, OFDM demodulator and channel effects with different noise models can be considered as we did this experimentation under neutral environment.

References

[1] Jan Erick H, and Knut Grythe, "Effects of Channel Estimation Errors in OFDM-MIMO-Based Underwater Communications," International conference on Advanced Information Networking and Applications Workshops, pp.1130-1135, May 2009.

[2] Markus Rupp, Biljana Badic, and Hans Weinrichter, "Adaptive Channel Matched Extended ALAMOUTI SPACE-TIME CODE Exploiting Partial Feedback," International conference on cellular and intelligent communication (CIC), Seoul, Korea, pp.443-51, Oct. 2005.

[3] Fernando H. Gregorio,"Space time coding for MIMO systems,"[Online]. Available : http://www.comlab.hut.fi/opetus/333/2004_2005_slides/space_time_codes_text.pdf . [Accessed Oct.08, 2009]