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PERFORMANCE ANALYSIS OF 2X2 MIMO and 1X2 SIMO SYSTEMS USING DIFFERENT MODULATION TECHNIQUE WITH RAYLEIGH CHANNEL

Nilesh Dubey*[1] and Abhishek Rawat[2]

*1,2Assistant Professor Acropolis Technical Campus Indore, India

ABSTRACT

WiMAX which represents (Worldwide Interoperability for Microwave Access) is a major part of broad band wireless network having IEEE 802.16 standard provides innovative fixed as well as mobile platform for broad-band internet access anywhere in anytime. IEEE 802.16 standard has bandwidth of 2GHz-11GHz for fixed applications and 2-6GHz for mobile applications. It is considered the most interesting opportunity which is able to provide data throughput up to 70 Mbps and radio coverage distances of almost 50 kilometers, and to complete wired network architectures, ensuring a cheap flexible solution for the last-mile. WiMAX can be seen as the fourth generation (4G) of mobile communications systems. Pursuance for better ways of living has been instrumental in advancing human civilization. In this project analysis of the multiple antenna technologies like Single input signal output antenna system, multiple input multiple output antenna system under different combination of modulation technologies (BPSK, QPSK, 8-QAM and 16-QAM) with Additive white Gaussian noise channel used and the performance results shows under the bit error rate versus signal to noise ratio.

Keywords- *Additive White Gaussian Noise channel (AWGN), Orthogonal Frequency Division Multiplexing (OFDM), multiple-input and multiple output (MIMO) Bit Error rate (BER), Signal to Noise ratio (SNR).*

I. INTRODUCTION

Based on the IEEE 802.16, the WiMAX Forum develops system profiles, which define mandatory and optional capabilities for WiMAX products. The list of features tested in system profiles is more stringent than the underlying standards, but does not include any new feature that is not included in the standards [7]. Initially, the WiMAX Forum focused on the 10-66GHz frequencies in the Wireless MAN-SC physical layer specifications of IEEE Standard 802.16- 2001. The WiMAX Forum collaborated on the IEEE Std 802.16c-2002 amendment to develop the system profiles for Wireless MAN-SC, it is forum helped developing IEEE Std 802.16-Conformance Jan-2005, IEEE Std 802.16- Conformance Feb-2005 and IEEE Std 802.16-Conformance Mar-2005 for a Protocol Implementation Conformance Statement (PICS) Performa, Test Suite Structure (TSS) and Test Purpose (TP) and Radio Conformance Test (RCT), respectively [7]. It is a new broadband wireless data communication technology or mobile internet based around the IEEE 805.16 standard that will provide high-speed data communication up-to 70 Mb/s over a wide area. The letters of WiMAX stand for worldwide interoperability for microwave access and it is a technology for point-to-multipoint wireless networking.

II. IMPLEMENTATION

A MIMO detector for detecting receive symbols, which correspond to symbols transmitted through transmit antennas from receive signals, when the transmit data transmitted by the terminal group are received through receive antennas.

A terminal identifier for identifying the receive symbols detected by the MIMO and SIMO detector as symbols which correspond to respective terminals in the terminal group; a symbol de-mapper for de-mapping the receive symbols identified by the terminal identifier to binary data which correspond to a modulation method used by the terminal.

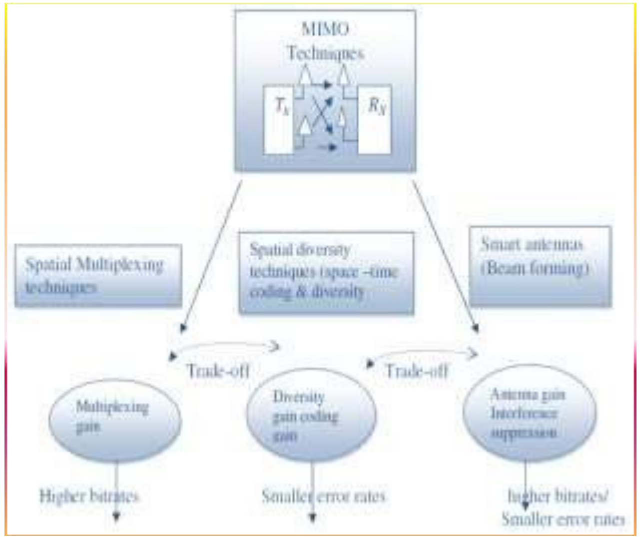

Fig. 1 Transmit 2 Receive (2×2) MIMO channel

An attempt is made to improve the bit error rate performance by trying out Successive Interference Cancellation (SIC). We will assume that the channel is a flat fading Rayleigh multipath channel and the modulation is BPSK. To do the SIC, the receiver needs to perform the following.

Using the ZF equalization approach described above, the receiver can obtain an estimate of the two transmitted symbols *x1, x2* , i.e.

$$\begin{bmatrix} \hat{x}_1 \\ \hat{x}_2 \end{bmatrix} = \left(H^H H\right)^{-1} H^H \begin{bmatrix} y_1 \\ y_2 \end{bmatrix}$$

Take one of the estimated symbols (for example $\hat{x}_2$) and subtract its effect from the received vector y1 and y2, i.e.

$$\begin{bmatrix} r_1 \\ r_2 \end{bmatrix} = \begin{pmatrix} y_1 - h_{1,2} & \hat{x}_2 \\ y_2 - h_{2,2} & \hat{x}_2 \end{pmatrix} = \begin{pmatrix} h_{1,1} & x_1 + n_1 \\ h_{2,1} & x_1 + n_2 \end{pmatrix}$$

Expressing in matrix notation,

$$\begin{bmatrix} r_1 \\ r_2 \end{bmatrix} = \begin{pmatrix} h_{1,1} \\ h_{2,1} \end{pmatrix} x_1 + \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}$$

$$r = h\, x_1 + n$$

The equalized symbol is,

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$$\hat{x}_1 = \frac{h^H r}{h^H h}$$

This forms the explanation for ZF Equalizer with Successive Interference Cancellation (ZF-SIC) approach.

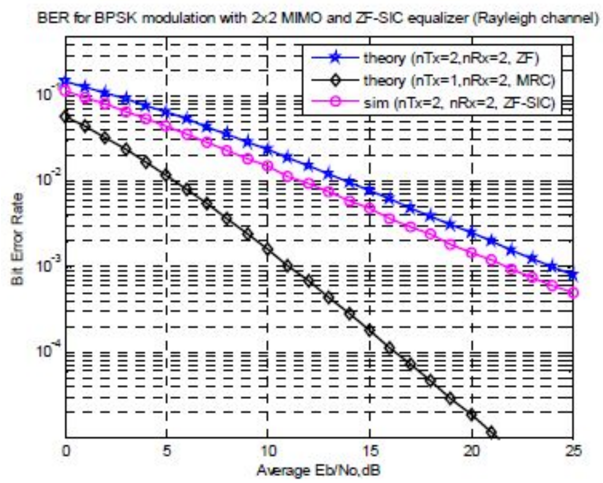

Fig. 2: BER plot for BPSK in 2×2 MIMO channel with Zero Forcing

Successive Interference Cancellation equalization

A. *MIMO with ZF-SIC and optimal ordering*

In the variant of ZF-SIC optimal ordering, assume that the channel is a flat fading Rayleigh multipath channel and the modulation is BPSK. Using the ZF equalization, the receiver can obtain an estimate of the two transmitted symbols *x1, x2, i*.e.

$$\begin{bmatrix} \hat{x}_1 \\ \hat{x}_2 \end{bmatrix} = \left(H^H H\right)^{-1} H^H \begin{bmatrix} y_1 \\ y_2 \end{bmatrix}$$

B. *Successive Interference Cancellation with optimal ordering*

In classical SIC, the receiver arbitrarily takes one of the estimated symbols, and subtract it effect from the received symbol y1 and y2. However, we can have more intelligence in choosing whether we should subtract the effect $\hat{x}_1$ of first or $\hat{x}_2$ first. To make that decision, let us find out the transmit symbol (after multiplication with the channel) which came at higher power at the receiver. The received power at the both the antennas corresponding to the transmitted symbol x1 is,

$$Px_1 = |h_{1,1}|^2 + |h_{2,1}|^2$$

The received power at the both the antennas corresponding to the transmitted symbol x2 is,

$$Px_1 = |h_{2,1}|^2 + |h_{2,2}|^2$$

Optimal way of combining the information from multiple copies of the received symbols in receive diversity case is to apply MRC. The equalized symbol is,

$$\hat{x}_2 = \frac{h^H r}{h^H h}$$

Doing SIC with optimal ordering ensures that the reliability of the symbol which is decoded first is guaranteed to have a lower error probability than the other symbol. This results in lowering the chances of incorrect decisions resulting in erroneous interference cancellation. Hence gives lower error rate than simple successive interference cancellation.

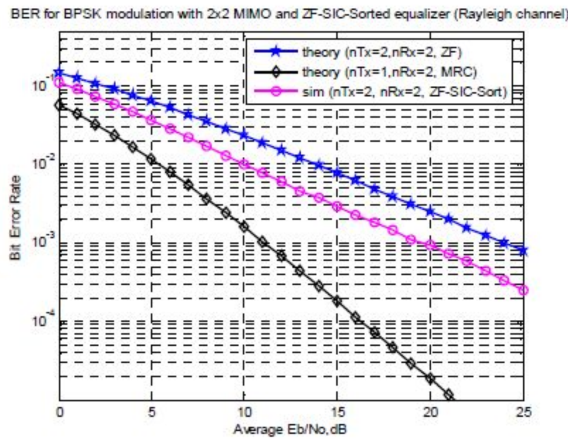

Fig. 3: BER plot for BPSK in 1×2 SIMO equalized by ZF-SIC with optimal ordering

The MIMO- ZF equalization with SIC detection is compared with optimal ordering and shown in figure 3 along with 1X2 transmit diversity scheme. It can
be seen from the figure the performance of BER decreases with the SNR in all the cases. The figure indicates that for BER of 10^{-3} the transmit diversity SNR11 dB. For the same BER values the figure shows different SNR for the two cases. The SNR for optimal ordering is 20 dB and for ZF-SIC the SNR ~24dB. The figure indicates that there is a marked difference in SNR > 9 dB between the transmit diversity and MIMO receiver diversity. The figure also suggests that between ZF-SIC and optimal ordering there is an improvement ~4 dB performance at BER of 10^{-3}

C. *Minimum Mean Square Error (MMSE) equalizer for 2×2 MIMO and 1x2 SIMO channel*

The MMSE approach tries to find a coefficient W which minimizes the criterion,

$$E\{[W_y - x][W_y - x]^H\}$$

Solving,

$$W = \left[H^H H + N_0 I\right]^{-1} H^H$$

When comparing to the equation in ZF equalizer, apart from the No I term both the equations are comparable. When the noise term is zero, the MMSE equalizer reduces to ZF equalizer.

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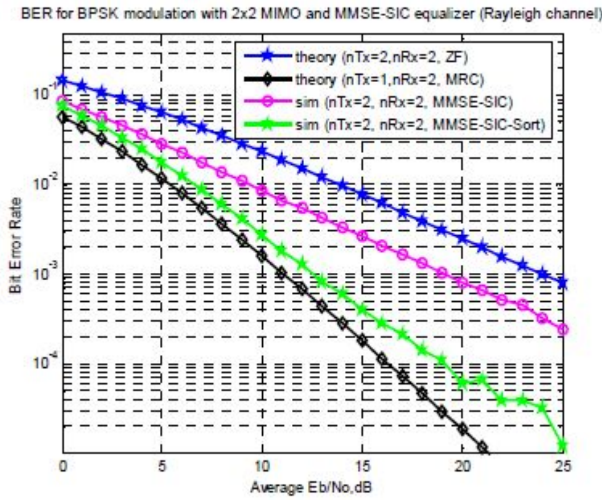

Fig.4 BER plot for 2×2 MIMO with MMSE equalization for BPSK in Rayleigh channel

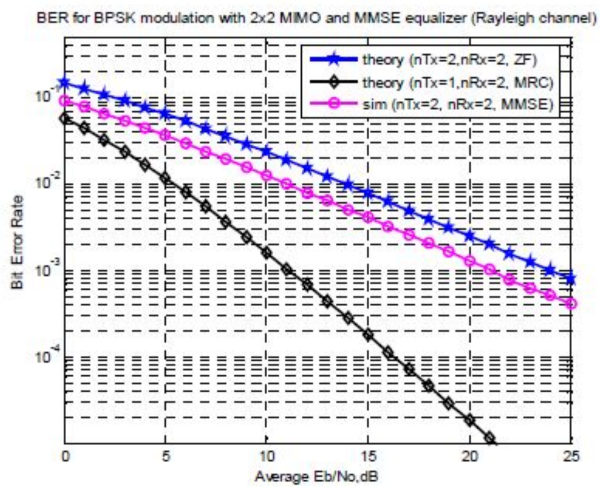

Fig.4 BER plot for 1×2 SIMO with MMSE equalization for BPSK in Rayleigh channel

The simulated results for the SIMO - ZF equalizer and MMSE detectors are shown in figure 4 along with 1X2 transmit diversity scheme. The figure indicates that at BER of 10-3 the transmit diversity SNR ~11 dB. The figure shows that at 10-3 BER, the MMSE equalizer the SNR ~22 dB and for ZF equalizer the SNR ~ 25 dB.

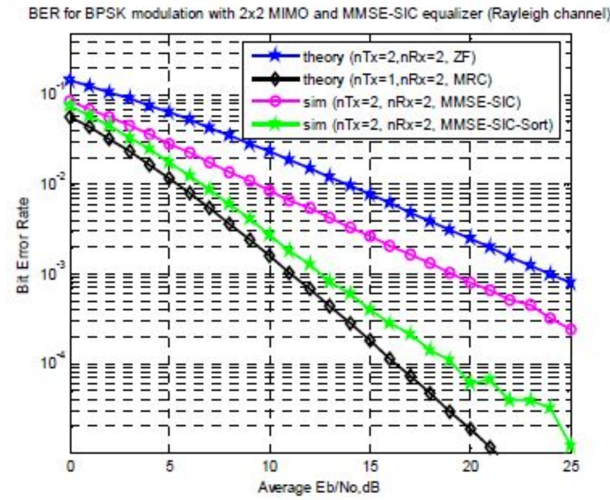

Fig. 5: BER plot for 2×2 MIMO channel with MMSE-SIC equalization with and without optimal ordering

From the above receiver structures, we saw that MMSE equalization with optimally ordered SIC gave the best performance. Here we are discussing another receiver structure called ML decoding which gives us an even better performance [6]. We will assume that the channel is a flat fading Rayleigh multipath channel and the modulation is BPSK.

D. ***Maximum Likelihood (ML) Receiver***

The ML receiver tries to find $\hat{x}$ which minimizes

$$J = \left| y - H\hat{x} \right|^2$$

$$\left[\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} - \begin{pmatrix} h_{1,1} & h_{1,2} \\ h_{2,1} & h_{2,2} \end{pmatrix} \begin{pmatrix} \hat{x}_1 \\ \hat{x}_2 \end{pmatrix} \right]^2$$

The simulation mainly includes finding the minimum among the four possible transmit symbol combinations, based on the minimum chose the estimate of the transmit symbol and repeat for multiple values of E_b/N_0 and plot the simulation and theoretical results.

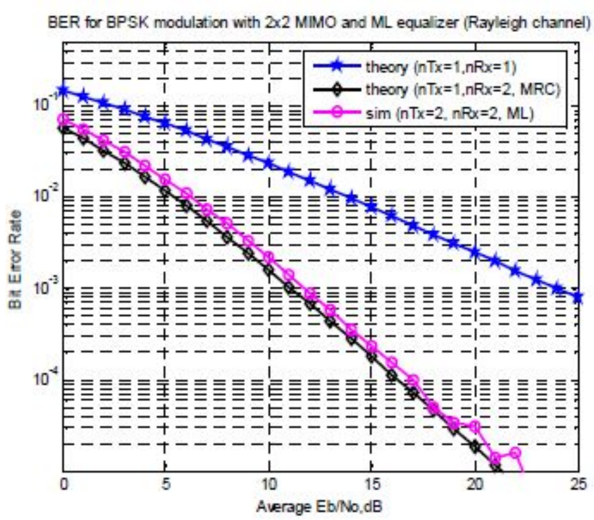

Fig.6: BER plot 2×2 MIMO Rayleigh channel with ML equalization

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The figure 6 shows the BER performance for different SNR for MIMO-ML equalization detection and 1x2 transmit diversity system. The BER decreases with increase with SNR and indicates that at BER ~$10^{-3,}$ the SNR values ~11 dB for both the cases and shows that the MIMO detection with ML equalization shows same performance as those of 1x2 transmit diversity system.

III. CONCLUSION

From the results and discussions presented above we conclude the following,

1. The combination of linear and non linear detection techniques can improve the BER performance of MIMO systems.
2. When Compared to various MIMO linear and non linear detection techniques, the maximum BER performance very close to 1x2 transmit diversity can be achieved for MIMO-Maximum Likelihood detection (ML) scheme with receiver diversity.

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