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Bit Error Rate Investigations on Mimo System With Different Number of Transmitting Antennas

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Abstract: Fading is a common problem in wireless communication systems. MIMO has emerged as a technology that can be used to combat this problem using multiple antennas at transmitter and receiver. In this paper bit error performance of MIMO system with different transmitting antennas has been investigated.
Key Words: Alamouti Scheme, Bit Error Rate, Fading, MIMO, Rayleigh Fading.

I. INTRODUCTION

As wireless channel is random and unpredictable by its nature, and in general channel error rates are poorer over a wireless channel than over a wired channel. A major problem in the wireless channel is reception of multi-path signal. This multiplicity of paths leads to a phenomenon known as multi-path fading [4]. These multiple paths are caused by the presence of objects in the physical environment that, through the mechanisms of propagation, alter the path of radiated energy. This result in rapid fluctuation in amplitude, phase or multi-path delays of a transmitted signal over a small period of time or travel distance [18]. In some cases, the multiple signals add destructively at the receiver, creating points in space where the composite received signal is greatly attenuated [1].Also the relative motion between the communicating devices induce Doppler shift on multi-path components and results in fading of the signal.

To combat the effect of fading, an emerging technology called multiple input and multiple output (MIMO) has appeared. In MIMO systems, multiple antennas at both transmitter & receiver and diversity techniques can be used to reduce multi-path fading and interference. Diversity can be achieved by providing a copy of the transmitted signal over frequency, time and space. In 1991, Alamouti proposed a transmit diversity technique using two transmit antennas, whose key advantage was the employment of low complexity use of multiple symbols. The decoding algorithm proposed in this can be generalized to an arbitrary number of receive antennas using MRC, equal gain combining (EGC) or successive combining (SC). The new scheme does not require any bandwidth expansion any feedback from the receiver to the transmitter and its computation complexity is similar to MRRC. This paper presents bit error investigations on MIMO system for different Number of transmitter antennas.

II. ALAMOUTI SCHEME

Alamouti scheme, a simple transmit diversity scheme suitable for two transmit antennas. Before coding the base band signal would be modulated at each antenna using an M-PSK modulated scheme. Then the modulated signal has been encoded by space time block code technique. It should be assumed here the transmitter does not have channel knowledge but the receiver full knowledge about the channel. It would first see, two transmit antenna and one receive scheme then two transmit and two receive scheme.

The system model for the Alamouti Space-Time scheme has been shown in Fig 1. The model consists of two transmit antennas T_X1 and T_X2 with the associated channel gains h_1 and h_2 respectively which may be modeled as Rayleigh fading channel. At the transmitter, the information bits have been first modulated using an *M*-ary modulation scheme.

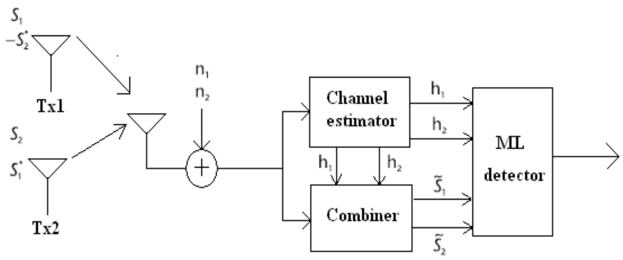

Fig 1: Alamouti Space-Time Coding Scheme using Maximum likelihood decoding

The encoder then takes a block of two modulated symbols s_1 and s_2 in each encoding operation and gives it to the transmit antennas according to the code matrix given in equation (1).

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

Where, the first column represents the first transmission period and the second column the second transmission period. The first row corresponds to the symbols transmitted from first antenna and second row corresponds to the symbols transmitted. At the receiver the faded signals are corrupted by Additive White Gaussian Noise (AWGN) process. Where r_1 correspond to the symbols s_1 and s_2 sent from antennas 1 and 2 respectively at time $t = t_1$ and r_2 corresponds to the symbols $-s_2^*$ and s_1^* sent from antennas 1 and 2 respectively at time $t = t_1 + T$. n_1 and n_2 are the sample functions of an additive white Gaussian noise process. r_1 and r_2 can be given as

$$r_1 = h_1 s_1 + h_2 s_2 + n_1$$
$$r_2 = -h_1 s_2^* + h_2 s_1^* + n_2 \qquad (2)$$

This can be written in matrix form as:

$$r = Sh + n \qquad (3)$$

III. MAXIMUM LIKELIHOOD DECODING

While the encoder may utilize any modulation scheme, the decoder consists of first estimating the channel gains for reliable decoding and a combiner that utilizes the estimated gains and the received data sequences to correctly decode the symbols. It has been assumed that the receiver is able to perfectly estimate the channel gains h_1 and h_2 [11]. The combiner combines these estimated channel gains h_1 , h_2 and the received vectors r_1 and r_2 to generate $\tilde{s}_1$ and $\tilde{s}_2$ as

$$\tilde{s}_1 = h_1^* r_1 + h_2 r_2^* = (\alpha_1^2 + \alpha_2^2) s_1 + h_1^* n_1 + h_2 n_2^*$$
$$\tilde{s}_2 = h_2^* r_1^* - h_1 r_2^* = (\alpha_1^2 + \alpha_2^2) s_2 - h_1 n_2^* + h_2^* n_1 \qquad (4)$$

The ML detector then calculates the decision metric for all combinations of s_1 and s_2 and chooses the one which minimizes it. The decision metric has been given in equation (5).

$$\left|r_1 - h_1 s_1 - h_2 s_2\right|^2 + \left|r_2 + h_1 s_2^* - h_2 s_1^*\right|^2 \qquad (5)$$

Conjugating the signal r_2 in (2) that has been received in the second symbol period, the received signal may be written equivalently as

$$r_1 = h_1 s_1 + h_2 s_2 + \tilde{n}_1$$
$$r_2 = -h_1^* s_2 + h_2^* s_1 + \tilde{n}_2 \qquad (6)$$

over all possible values of s_1 and s_2 . Expanding this and deleting terms that has independent of the code words, the above minimization reduces to separately minimizing

$$\left|r_1 h_1^* + r_2^* h_2 - s_1\right|^2 + \left(\alpha_1^2 + \alpha_2^2 - 1\right)\left|s_1\right|^2 \qquad (7)$$

for detecting s_1 and

$$\left|r_1 h_2^* + r_2^* h_1 - s_2\right|^2 + \left(\alpha_1^2 + \alpha_2^2 - 1\right)\left|s_2\right|^2 \qquad (8)$$

for decoding s_2 .

IV. SIMULATION AND DISCUSSION

First a random bit stream has been generated. Then signal power level can be defined and using the encoding scheme the symbols are generated that are supposed to be transmitted. The encoded symbols can be transmitted through multipath faded channel. Here channel can be assumed to be flat faded and channel distortion can be assumed to be multipath. The channel can be generated as CN (m,N) where CN stands for circularly symmetric Gaussian random variable, m is mean and N is variance. The symbols have been estimated at the receiver using ML detection. Then AWGN can be added in the system which has been generated using normally distributed and generated as N (0, 1), where N stands for normally distributed RV with 0 mean and variance 1. The system performance has then checked at different values of SNR and for different modulation schemes.10,000 symbols have been generated for each simulation and then the BER Vs SNR curves are plotted.

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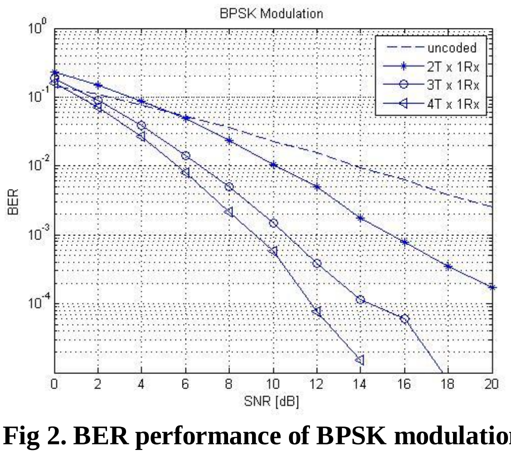

Fig 2. BER performance of BPSK modulation scheme for different antennas under Rayleigh fading environment

Fig 2 shows the BER performance of BPSK modulation scheme for different antennas under Rayleigh fading environment. Table 1 shows the BER Performance of BPSK modulation scheme for 2 transmitting and 1 receiving antenna under Rayleigh fading environment.

Table 1: BER performance of BPSK modulation scheme for 2 transmitting and 1 receiving antenna under Rayleigh fading environment

Signal to Noise Ratio (SNR)	Bit Error Rate (BER)
0	0.219
2	0.190
4	0.099
6	0.075
8	0.055
10	0.018
12	0.009
14	0.005
16	0.002
18	0.0007
20	0.00022

Table 2 shows the BER performance of BPSK modulation scheme for 2 transmitting and 1 receiving antenna under Rayleigh fading environment. By comparing figures 2 and 3, it is clear that with increasing transmitting antennas, BER rapidly decreases as compare to BPSK modulation scheme and tables 1 and 2, it is clear that BER decreases with increasing SNR.

Table 2: BER performance of BPSK modulation scheme for 3 transmitting and 1 receiving antenna under Rayleigh fading environment

Signal to Noise Ratio (SNR)	Bit Error Rate (BER)
0	0.211
2	0.130
4	0.075
6	0.055
8	0.0115
10	0.0050
12	0.0013
14	0.0012
16	0.0010
18	0.00005
20	0.00001

Table 3 shows BER performance of BPSK modulation scheme for 4 transmitting and 1 receiving antenna under Rayleigh fading environment. From figure 5.1 and table 5.3, it can be concluded that with increasing SNR, BER decreases when 4 transmitting and 1 receiving antennas of STBC using Alamouti scheme but it has lower BER as compared to using 2 transmitting and 3 transmitting antennas.

Table 3: BER performance of BPSK modulation scheme for 4 transmitting and 1 receiving antenna under Rayleigh fading environment

Signal to Noise Ratio (SNR)	Bit Error Rate (BER)
0	0.200
2	0.119
4	0.073
6	0.040
8	0.008
10	0.002
12	0.0007
14	0.00018
16	0.00002
18	0.00009
20	0.00004

V. CONCLUSION

From results, it has been concluded that Space-time block codes with larger number of transmit antennas always give better performance than space-time block codes with lower number of transmit antennas due to lager number of transmit antennas that has larger transmission matrices which means transmitting more data. This would give the receiver the ability to recover the transmitted data.

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