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PERFORMANCE ANALYSIS OF NARROWBAND MIMO CHANNEL IN AD HOC NETWORK

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Abstract- *Multiple-Input and Multiple-Output or MIMO has become an essential element of wireless communication standards including the use of multiple antennas at the transmitter and the receiver. In modern usage, MIMO refers to a practical technique for sending and receiving more than one data signal simultaneously over the same radio channel by exploiting multipath propagation. the use of orthogonal frequency division multiplexing to encode the channels that's responsible for the increase in data capacity.The narrowband MIMO performance is used to enhancechannelestimation in wireless MIMO ad hoc systems. In this paper we develop a model of MIMO ad hoc and measure the performance the network using the maximum likelihood (ML) estimator to formulate the channel model and measures the bit error rate (BER) in terms of signal to noise ratio (SNR) considering the Rayleigh fading channel with different number of receiver combination. Finally, we simulate a network implementing the Alamouti coding scheme and results are shown for the channel estimation.*

Keywords— MIMO,Maximum Likelihood Channel Estimation,Alamouti Coding,fading channel.

I. INTRODUCTION

In wireless communicationsystem, MIMO plays an important role of multiplexing-diversity tradeoff betweenspace-time and space-time block coding by improvingthe process of sending same data simultaneously through multiple antennasusing a single communication carrier sense channel[1,2].

MIMO Alamouti coding scheme is used here because of its advantage that transmit diversity scheme for two transmit antennas that does not require transmit channel knowledge

In our scheme, the data is split into multiple data streams at the transmission point and recombined on the receive side by another MIMO radio configured with the same number of antennas[3,4]. The receiver is designed to take into account the slight time difference between receptions of each signal, any additional noise or interference, and even lost signals [5,6].

In this paper we have made performance analysis of the Narrowband MIMO channel by deriving the formulas with Maximum Likelihood Channel Estimation method.Finally the simulated results are shown by predictingBit Error ProbabilityusingAlamouti Coding in the fading channel[7,8] .

II. SYSTEM MODEL

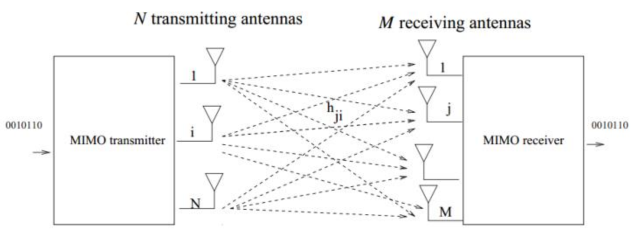

Figure1- MIMO Channel Model with a Receiver Diversity Combination.

Let us assume that $\mathbf{D}_p$ is a random function of **H**.The definition of the likelihood function of **H** is given by p($\mathbf{D}_p$|**H**), where p(.) is a multivariate probability density function. So, the maximum likelihood (ML) estimate of H is given by,

$$\widehat{\boldsymbol{H}}_{ML} \triangleq \arg\max p(\boldsymbol{D}_p\,|\boldsymbol{H}) \qquad \text{..... (Eqn.1.1)}$$

From equation 1.1 we can see that if **Z** consists of independent Gaussian elements that are temporally and spatially white, then the ML channel estimate becomes,

$$\widehat{\boldsymbol{H}}_{ML} = \arg\min ||\boldsymbol{D}_p - \sqrt{\rho}\boldsymbol{H}\boldsymbol{S}_p||_F^2 \qquad \text{.... (Eqn. 1.2)}$$

Now, let us take the derivative of $||\boldsymbol{D}_p - \sqrt{\rho}\boldsymbol{H}\boldsymbol{S}_p||_F^2$ rom Eqn 1.2 with respect to **H.** Then solve the equation for H, we get,

$$C \triangleq ||\boldsymbol{D}_p - \sqrt{\rho}\boldsymbol{H}\boldsymbol{S}_p||_F^2$$

$$= Tr\{(\boldsymbol{D}_p - \sqrt{\rho}\boldsymbol{H}\boldsymbol{S}_{\boldsymbol{p}})(\boldsymbol{D}_p - \sqrt{\rho}\boldsymbol{H}\boldsymbol{S}_{\boldsymbol{p}})^H$$

$$= Tr\{\boldsymbol{D}_p\boldsymbol{D}_p^H - \sqrt{\rho}\boldsymbol{D}_p\boldsymbol{S}_p^H\boldsymbol{H}^H - \sqrt{\rho}\boldsymbol{H}\boldsymbol{S}_{\boldsymbol{p}}\boldsymbol{D}_p^H + \rho\boldsymbol{H}\boldsymbol{S}_p\boldsymbol{S}_p^H\boldsymbol{H}^H)\text{..... (Eqn. 1.3)}$$

Now, we have to Solve $\frac{\partial C}{\partial \boldsymbol{H}}$ = 0, we will use the matrix theorem, which states that for any two matrices, **A** and **B**, $\frac{\partial(Tr(\boldsymbol{AB}))}{\partial \boldsymbol{B}} = \boldsymbol{A}^T$. Therefore,

$$\frac{\partial C}{\partial \boldsymbol{H}} = -\sqrt{\rho}\frac{\partial}{\partial \boldsymbol{H}}Tr\{\boldsymbol{H}\boldsymbol{S}_p\boldsymbol{D}_P^H\} + \rho\frac{\partial}{\partial \boldsymbol{H}}Tr\{\boldsymbol{H}\boldsymbol{S}_P\boldsymbol{S}_P^H\boldsymbol{H}^H\}$$

$$= -\sqrt{\rho}(\boldsymbol{S}_p\boldsymbol{D}_P^H)^T + \rho(\boldsymbol{S}_P\boldsymbol{S}_P^H\boldsymbol{H}^H)^T$$

$$= -\sqrt{\rho}(\boldsymbol{D}_P^*\boldsymbol{S}_P^T) + \rho(\boldsymbol{H}^*\boldsymbol{S}_P^*\boldsymbol{S}_P^T) = 0 \quad \text{..... (Eqn. 1.4)}$$

From Eqn 1.4 we can solve that,

$$\rho\boldsymbol{H}^*\boldsymbol{S}_P^*\boldsymbol{S}_{\boldsymbol{P}}^{\boldsymbol{T}} = \sqrt{\rho}\boldsymbol{D}_P^*\boldsymbol{S}_P^T$$

$$===>\boldsymbol{H}^* = \frac{1}{\sqrt{\rho}}(\boldsymbol{D}_P^*\boldsymbol{S}_P^T)(\boldsymbol{S}_P^*\boldsymbol{S}_P^T)^{-1}$$

$$===>\widehat{\boldsymbol{H}}_{ML} = \frac{1}{\sqrt{\rho}}(\boldsymbol{D}_P^*\boldsymbol{S}_P^T)^*[(\boldsymbol{S}_P^*\boldsymbol{S}_P^T)^{-1}]^*$$

$$===>\widehat{\boldsymbol{H}}_{ML} = \frac{1}{\sqrt{\rho}}(\boldsymbol{D}_P\boldsymbol{S}_P^H)[(\boldsymbol{S}_P^*\boldsymbol{S}_P^T)^*]^{-1}$$

$$===>\widehat{\boldsymbol{H}}_{ML} = \frac{1}{\sqrt{\rho}}(\boldsymbol{D}_P\boldsymbol{S}_P^H)(\boldsymbol{S}_P\boldsymbol{S}_P^H)^{-1} \qquad \text{.... (Eqn. 1.5)}$$

We Shall note that the preceding sequence of operations has taken into account that: a) the trace operation is linear ; b) the transpose of a product of arrays is the product of the transposes of the individual arrays in reverse order. It has also taken into account that for any square array **A**,$(\boldsymbol{A}^*)^{-1} = (\boldsymbol{A}^{-1})^*$

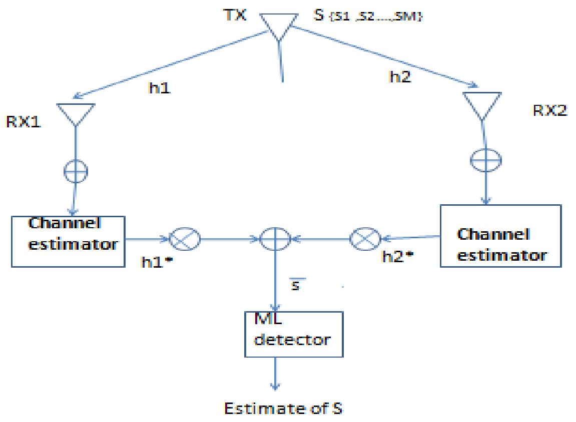

Figure2- Estimator of a receiver with MLdetection.

III. SIMULATION RESULT

The Figure 1 shows the bit error rate performance associated with TM based matrices and Alamouti coding in Rayleigh fading. The simulated results predicts the bit error probability associated with Alamouti Coding. The Two sets of curves associated with$\mathbf{N_r=1}$ and $\mathbf{N_r=2}$ are shown. In each set, results are shown assuming perfect knowledge of the channel (the solid curve) as-

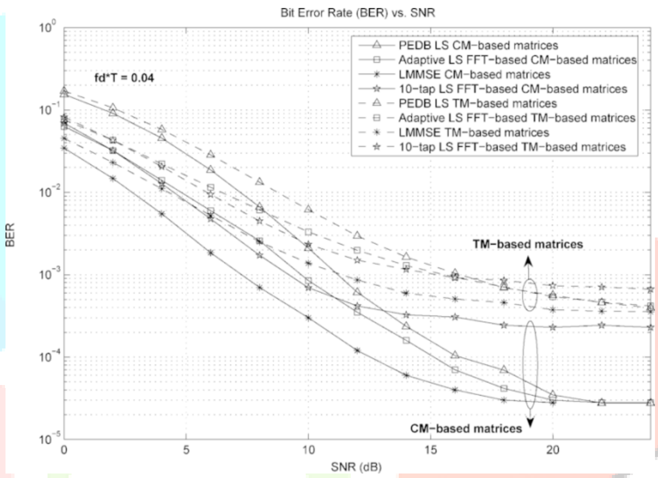

Figure 3- Alamouti Performance showing the impact of channel estimation error on bit error probability.

as well as predictions based on performing ML/LS channel estimation uing pilot matrices with lengths equal to two and four symbols. The results in this plot assume Rayleigh fading, BPSK modulation, and the following the two pilot matrices for p=2 and p=4 curves:

$$\text{p=2:} \quad S_p = \frac{1}{\sqrt{2}}\begin{pmatrix} \mathbf{1} & \mathbf{1} \\ \mathbf{1} & \mathbf{-1} \end{pmatrix},$$

$$\text{p=4:} \quad \boldsymbol{S_p} = \frac{1}{\sqrt{2}}\begin{pmatrix} \mathbf{1} & \mathbf{1} \\ \mathbf{1} & \mathbf{-1} \end{pmatrix}\begin{pmatrix} \mathbf{-1} & \mathbf{-1} \\ \mathbf{1} & \mathbf{-1} \end{pmatrix}$$

From These results we can learn that even with imperfect knowledge of the channel, the slopes and, hence, the diversity orders, are not impacted. We can also note that even with the short pilot matrices assumed in this simulation, the performance degradation is relatively modest, ranging from about 1.75 to 3 dB of p=4 and 2 , respectively.

Figure 2 shows similar computer simulation results for a 2x2 MIMO system employing ZF-IC spatial multiplexing in Rayleigh Fading. The pilot matrices defined in Equations above are also assumed in this figure. Again, we observe that the diversity order is unaffected by the channel estimation process and that the degradation in performance varies from about 2 to 3 dB for p=4 and p=2 respectively.

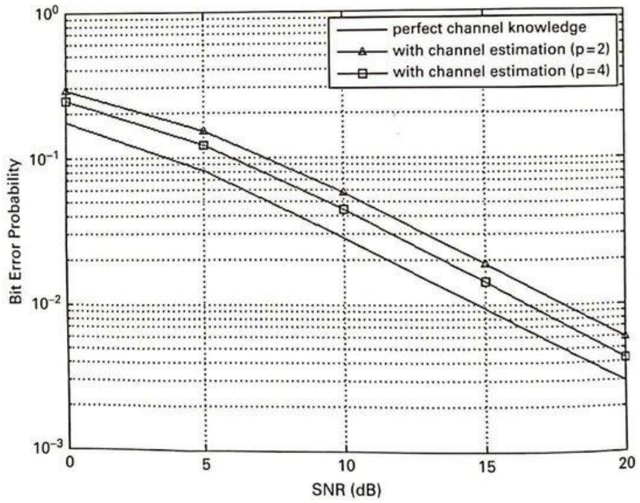

Figure 4- ZF-IC performance showing the impact of channel estimaton error on bit error probability. These results assume that N_t=N_r=2.

IV. CONCLUSION

In this paper we have predicted the bit error rate (BER) for Alamouti system for the certain modulation scheme in Rayleigh fading environment. The practical implementation is used here to derived the expression of channel estimation and finding BER in terms of signal to noise ratio (SNR)by using Alamouti coding in Rayleigh fading channelwith different number of receiver combination. In future we want to measure the BER for maximal ratio receives combining (MRRC) for a comparative study of Alamouti coding with same environment of Rayleigh fading.

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