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PERFORMANCE ANALYSIS OF MIMO RELAY SYSTEM IN RAYLEIGH FADING CHANNEL

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Abstract- *In this paper, In radio multiple-input and multiple output, or MIMO is a method for multiplying the capacity of a radio link using multiple transmit and receive antennas to exploit multipath. A relay channel is a probability model of the communication between a sender and a receiver aided by one or more intermediate relay nodes. The OSTBC Encoder block encodes an input symbol sequence using orthogonal space-time block code(OSTBC).In telecommunication(MRC) is a method of diversity combining in which the signals form each channel are added together, the gain of each channel is made proportional to the rms signal level and inversely proportional to the mean square noise level in that channel. Signal to noise ratio is a measure used in science and engineering that compares the level of a desired signal to the level of background noise. S/N ratio is defined as the ratio of signal power to the noise power often expressed in decibels.*

Keywords: *- MIMO relay channel, BER(Bit Error Rate)*

1. Introduction:

Relay channels will play a central role in next-generation wireless systems. If a source wants to send a message to a distant sink in a relatively dense network, it can forward the message via several intermediate nodes. This would improve overall throughput and coverage.

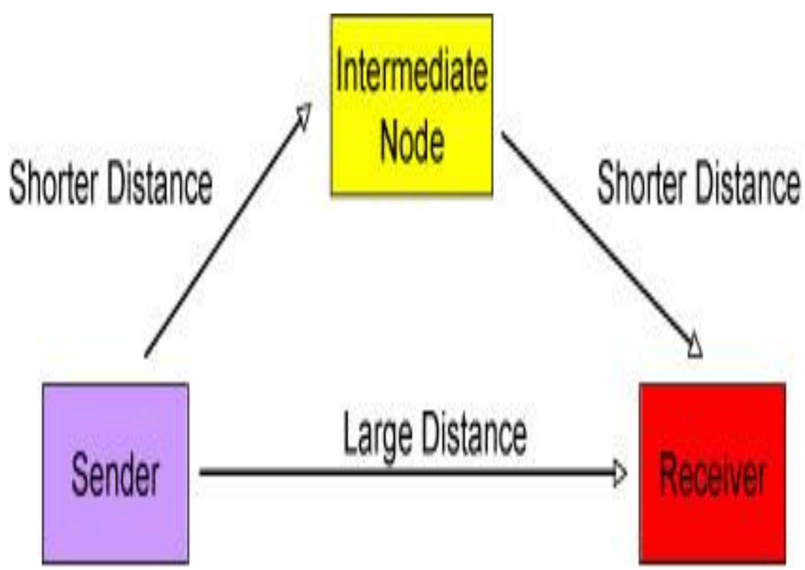
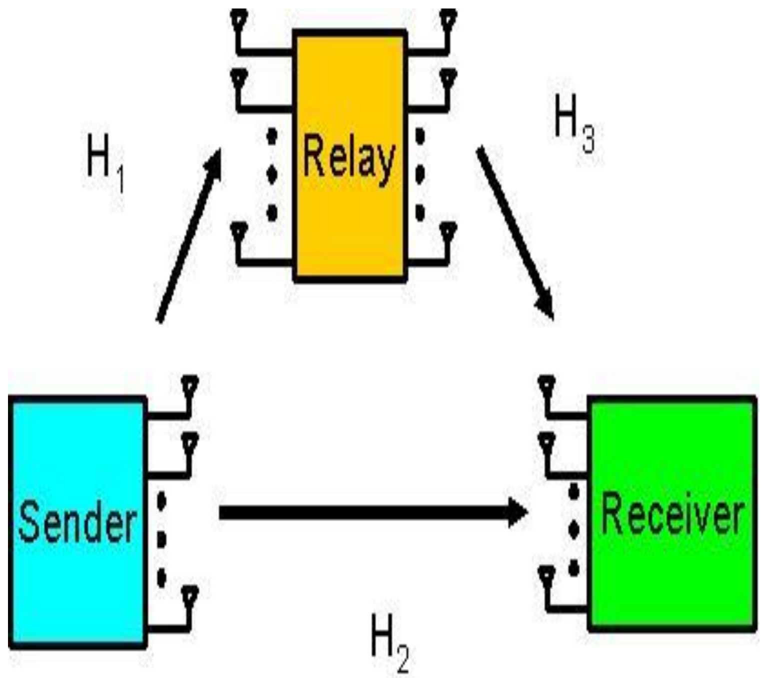


Fig.1 MIMO Relay Channel

We can consider SISO relay channels, where each terminal employs a single antenna. Under this setup, though, there are channel conditions where the relay may not be able to assist the source in its transmission. For example, the minimum of the source-relay and relay-sink channel gains may be less than the source-sink channel gain. We can avoid this issue by considering MIMO relay channels, where each terminal employs multiple antennas. Under this setup, we can exploit the multiple antennas at the source and the relay to perform more sophisticated encoding and decoding schemes, which will lead to improved performance.[1]



The signal outage probability is fairly simple to compute if one knows the probability distribution of the fading (e.g. Rayleigh or Rician) and outage occurs if the signal drops below the noise power level. The derivation involves an integration over the pdf of wanted and interfering signal power.[2]

2. SNR(Signal-to-noise ratio):- Short for **s***ignal-to-***n***oise* **r***atio*, the ratio of the amplitude of a desired analog or digital data signal to the amplitude of noise in a transmission channel at a specific point in time. SNR is typically expressed logarithmically in decibels (dB).

SNR measures the quality of a transmission channel or an audio signal over a network channel. The greater the ratio, the easier it is to identify and subsequently isolate and eliminate the source of noise. A SNR of zero indicates that the desired signal is virtually indistinguishable from the unwanted noise.

In Information theory, outage probability of a communication channel is the probability that a given information rate is not supported, because of variable channel capacity. Outage probability is defined as the probability that information rate is less than the required threshold information rate. It is the probability that an outage will occur within a specified time period.[1]

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3. BER ANALYSIS: . The bit error rate (BER) is the number of bit errors per unit time. The bit error ratio (also BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. Bit error ratio is a unitless performance measure, often expressed as a percentage.
In a 2×2 MIMO channel, probable usage of the available 2 transmit antennas can be as follows:

1. Consider that we have a transmission sequence, for example $\{x_{1,} x_{2,} x_{3,} ......, x_n\}$

2. In normal transmission, we will be sending x_1 in the first time slot, x_2 in the second time slot, x_3 and so on.

3. However, as we now have 2 transmit antennas, we may group the symbols into groups of two. In the first time slot, send x_1 and x_2 from the first and second antenna. In second time slot, send x_3 and x_4 from the first and second antenna, send x_5 and x_6 in the third time slot and so on.

4. Notice that as we are grouping two symbols and sending them in one time slot, we need only $\frac{n}{2}$ time slots to complete the transmission – data rate is doubled.

5. This forms the simple explanation of a probable MIMO transmission scheme with 2 transmit antennas and 2 receive antennas.

$$p(n) = \frac{1}{\sqrt{2\Pi\sigma^2}} e^{\frac{-(n-\mu)^2}{2\sigma^2}} \text{ with } \mu = 0 \text{ and } \sigma^2 = \frac{N_0}{2}$$

Minimum Mean Square Error(MMSE) equalizer for 2x2 MIMO Channel-

Let us now try to understand the math for extracting the two symboles which interfered with each other.In the first time slots, the recived signal to first reciver antenna is,

$$y_1 = h_1,1x_1 + h_1,2x_2 + n_1 = [h_{1,1}h_{1,2}]\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + n_1$$

The recived signal on the second reciver antenna is

$$y_2 = h_2,1x_1 + h_2,2x_2 + n_2 = [h_{2,1}h_{2,2}]\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + n_2$$

Where

y_1, y_2 are the received symbol on the first and second antenna respectively,

$h_{1,1}$ is the channel form 1^{st} transmit antenna to 1^{st} receive antenna,

$h_{1,2}$ is the channel form 2^{nd} transmit antenna to 1^{st} receive antenna,

$h_{2,1}$ is the channel form 1^{st} transmit antenna to 2^{nd} receive antenna,

$h_{2,2}$ is the channel form 2^{nd} transmit antenna to 2^{nd} receive antenna,

x_1, x_2 are the transmitted symbols and

n_1, n_2 is the noise on $1^{st}, 2^{nd}$ receive antennas.

We assume that the receiver knows $h_{1,1}, h_{1,2}, h_{2,1}, h_{2,2}$ The receiver also knows y_1 and y_2 For convenience, the above equation can be represented in matrix notation as follows.

$$\begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} h_{1,1} & h_{1,2} \\ h_{2,1} & h_{2,2} \end{pmatrix}\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} n_1 \\ n_2 \end{pmatrix}$$

Equivalently,

$$y = Hx + n$$

The Minimum Mean Square Error (MMSE) approach tries to find a coefficient w which minimizes the criterion,

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

Solving,

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

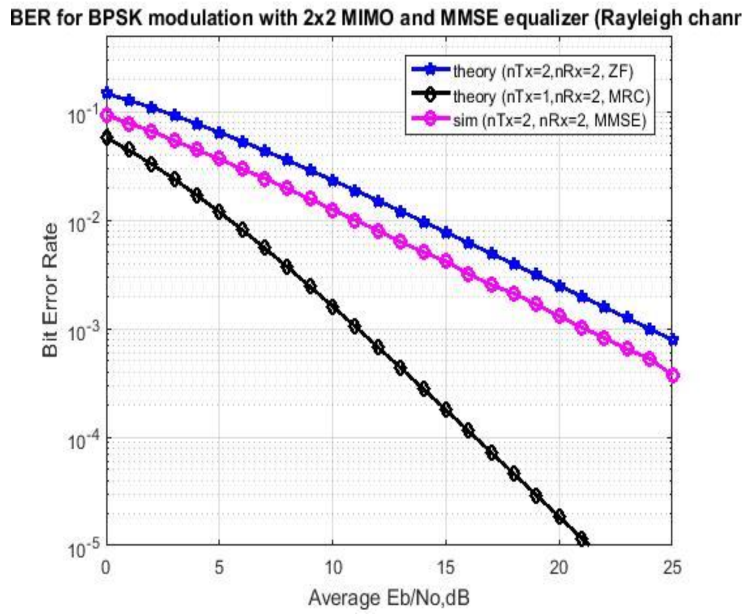

Fig.3 BER plot for 2x2 MIMO with MMSE equalization for BPSK in Rayleigh channel.

In telecommunication, maximum ratio combining (MRC) is a method of diversity combining in which the signals from each channel are added together, the gain of each channel is made proportional to the rms signal level and inversely proportional to the mean square noise level in that channel.

A minimum mean square error (MMSE) estimator is an estimation method which minimizes the mean square error (MSE) which is a common measure of estimator quslity, of the fitted values of a dependent variable.

CONCLUSION:

We have developed the theory of MIMO relay, Rayleigh fading channel and space-time block coding, a simple and elegant method for transmission using multiple transmit antennas in wireless Rayleigh and Rician environment. These codes have a very simple maximum likelihood decoding algorithm which is only based on linear processing. we also present lower bounds on the MIMO relay channel capacity and provide algorithms to compute the bounds.

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