



Interference Elimination in Wireless Networks using Chi-Square random variable

B.Anil kumar¹, Dr.P.Trinath Rao²

Research Scholar, Dept. of ECE, GITAM University, Hyderabad, Andhra Pradesh, India ¹

Associate Professor, Dept. of ECE, GITAM University, Hyderabad, Andhra Pradesh, India ²

ABSTRACT: In multiple access channels, when users know each other's channels, precoders can be designed utilizing channel information to cancel the interference at the receiver without sacrificing the diversity or the complexity of the system. Previous papers contain one transmitter and number of receivers. Now we extend this with two antennas and two receivers. Those have same frequency or different. The results are shown in data as bits. To solve this problem for used the techniques of Maximal Combine Ratio (MCR) and Maximal likelihood receiver. Transmission of data using BPSK (Binary Phase Shift Keying) modulation scheme.

Key Words: MRC, Maximal likelihood receiver, AWGN

I. INTRODUCTION

Number of users increase in the any wireless systems needs number of Antennas are increase. Because every user had a antenna within the dynamic device. Using that antenna we receive or transmit signals. In market Lot of operators are there. Each operator had his own antennas. There is a chance to occur crosstalk between same channel or different channels. Means one operator signal is overlapped with another operator signal that we call as interference. To minimize that interference problems lot of solutions were invented. Depend on the author different techniques are used. Example of that one is in previous MIMO solves using Space Time Block Codes.

In this paper we solutes that problem with Maximal Ratio Combining (MRC) and Maximum likelihood receiver technique. In last versions this technique is used at N receive antennas and one transmit antenna. Now we take two antennas for transmitting and two antennas for receiving the signals. In this paper we took data as group of bits. That group contains the data of 1 and -1. That group of data transmitting through channel. Generally within the free space some noise is added. That noise is taken here as additive white Gaussian noise (AWGN). Using Maximal Raito Combine (MRC) we combine the group data and noise. At the receiver using of Maximum likelihood Receiver we received the data without any interference. That result will show in simulation result chapter. In next chapters first we designing the MRC for N receive antennas and one transmit antenna. Later we extend the technique for MIMO which is two transmitters and two receivers.



II. DESIGNING APPROACH

A. Maximal Ratio Combine (MRC)

The channel is flat fading – In simple terms, it means that the multipath channel has only one tap. So, the convolution operation reduces to a simple multiplication. The channel experienced by each receive antenna is randomly varying in time. For the i^{th} receive antenna, each transmitted symbol gets multiplied by a randomly varying complex number h_i . As the channel under consideration is a Rayleigh channel, the real and imaginary parts of h_i are Gaussian distributed having mean $\mu_{h_i} = 0$ and variance $\sigma_{h_i}^2 = \frac{1}{2}$. The channel experience by each receive antenna is independent from the channel experienced by other receive antennas. On each receive antenna, the noise n has the Gaussian probability

density function with
$$p(n) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(n-\mu)^2}{2\sigma^2}}$$
 with $\mu = 0$ and $\sigma^2 = \frac{N_0}{2}$.

The noise on each receive antenna is independent from the noise on the other receive antennas. At each receive antenna, the channel h_i is known at the receiver. In the presence of channel h_i , the instantaneous bit energy to noise ratio at i^{th} receive antenna is $\frac{|h_i|^2 E_b}{N_0}$.

For notational convenience, let us define $\gamma_i = \frac{|h_i|^2 E_b}{N_0}$.

ASSUMPTIONS:

On the i^{th} receive antenna, the received signal is $y_i = h_i x + n_i$ where y_i is the received symbol on the i^{th} receive antenna, h_i is the channel on the i^{th} receive antenna, x is the transmitted symbol and n_i is the noise on i^{th} receive antenna. Expressing it in matrix form, the received signal is, $\mathbf{y} = \mathbf{h}\mathbf{x} + \mathbf{n}$, where $\mathbf{y} = [y_1 y_2 \dots y_N]^T$ is the received symbol from all the receive antenna $\mathbf{h} = [h_1 h_2 \dots h_N]^T$ is the channel on all the receive antenna \mathbf{x} is the transmitted symbol $\mathbf{n} = [n_1 n_2 \dots n_N]^T$ is the noise on all the receive antenna. The equalized symbol is, It is intuitive to note that the term,

$$\mathbf{h}^H \mathbf{h} = \sum_{i=1}^N |h_i|^2$$

i.e. sum of the channel powers across all the receive antennas.

Effective E_b/N_0 with Maximal Ratio Combining (MRC):



To simulate for the internal noise is added. That is assumed as, we noted that in the presence of channel h_i , the instantaneous bit energy to noise ratio at i^{th} receive antenna is

$$\gamma_i = \frac{|h_i|^2 E_b}{N_0}$$

Given that we are equalizing the channel with h^H , with the N receive antenna case, the effective bit energy to noise ratio is,

$$\begin{aligned} \gamma &= \sum_{i=1}^N \frac{|h_i|^2 E_b}{N_0} \\ &= N \gamma_i \end{aligned}$$

Effective bit energy to noise ratio in a N receive antenna case is N times the bit energy to noise ratio for single antenna case shown in results Fig: 3.1.

B. Error Rate with CHI-SQUARE Random Variable

From the discussion on chi-square random variable, we know that, if h_i is a Rayleigh distributed random variable, and then h_i^2 is a chi-squared random variable with two degrees of freedom. The pdf of γ_i is

$$p(\gamma_i) = \frac{1}{(E_b/N_0)} e^{-\frac{\gamma_i}{(E_b/N_0)}}$$

Since the effective bit energy to noise ratio γ is the sum of N such random variables, the pdf of γ is a chi-square random variable with $2N$ degrees of freedom. The pdf of γ is

$$p(\gamma) = \frac{1}{(N-1)!(E_b/N_0)^N} \gamma^{N-1} e^{-\frac{\gamma}{(E_b/N_0)}}, \quad \gamma \geq 0$$

Here we added some noise which means the Bit Error Rate (BER) is occurred. In the post on BER computation in AWGN, with bit energy to noise ratio of $\frac{E_b}{N_0}$, the bit error rate for BPSK in AWGN is derived as

$$P_b = \frac{1}{2} \text{erfc} \left(\sqrt{\frac{E_b}{N_0}} \right)$$



That the effective bit energy to noise ratio with maximal ratio combining is γ , the total bit error rate is the integral of the conditional BER integrated over all possible values of γ . This equation reduces to

$$P_e = p^N \sum_{k=0}^{N-1} \binom{N-1+k}{k} (1-p)^k, \text{ where}$$

$$p = \frac{1}{2} - \frac{1}{2} \left(1 + \frac{1}{E_b/N_0} \right)^{-1/2}$$

That Resultant BER of graph is shown in Fig3.2.

Now in this paper we solve the problem of two transmitters and two receivers which means multi input and multi output devices (MIMO). Consider that we have a transmission sequence, for example $x_1, x_2, x_3, \dots, x_n$. 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. 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. 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. This forms the simple explanation of a probable MIMO transmission scheme with 2 transmit antennas and 2 receive antennas.

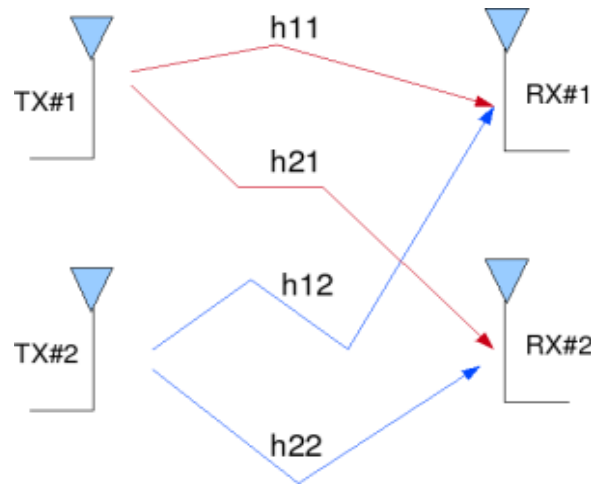


Fig: 2.1 Transmit 2 Receive (2x2) MIMO channel

Let us now try to understand the math for extracting the two symbols which interfered with each other. In the first time slot, the received signal on the first receive antenna is,



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

The received signal on the second receive antenna is

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

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

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

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

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

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

x_1, x_2 are the transmitted symbols and

n_1, n_2 is the noise on 1st, 2nd receive antennas.

C .Multi Input and Multi Output

We assume that the receiver knows $h_{1,1}, h_{1,2}, h_{2,1}$ and $h_{2,2}$. The receiver also knows y_1 and y_2 . The unknowns are x_1 and x_2 .

For convenience, the above equation can be represented in matrix notation as follows:

Equivalently $y = Hx + n$

ASSUMPTIONS:

The channel is flat fading – In simple terms, it means that the multipath channel has only one tap. So, the convolution operation reduces to a simple multiplication. The channel experience by each transmit antenna is independent from the channel experienced by other transmit antennas. For the i^{th} transmit antenna to j^{th} receive antenna, each transmitted symbol gets multiplied by a randomly varying complex number $h_{j,i}$. As the channel under consideration is a



Rayleigh channel, the real and imaginary parts of $h_{j,i}$ are Gaussian distributed having mean $\mu_{h_{j,i}} = 0$ and variance $\sigma_{h_{j,i}}^2 = \frac{1}{2}$.

The channel experienced between each transmit to the receive antenna is independent and randomly varying in time. On the receive antenna, the noise n has the Gaussian probability density function with

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

and $\sigma^2 = \frac{N_0}{2}$. The channel $h_{j,i}$ is known at the receiver.

D. Maximal Likelihood Receiver (ML)

The Maximum Likelihood receiver tries to find \hat{x} which minimizes, $J = |y - H\hat{x}|^2$

Since the modulation is BPSK, the possible values of x_1 is +1 or -1. Similarly x_2 also take values +1 or -1. So, to find the Maximum Likelihood solution, we need to find the minimum from the all four combinations of x_1 and x_2 .

The estimate of the transmit symbol is chosen based on the minimum value from the above four values i.e.

if the minimum is $J_{+1,+1} \Rightarrow [1 \ 1]$

if the minimum is $J_{+1,-1} \Rightarrow [1 \ 0]$,

if the minimum is $J_{-1,+1} \Rightarrow [0 \ 1]$

and

if the minimum is $J_{-1,-1} \Rightarrow [0 \ 0]$.

III. SIMULATION RESULTS



Generate random binary sequence of +1's and -1's. Group them into pair of two symbols and send two symbols in one time slot. Multiply the symbols with the channel and then add white Gaussian noise. Find the minimum among the four possible transmit symbol combinations. Chose that receive path, equalize the received symbols per maximal ratio combining. Perform hard decision decoding and count the bit errors. Based on the minimum chose the estimate of the transmit symbol. Repeat for multiple values of $\frac{E_b}{N_0}$ and plot the simulation and theoretical results.

Fig: 3.1 contains Signal to noise ratio improvement which means the basic development of Maximal Ratio Combining.

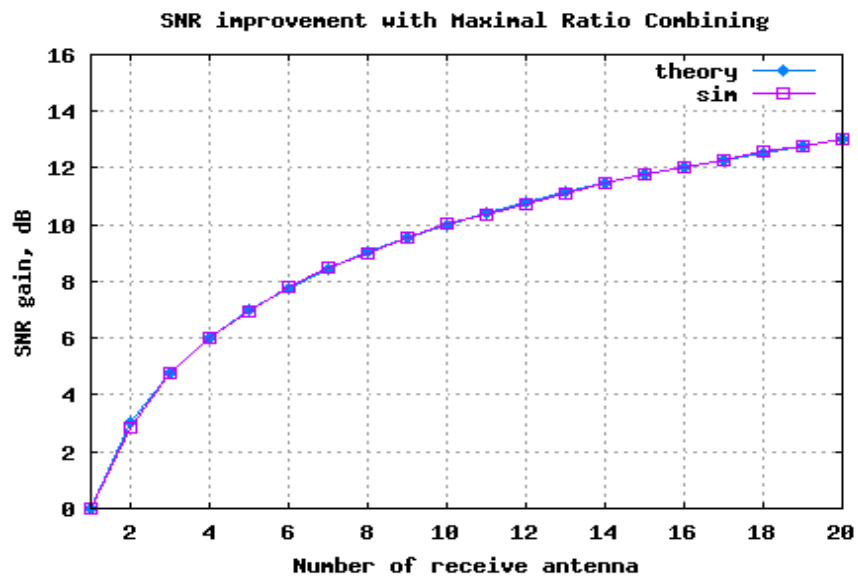


Fig:3.1 Effective SNR with Maximal Ratio Combining in Rayleigh fading channel

Fig 3.2 contains at the transmitter we added Rayleigh function with BPSK modulation scheme. That Bit error rate data is transmitted. At the receiver the antenna received data is shown. Fig:3.3 contains MRC added for multi input and multi output(MIMO). At the receiver using of Maximum likelihood(ML) Receiver the data is received without any interference.



BER for BPSK modulation with Maximal Ratio Combining in Rayleigh

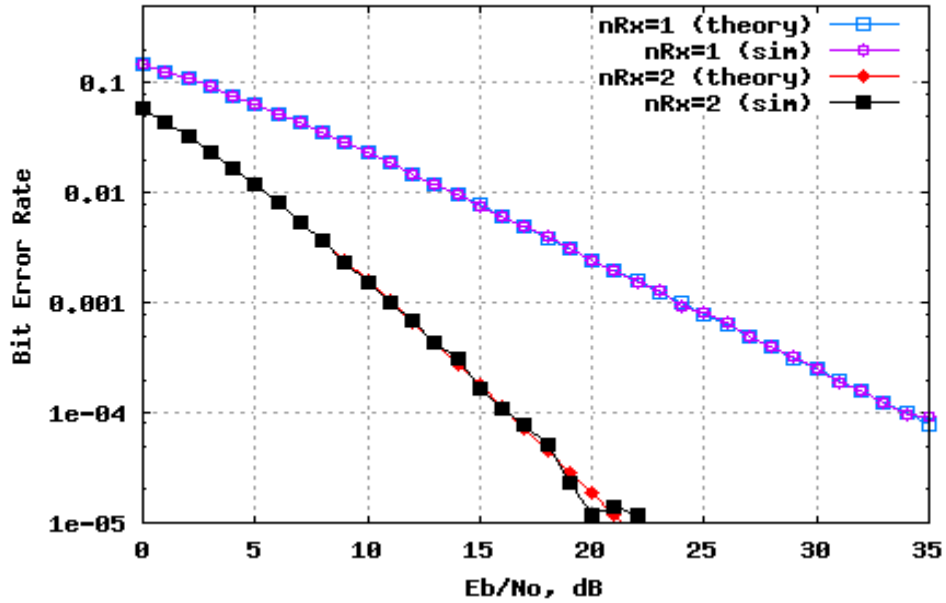


Fig: 3.2 BER plot for BPSK in Rayleigh channel with Maximal Ratio Combining

BER for BPSK modulation with 2x2 MIMO and ML equalizer (Rayleigh

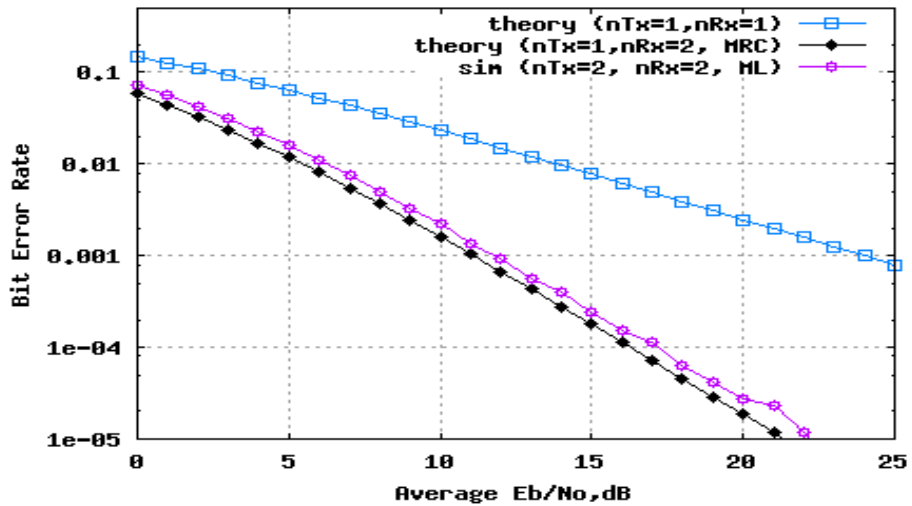


Fig: 3.3 BER plot 2x2 MIMO Rayleigh channel with Maximum Likelihood equalization.



IV. CONCLUSION

In the free space different signals are transmitting from one place to another place. Depend on the phase or frequency we receive the signals at antenna. If the antennas receive the interfered signal there is no use. To eliminate the interference we used the technique of combination of MRC and ML receiver is successfully eliminates the interference of different and internal data.

REFERENCES

- [1]. Y. Wu and A. R. Calderbank, "Code diversity in multiple antenna wireless communication," in *Proc. IEEE International Symp. Inf. Theory*, Toronto, Canada, July 2008.
- [2]. Analysis of Transmit Antenna Selection/Maximal-Ratio Combining in Rayleigh Fading Channels Zhuo Chen ; Sch. of Electr. & Inf. Eng., Univ. of Sydney, NSW, Australia ; Jinhong Yuan ; Vucetic, B, *IEEE Vehicular technology*, july2005.
- [3]. Performance analysis of maximum ratio combining with imperfect channel estimation in the presence of cochannel interferences Kyung Seung Ahn ; Telecommun. R&D Center, Samsung Electron., Suwon ; Heath, R.W. *Wireless Communications, IEEE Transactions on (Volume:8 , Issue: 3)*, March, 2009.
- [4]. An adaptive maximum likelihood receiver for correlated Rayleigh-fading channels *Communications, IEEE Transactions on (Volume:42 , Issue: 9)*, Sep, 1994.
- [5]. Maximum Likelihood Receiver for Multiple Channel Transmission Systems van Etten, W. ; Dept. of Electrical Engineering, Eindhoven Institute of Technology, Eindhoven, The Netherlands *Communications, IEEE Transactions on (Volume:24 , Issue: 2)*, Feb, 1994.
- [6]. <http://www.dsplog.com/2008/07/28/chi-square-random-variable/>
- [7]. <http://www2.econ.iastate.edu/classes/econ500/bunzel/documents/ProbabilitySpecificSlides2.pdf>
- [8] [DIG-COMM-BARRY-LEE-MESSERSCHMITT] Digital Communication: Third Edition, by John R. Barry, Edward A. Lee, David G. Messerschmitt
- [9] Receive diversity – Notes by Prof. Raviraj Adve
- [11] [WIRELESS-TSE, VISWANATH] Fundamentals of Wireless Communication, David Tse, Pramod Viswanath