Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 5, Issue 04, April -2018

PERFORMANCE ANALYSIS OF MULTI HOP RELAY NETWORK IN RAYLEIGH FADING CHANNEL

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Abstract:- *In this paper we present the performance analysis of Bit error rate (BER) of two combining schemes- Maximal ration combining (MRC) and Selection Combining (SC) techniques. In this contribution all the study is based on MATLAB environment when communication over Rayleigh fading channels. A simple BPSK modulation is considered.*

Keywords: *- Rayleigh Fading channel, Bit Error Rate (BER),Diversity*

1. Introduction- Multi Hop Communication and Relaying: In multi hop wireless networks, communication between two end nodes is carried out through a number of intermediate nodes whose function is to relay information from one point to another. Multi hop communication is a wireless network adopting multi hop wireless technology without deployment of wired backhaul links. Relaying systems realize a number of benefits over traditional systems in the areas of deployment, connectivity, adaptability and capacity. In cooperative relay systems, system designers should
be able to exploit both frequency diversity and cooperative diversity, and existing techniques for flat channels need to be adapted or new techniques need to be designed.
Relay is used to receive and transmit the signal between base station and mobile user.

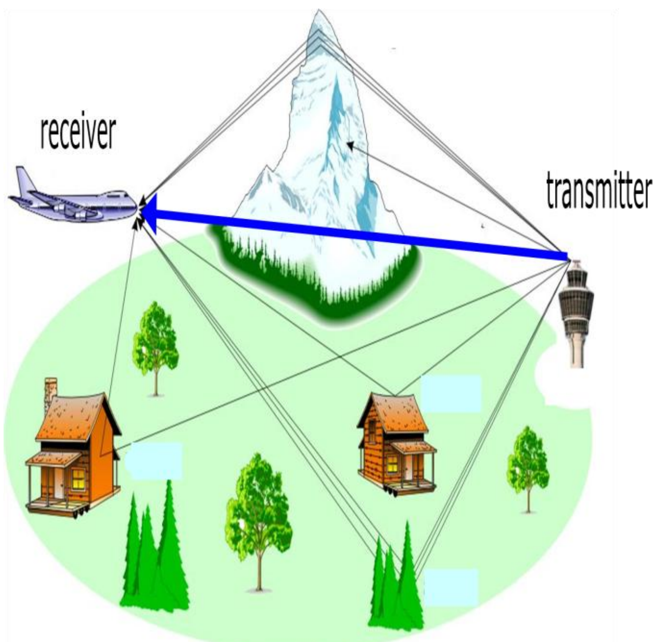

Fig. 1- multi hop communication

Cooperative communication is one of the fastest growing areas of research and it is likely to be a key enabling technology for efficient spectrum use. The key idea in user-cooperation is that of resource-sharing among multiple nodes in a network. The reason behind the exploration of user-cooperation is that willingness to share power and computation with neighboring nodes can lead to savings of overall network resources. Mesh networks provide an enormous application space for user-cooperation strategies to be implemented. In traditional communication networks, the physical layer is only responsible for communication implies a paradigm shift, where the channel is not just one link but the network itself.

Cooperation is possible whenever the number of communicating terminals exceeds two. Therefore, a three-terminal network is a fundamental unit in user-cooperation. The focus of our discussion will be relay channel, and its various extensions.

2. SYSTEM MODEL:-

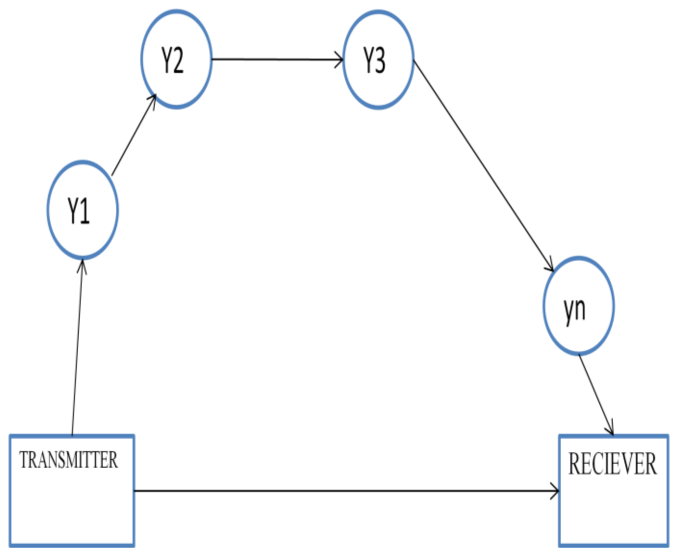

Fig.2- SYSTEM MODEL

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The received signal in **Rayleigh fading channel** is of the form,

$y = hx + n$, where

y is the received symbol,

h is complex scaling factor corresponding to Rayleigh multipath channel

x is the transmitted symbol (taking values +1′s and -1′s) and

n is the Additive White Gaussian Noise (AWGN)

3. BER ANALYSIS: The probability of error for transmission of either +1 or -1 is computed by integrating the tail of the Gaussian probability density function for a given value of bit energy to noise ratio $\frac{E_b}{N_0}$ .The bit error rate is,

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

However in presence of channel h, the effective bit energy to noise ratio is $\frac{|h|^2 E_b}{N_0}$. So the bit error probability for a given value of h is,

$$P_{b/h} = \frac{1}{2} erfc\left(\sqrt{\frac{|h|^2 E_b}{N_0}}\right) = \frac{1}{2} erfc\left(\sqrt{\Upsilon}\right)$$

Where, $\Upsilon = \frac{|h|^2 E_b}{N_0}$

To find the error probability over all random values of $|h|^2$, one must evaluate the conditional probability density function $P_{b/h}$ over the probability density function of Υ.

Probability density function-

We know that if $|h|$ is a Rayleigh distributed random variable, then $|h|^2$ is chi-square distributed with two degree of freedom. Since $|h|^2$ is chi-square distributed, Υ is also chi square distributed. The probability density function of Υ is,

$$P(\Upsilon) = \frac{1}{(E_b/N_0)} e^{\frac{-\Upsilon}{(E_b/N_0)}}, \Upsilon \geq 0$$

Error probability-

So the error probability is,

$$P_b = \int_0^\infty \frac{1}{2} erfc\left(\sqrt{\Upsilon}\right) p(\Upsilon) d\Upsilon$$

This equation reduces to,

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

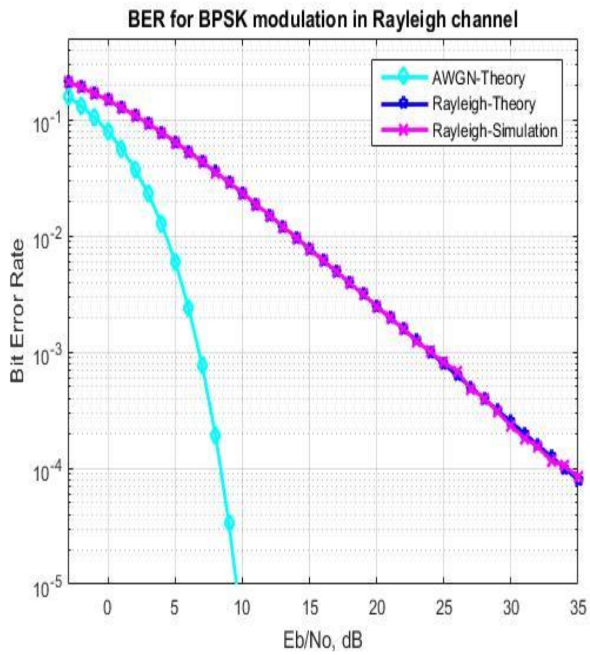

Fig.3- BER plot for BPSK modulation in Rayleigh fading

4. MRC ANALYSIS: Maximal ratio combining (MRC) is a method of diversity combining. The signals of each channel are added together. In Maximal Ratio Combining each signal branch is multiplied by a weight factor that is proportional to the signal amplitude. That is, branches with strong signal are further amplified, while weak signals are attenuated.

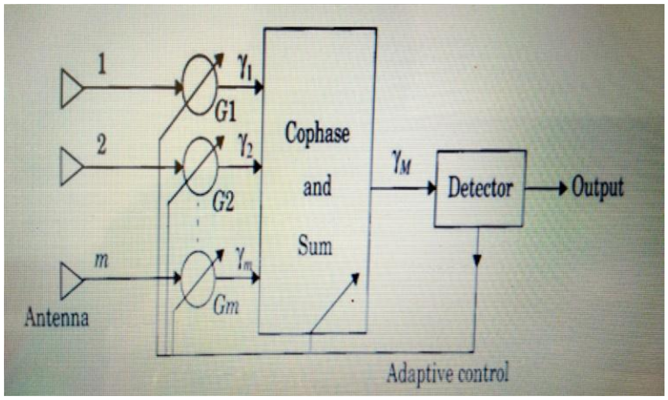

Fig.4- Maximal Ratio Combiner

On the i th receive antenna, the receive signal is,

$y_i = h_i x + n_i$ Where,

y_i is the receive signals 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.

The receive signal is,

$y = hx + n$, where

$y = [y_1 y_{2K} y_N]^T$ is the received symbol from all the receive antenna

$h = [h_1 h_{2K} h_N]^T$ is the channel on all the receive antenna

x is transmitted signals and

$n = [n_1 n_{2K} n_N]^T$ is the noise on all the receive antenna

The equalized symbol is,

$$\hat{x} = \frac{h^H y}{h^H h} = \frac{h^H hx}{h^H h} + \frac{h^H n}{h^H h} = x + \frac{h^H n}{h^H h}$$

It is intuitive to note that the term,

$h^H h = \sum_{i=1}^{N} |h_i|^2$ i.e. sum of the channel powers across all the receive antennas.

ERROR RATE WITH MRC- from the discussion of chi-square random variable, we know that, if h_i is the is a Rayleigh distributed random variable, then h_i^2 is a chi-squared random variable with two degrees of freedom. The pdf of y_i is,

$$P(y_i) = \frac{1}{(E_b/N_0)} e^{-\Upsilon/(E_b/N_0)}$$

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

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

If you recall the with bit energy to noise ratio of $\frac{E_b}{N_0}$, the bit error rate is derived as,

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

Given that the effective bit energy to noise ratio with maximal ratio combining is Υ, the total bit error rate is the integral of the conditional BER integrated over all possible values of Υ.

$$P_e=\int_0^\infty \frac{1}{2}erfc\left(\sqrt{\Upsilon}\right)p(\Upsilon)d\Upsilon$$

$$=\int_0^\infty \frac{1}{2}erfc\left(\sqrt{\Upsilon}\right)\frac{1}{(N-1)!(E_b/N_0)^N}\Upsilon^{N-1}e^{\frac{-\Upsilon}{(E_b/N_0)d\Upsilon}}$$

This equation reduces to,

$$P_e=p^N\sum_{k=0}^{N-1}(N-1\pm k)(1-p)^k$$

where

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

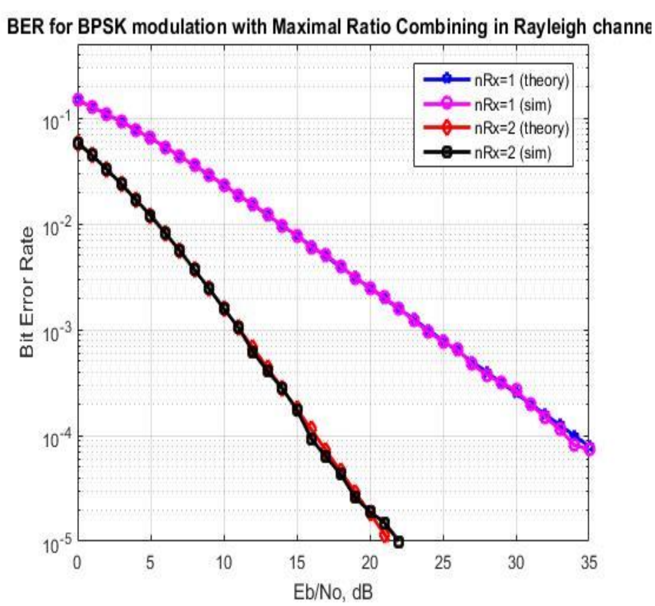

Fig.5- BER plot for BPSK in Rayleigh fading with maximal Ratio Combining Technique.

5. SC ANALYSIS: 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 part of h_i are Gaussian distributed having mean 0 and variance ½. The channel experience by each receive antenna is independent from the channel experienced by other receive antenna.

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.

BIT ERROR PROBABILITY WITH SELECTION DIVERSITY- If we recall, 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,

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

Given that the effective bit energy to noise ratio with selection diversity is Υ, the total bit error rate is the integral of the conditional BER integrated over all possible values of Υ.

$$P_e=\int_0^\infty \frac{1}{2}erfc\left(\sqrt{\Upsilon}\right)p(\Upsilon)\,d\Upsilon$$

$$=\int_0^\infty \frac{1}{2}erfc\left(\sqrt{\Upsilon}\right)\frac{N}{(E_b/N_0)}e^{-\frac{\Upsilon}{(E_b/N_0)}}\left[1-e^{-\frac{\Upsilon}{(E_b/N_0)}}\right]^{N-1}d\Upsilon$$

This equation reduces to,

$$P_e=\frac{1}{2}\sum_{k=0}^{N}(-1)^k\left(N_k\right)\left(1+\frac{k}{(E_b/N_0)}\right)^{-1/2}$$

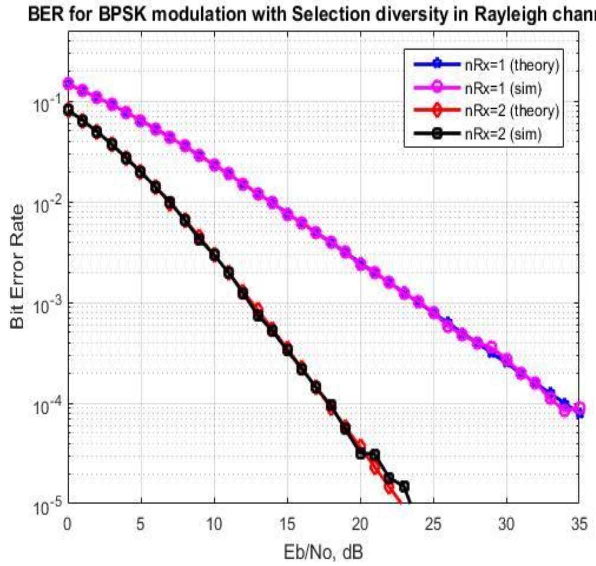

Fig.6- BER plot for BPSK in Rayleigh Channel with selection combining technique

CONCLUSION: In this paper we have generated random variables having Rayleigh fading and then implemented with the two different combing schemes. Then we studied the additive white Gaussian noise. We have introduced the different level of noise in the channel. Analysis for different values is presented. We found that MRC gives minimum values of BER. And SC gives maximum values of BER. All the result are evaluated with the help of monte carlo simulations in MATLAB environment. It is expected that the work presented in the paper will be helpful for diversity schemes in communication systems for obtaining the higher data rates.

REFERENCES

[1] Ahlswede, R.,Cai, N., Li, S.-Y.R., and Yeung, R. W.(2000). Network information flow. *IEEE Trans. Inform. Theory*, 46(4):1204-1216.
[2] Andrea Goldsmith,Stanford university, "Wireless Communications", Cambridge University Press, 2005.
[3] DIG-COMM-BARRY-LEE MESSERSCHMITT Digital Communication: Third Edition, by John R. Barry, Edward A. Lee, David G. Messerschmitt
[4] Theodore S. Rappaport, "Wireless Communication", second edition, pp. 210.
[5] R. Price and P.E. Green, "A communication technique for multipath channels," Proc.IEEE, vol. 46, pp. 555-570, Mar. 1958.
[6] Andrew Sendonaris, ElzsErkip and BehnaamAazhang, "User cooperation diversity part 1: System Description," IEEE Transaction on communication, vol. 51 (2003), pp 1927-1938.
[7] Andrew Sendonaris, ElzsErkip and BehnaamAazhang, "User cooperation diversity part 2: Implementation Aspects and Performance Analysis," IEEE Transaction on communication, vol. 51 (2003), pp 1939-1948.
[8] T. S. Rappaport, Wireless Communication, Chs. 3 and 4, Upper Saddle River, NJ: Prantice Hall, 1996.

