ANALYSIS OF RECIVER DIVERCITY TECHNIUES FOR CAPACITY SCALING IN MIMO WIRELESS SYSTEM

A.Ramesh, P.Bhaskar Rakesh, P.S.S.Sekhara Gupta, J.Ravi Kiran,G.Bhargava
Vignan's Institute Of Inforamaiton Technology, Visakhapatanam

Abstract

In this paper we mainly focus on the information-theoretic capacity of multiple-input multiple-output (MIMO) independent and identically distributed Rayleigh flat-fading channels assuming equal power allocation to each of the transmit antennas. Multiple-antenna systems, MIMO improves the capacity and reliability of wireless communications. MIMO system can improve wireless communication in spatial diversity by different methods. Spatial Diversity is used to improve the system performance in the presence of fading channel. Combining the multiple signals so as to reduce the effects of multiple deep fades the following spatial diversity methods are implemented: Selection Diversity Combining, Scanning Diversity Combining, Maximal Ratio Combining, Equal Gain Combining.

1.Introduction

This paper compares the various diversity techniques in MIMO wireless systems assuming an (i.i.d) independent and identically distributed Rayleigh fading channel [7]. Modern radio communication systems have to provide higher and higher data rates [3,4]. As conventional methods like using more bandwidth or higher order modulation types are limited, new methods of using the transmission channel have to be used. Multiple antenna systems (Multiple Input, Multiple Output – MIMO) gives a significant enhancement to data rate and channel capacity. This application note gives an introduction to basic MIMO concepts and terminology and explains how MIMO is implemented in different radio communications standards.

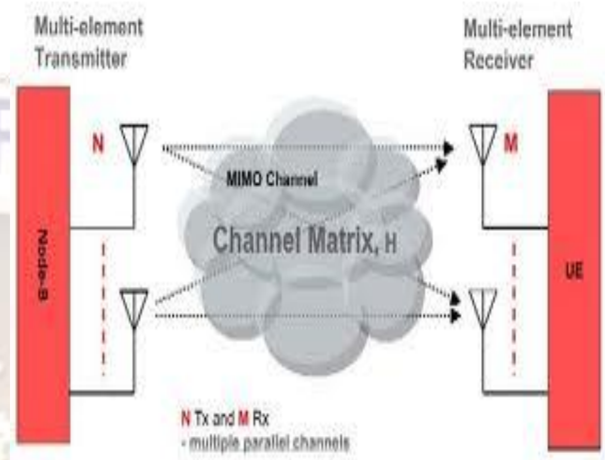

Figure 1.MIMO representation

Diversity techniques can be used to improve system performance in fading channels [11]. Instead of transmitting and receiving the desired signal through one channel, we obtain L copies of the desired signal through M different channels. The idea is that while some copies may undergo deep fades, others may not. We might still be able to obtain enough energy to make the correct decision on the transmitted symbol. However, physical constraints may limit its applications. Sometimes, several transmission antennae are also employed to send out several copies of the transmitted signal.

2.Types of Diversity

There are several different kinds of diversity which are commonly employed in wireless communication systems [2].

A. Frequency Diversity

One approach to achieve diversity is to modulate the information signal through M different carriers. Each carrier should be separated from the others by at least the coherence bandwidth (Δf_c) so that different copies of the signal undergo independent fading. At the receiver, the L independently faded copies are "optimally" combined to give a statistic for decision. The optimal combiner is the maximum ratio combiner, which will be introduced later. Frequency diversity can be used to combat frequency selective fading.

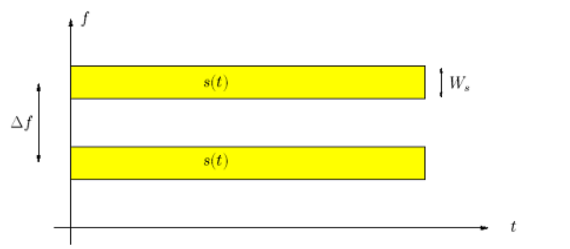

Figure.2 Frequency diversity

B. Time Diversity

Another approach to achieve diversity is to transmit the desired signal in M different periods of time, i.e., each symbol is transmitted M times. The intervals between transmissions of the same symbol should be at least the coherence time $(\Delta t)_c$ so that different copies of the same symbol undergo independent fading. Optimal combining can also be obtained with the maximum ratio combiner. We notice that sending the same symbol M times is applying the (M,1) repetition code. Actually, non-trivial coding can also be used. Error control coding, together with interleaving, can be an effective way to combat time selective (fast) fading.

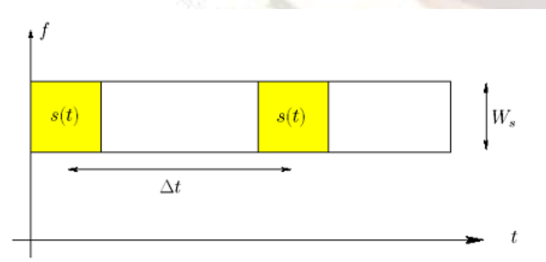

Figure .3 Time diversity

C. Space Diversity

Another approach to achieve diversity is to use M antennas to receive M copies of the transmitted signal. The antenna should be spaced far enough apart so that different received copies of the signal undergo independent fading. Different from frequency diversity and temporal diversity, no additional work is required on the transmission end, and no additional bandwidth or transmission time is required. However, physical constraints may limit its applications. Sometimes, several transmission antennae are also employed to send out several copies of the transmitted signal. Spatial diversity can be employed to combat both frequency selective fading and time selective fading.

As higher as the received signal replicas are decor related, as much as the diversity gain .Diversity Combining MRC outperforms the Selection Combining; Equal gain coordinating.

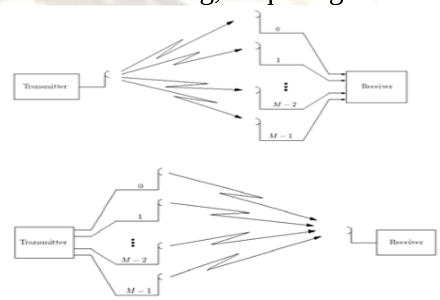

Figure.4 Space diversity

3.Implementation of Diversity techniques

The idea of diversity is to combine several copies of the transmitted signal, which undergo independent fading, to increase the overall received power [11]. Different types of diversity call for different combining methods. Here, we review several common diversity combining methods. For a slowly flat fading channel, the equivalent low-pass of the received signal of branch *k* can be written as

$$r_k(t) = A_k e^{j\theta} s(t) + z_k(t), k = 0,2,....., M-1 \quad (1)$$

where s(t) is the equivalent low-pass of the transmitted signal, $A_k e^{j\theta_k}$ is the fading attenuation of branch k, $Z_k(t)$ is the AWGN.

Out of M branches, M replicas of the transmitted signal are obtained

$$\mathbf{r} = [r_1(t) \;\; r_2(t) \;\; \ldots r_{M-1}(t)] \quad (2)$$

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A. Selection Combining

In this method, the strongest signal branch is selected as shown in Figure 2

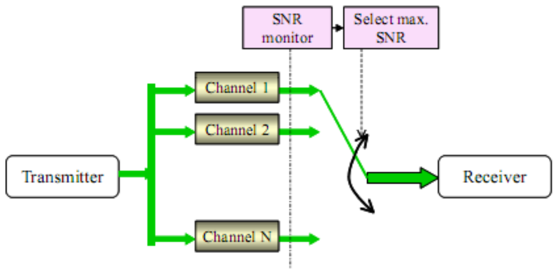

Figure 2. Selection Combining

The combiner output is given by

$$y(t) = Ae^{j\theta_k} s(t) + z(t),$$

$$\text{with} \quad A = \max\{A_0, A_1, ..., A_{M-1}\} \tag{3}$$

The received SNR can be written as follows:

$$\Gamma = A^2 E_b / N_o = \max\{\Gamma_0, \Gamma_1, ..., \Gamma_{M-1}\} \tag{4}$$

With uncorrelated branches, the CDF of is Γ

$$P_\Gamma(\gamma) = \Pr\{\Gamma < \gamma\} = \prod_{k=0}^{M-1} P_{\Gamma_k}(\gamma) \tag{5}$$

For i.i.d branches, we have

$$p_\Gamma(\gamma) = \left[P_{\Gamma_o}(\gamma)\right]^M, \text{ and}$$

$$p_\Gamma(\gamma) = M p_{\Gamma_o}(\gamma)\left[p_{\Gamma_o}(\gamma)\right]^{M-1} \tag{6}$$

Example: Rayleigh Fading Channel

The outage probability is given by

$$P_\Gamma(\gamma) = \left(1 - e^{-\gamma/\gamma_o}\right)^M, \gamma_o = 2\sigma^2 E_b / N_o \tag{7}$$

B. Maximal Ratio Combining

In this method, the diversity branches are weighted for maximum SNR [8] as can be seen in Figure 3.

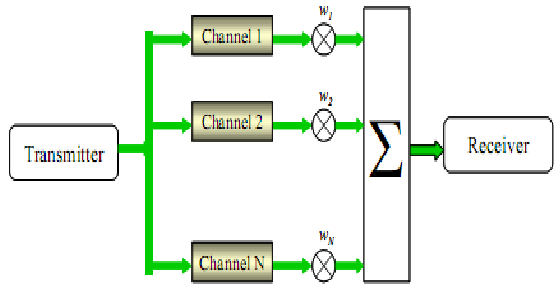

Figure 3.Maximal ratio combining

The combiner output is given by

$$y(t) = \sum_{k=0}^{M-1} w_k r_k(t) \tag{8}$$

Choose the weights to be the channel gain conjugate [must be

estimated]

$$y(t) = \sum_{k=0}^{M-1} A_k e^{-j\theta_k} r_k(t) = \sum_{k=0}^{M-1} A_{ki} e^{-j\theta_k} [A_k e^{j\theta_k} s(t) + z_k(t)]$$

$$= \left(\sum_{k=0}^{M-1} A_k^2\right) s(t) + \sum_{k=0}^{M-1} A_k e^{-j\theta_k} z_k(t) \tag{9}$$

The SNR of the combined signal is

$$\Gamma = \frac{\sum_{k=0}^{M-1} A_k^2 E_b}{N_o} = \sum_{k=0}^{M-1} \Gamma_k \tag{10}$$

For Rayleigh Fading channel, the outage probability is given by

$$P_\Gamma(\gamma) = 1 - e^{-\frac{\gamma}{\gamma_o}} \sum_{k=1}^{M} \frac{(\gamma/\gamma_o)^{k-1}}{(k-1)!} \tag{11}$$

C. Equal Gain Combining

Each branch signal is rotated by $e^{-j\theta_k}$, all branch signals are then added The combiner output is given by

$$y(t) = \sum_{k=1}^{M} e^{-j\theta_k} r_k(t) = \left(\sum_{k=0}^{M} A_k\right) s(t) + \sum_{k=0}^{M} e^{-j\theta_k} z_k(t) \tag{12}$$

The SNR is given by

$$\Gamma = \left(\sum_{k=0}^{M-1} A_k \right)^2 \frac{E_b}{MN_o} \qquad (13)$$

Conclusion

The diversity is used to provide the receiver with several replicas of the same signal. Diversity techniques are used to improve the performance of the radio channel without any increase in the transmitted power. As higher as the received signal replicas are decorrelated, as much as the diversity gain .Diversity Combining MRC outperforms the Selection Combining; Equal gain combining (EGC) performs very close to the MRC. Unlike the MRC, the estimate of the channel gain is not required in EGC Among different combining techniques MRC has the best performance and the highest complexity, SC has the lowest performance and the least complexity

References

[1] Aalborg University, Lecture notes, URL: http://kom.aau.dk/~imr/RadioCommIII/

[2] A. Goldsmith. Wireless Communications. New York: Cambridge University Press, 2005.

[3] J. Foschini andM. J. Gans. “On the limits of wireless communications in a fading environ-ment when using multiple antennas.” Wireless Pers. Commun., vol. 6, pp. 315–335,Mar. 1998.

[4] A. Goldsmith, S. A. Jafar, N. Jindal, and S. Vishwanath. “Capacity Limits of MIMO Channels.” IEEE JSAC, vol. 21, pp. 684–702, June 2003.

[5] Markku Juntti, et. al.,”MIMO Communications with Applications to 3G and 4G”, Oulu University,

[6] K. Yu. ”Multiple-Input Multiple-Output Radio Propagation Channels: Characteristics and Models”. Stockholm Sweden: KTH University, 2005.

[7] M. T. Ivrlac and J. A. Nossek. “Quantifying diversity and correlation in Rayleigh fading MIMO communication systems.” In Proceedings of the 3rd IEEE International Symposium on Signal Processing and Information Technology (ISSPIT 2003),Darmstadt, Germany, pp. 158–161, December 2003.

[8] Jing Ma; Yingjun Zhang; Xin Su; Yan Yao; Tsinghua Univ., Beijing “Maximal Ratio Combining in Cellular MIMO-CDMA

[9] L. Zhao, W. Mo, Y. Ma, and Z. Wang, “Diversity and multiplexing tradeoff in general fading channels,” IEEE Transactions on Information Theory, vol. 53, no. 4, pp. 1549–1557,Apr. 2007.

[10] S. M. Alamouti. “A simple transmit diversity technique for wireless communications.”IEEE JSAC, vol. 16, pp. 1451–1458, Oct. 1998.

[11] Hafeth Hourani “An Overview of Diversity Techniques in Wireless Communication Systems” Postgraduate Course in Radio Communications (2004/2005)