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Performance Enhancement in MIMO Two-Way AF Relaying System using Pre-coding Technique

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Abstract: MIMO (Multiple-input, multiple-output) systems are an essential component of future wireless communication systems, due to their promising improvement with regards to performance and bandwidth efficiency. A significant research topic is study regarding multi-user MIMO systems. Such systems have the possibility to combine the top throughput achievable with MIMO processing with the main advantages of space division multiple accesses (SDMA). In this paper, a Bit Error rate analysis is presented for multiple-input–multiple-output (MIMO) system with two way multiple relay system with AF considered in QPSK modulation technique, where a transmitted signal consists of a pre-coders followed by an space–time block code (STBC), such as dirty paper code (DPC). DPC primarily helps transmit data efficiently even though the communication channel offers interference. Its objective is always to send as much readable information on a channel with interference as you can. The BER performance of this method is compared with the pre-coder based methods like Minimum Mean Square Error and zero-forcing beam forming. This paper considers both one-way and two -way relaying systems with multiple relays between two terminal nodes where all nodes have MIMO antennas.

Keywords: Amplify-and-forward, MIMO, Space time block coding, Pre-coder (DPC), two ways relay, CSI, MMSE.

I. INTRODUCTION

Multiple-antenna technologies are a refreshing area of research. Whether for future military wireless networks, soldier radios, autonomous sensors, or robotics, the demand for improved performance could be met with multiple-antenna communication links and the advanced technology making those links effective [1]. Wireless communication is often a highly challenging because of complex, time-varying propagation method. When we consider a wireless link to one transmitter and something receiver, the transmitted signal that is certainly launched into wireless environment arrives at the receiver along several diverse path, termed as multipath. Recently, there has been a big desire for wireless multiple-input, multiple output (MIMO) AF two-way relays [2] communication systems due to their promising improvement with regards to performance and reduce the BER (bit error rate) and in addition help the convergence rate. The Two -way relay networks (TWRNs) [3], promise spectral efficiency improvements for wireless networks Moreover, multiple-input multiple-output (MIMO) [5], technologies can further enhance the performance of single-antenna TWRNs Consequently, amplify and-forward (AF) MIMO.

II. MIMO TWO WAY RELAY SYSTEM

Multiple-input multiple-output (MIMO) technology is among the most key technology due to its capability to increase system capacity and improve spectral efficiency without increasing the bandwidth. The relay technology is a very common space diversity way in which can effectively counteract channel fading. The combination of MIMO (multiple - input multiple- output) with relay technology can further improve the capacity and system performance with the relay network. There's been extensive theoretical research for the performance improvement of unidirectional MIMO relay system [10].

A) System Model

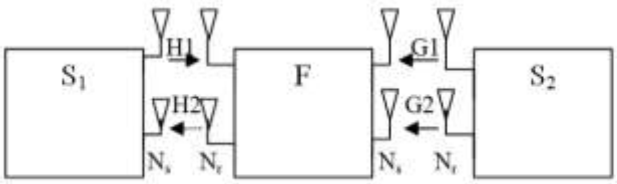

Figure 1 MIMO two- way relay system

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Considering MIMO two-way relay system as shown in Figure featuring its two source nodes S_1 and S_2 with one relay node denoted by F, both S_1 and S_2 include with n_s antennas. Relay node F has n_r antennas. Presently, the investigation for the performance of MIMO two-way relay system [10] will depend on the label of time division duplex (TDD). During the first phase, source nodes S_1 and S_2 transmit their information to relay node F.

In the first time slot, source nodes S_i (i= 1,2,) transmit information x_i ε c^{ns*1} to relay node, x_i is satisfied with covariance matrix $R_{xi} = \varepsilon\,[x_i\, x_i^H]$, ε[.] donates the statistical expectation, and then the signal vector Y_s ε C^{nr*1} received at relay node is

$$Y_s = H_1X_1 + H_2X_2 + n_r \ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Here H_i ε c^{nr*ns} represents the channel matrix of S_i to F and n_r ε c^{nr*1} denotes the additive white Gaussian noise (AWGN) vector with covariance matrix $R_{nr} = c[n_r n_r^H]$.
In the second time slot, relay node multiplies its received signal and forwards it to S_1 and S_2 , respectively. The received signal Y_i ε c^{ns*1} at S_i can be expressed as

$$Y_i = H_i^H F H_i x_i + H_i^H F H_i x_i + H_i^H F n_r + n_{i\ldots}.\ (2)$$

Where j = 2 if i = 1 and j = 1 if I = 2. n_i $\varepsilon[n_i n_i^H]$ denotes the AWGN vector with covariance matrix $R_{ni} = \varepsilon[n_i n_i^H]$.

B) **MU-MIMO Pre-coding**

- **Zero Forcing Pre-coding**

Since the base station doesn't have impact on the noise on the user terminals, the most intuitive way of pre-coding can be a zero forcing filter (ZF) which eliminates all interference in the user terminals. ZF pre-coding for single antenna receivers was investigated extensively inside the literature.
Now assuming single antenna terminals, the decoding matrix becomes $G = I_K$ and $M_R = K$. Allow us to define the pre-coding matrix F as $F = \beta F_a$. The pre-coding matrix Fa along with the scaling factor β results from this optimization.

$$F_a = \operatorname{argmin} E\{\|HF_a x - x\|^2\},\ : HF_a = I_k \ldots\ldots(3)$$

The parameter β is chosen such that the whole transmit power is $\beta^2\ \|HF_a x - x\|^2 \le P_T$. We think that the complex data symbols are i.i.d. uniformly distributed random variables knowing that the examples of the additive noise on the input of receive antennas are i. i.d. complex Gaussian white random variables with mean and variance such as respectively. The normal energy the complex data symbols is placed to -

$$P_t = 1$$

The solution to the optimization problem given in (3) is a pseudo-inverse of the combined channel matrix H:

$$F_a = H^H (HH^H)^{-1}, \beta = \sqrt{Pt/\|Fa\|^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

In the same way because decoding ZF filter, the transmit ZF filter also suffers from the noise enhancement problem and needs increased transmit power. It can be sub-optimal and results in significant performance degradation. The diversity order and array gain of each one stream is proportional to $(M_T - M_R + 1)$, [9].

- **Minimum Mean-Square-Error Pre-coding**

The ZF pre-coder completely eliminates multi-user interference at the cost of noise enhancement. The minimum mean-square-error (MMSE) pre-coder balances the multiuser interference mitigation with noise enhancement and minimizes the whole error. Unlike the ZF pre-coder, the MMSE pre-coder cannot be designed in such a straightforward way. A key to development with the MMSE pre-coder is to scale the transmit vector in ways that the whole transmit power contains the predefined level [13], i.e.

$$F_a = \operatorname{argmin} E\left\{\left\|\beta^{-1} y - x\right\|\right\}^2,:\ \beta^2\|F_a x\|^2 \le P_T..\ (5)$$

Where the parameters α and β are equal to;

$$\alpha = \delta^2 k/P_T \ \text{ And } \beta = \sqrt{pt/\|fa\|^2} \ldots\ldots\ldots\ldots\ldots(6)$$

The MMSE pre-coder is defined as-

$$F_a = (H^H H + \alpha I_{MT})^{-1 H^H} \ldots\ldots\ldots\ldots\ldots\ldots(7)$$

The total transmit power is PT and the volume of user terminals is K. The MMSE pre-coder, in the same way because receive spatial MMSE filter, approximates a matched filter at low SNRs and it is near optimal. At high SNRs, the MMSE pre-coder converges to a ZF pre-coder and don't be surprised it to extract $M_T - M_R + 1$ order diversity.

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III. DIRTY PAPER CODING (DPC)

In the dirty paper coding (DPC) is a technique for efficient transmission of digital data through a channel subjected to some interference known to the transmitter [9]. The technique consists of pre-coding the data in order to cancel the effect caused by the interference. In this case the dirt is interference, the paper is the channel, the writer on the paper is the transmitter, and the reader is the receiver. The pre-coding could both the sender as well as the receiver [6]. DPC coding is a technique of cancelling known interference at the transmitter.

A) Dirty paper Coding with Zero Forcing Equalizer

Within this paper, we design zero-forcing DPC (ZF-DPC) [9], scheme using pre-codes for any MIMO with two transmit antennas, four relay as well as users (receivers), each with one antenna. The DPC code design is the introduction of a 1 block delay that permits the channel encoder (and decoder) along with the shaping encoder (and decoder) to work independently. Inside the ZF-DPC method, the MIMO pre-coder makes sure that one user has interference. Another user uses DPC to combat interference.

We design zero-forcing DPC (ZF-DPC) scheme using pre-codes for a MIMO with two transmit antennas and two users each with four relay. BER performance of the proposed DPC scheme is compared with the Minimum Mean Square Error (MMSE) and ZF-BF techniques [6], [11].

B) Dirty Paper Coding with MMSE

The Zero Forcing equalizer neglects the effect of noise. A more robust equalizer is proposed based on the Minimum Mean Square Error (MMSE) criterion. The MSE equalizer is designed to minimize the error variance.

IV. RESULT

The simulation of our work is done in MATLAB R2010b. By using these tools first we create related parameters to develop DPC pre-coding and then we calculate BER for a two way relaying systems. After that we are applying different equalizer to investigate the BER values of the applying equalizer. In this work we also found channel capacity and SNR after applying a proposed method The bit-error-rate (BER) performance of those system was evaluated for several spectral efficiencies as being a purpose of the normal SNR per receive antenna. All performance comparisons are manufactured for any SNR vary from 0 to 12 db.

A) **BER Performance for DPC-ZF Equalizer**

Figure 2 a BER curve represents the simulated signals that spends a time at a given power level denoted by a points in a graph. In figure 2 the x- axis shows SNR in dB and y-axis shows the point at which the level of power according to the x-axis is spend by signals. In the above graph we can see that at point on y-axis at point $10^{-1.5}$ Hz the related SNR of pre-coded signal is 5 dB.

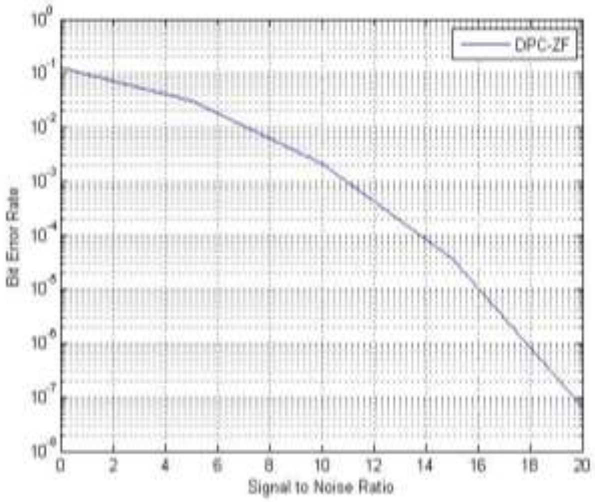

Figure 2 the BER performance of using ZF-DPC pre-coder

B) **Throughput performance for ZF-DPC**

In the below graph shows the throughput performance of MIMO two way relay system. Here the value of SNR is increases than the throughput of the system is increases exponentially.

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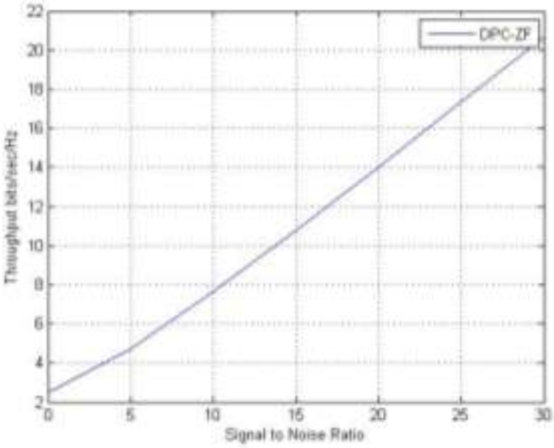

Figure 3 Throughput Performance of pre-coded ZF-DPC

C) BER Performance for DPC-MMSE Equalizer

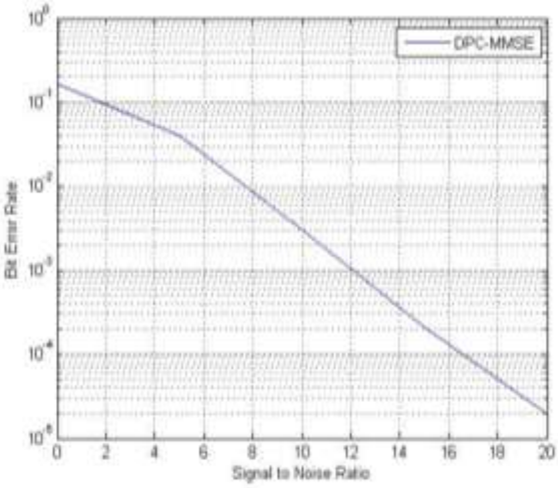

Figure 4 BER performances DPC with MMSE equalizer

In figure 4 BER curve represent the simulate signals. In the above figure 4 the x-axis shows SNR in dB and y-axis shows the BER. As we can see in the graph that BER is decreasing with the increase in SNR. BER is $10^{-1.0}$ Hz when SNR is 2 db. It decreases to $10^{-4.8}$ Hz when SNR is 20 db. In the case of BER, it also decreases exponentially with the increases in SNR. It decreases to $10^{-4.9}$ when the SNR = 20 db.

D) **Throughput Performance for DPC-MMSE Equalizer**

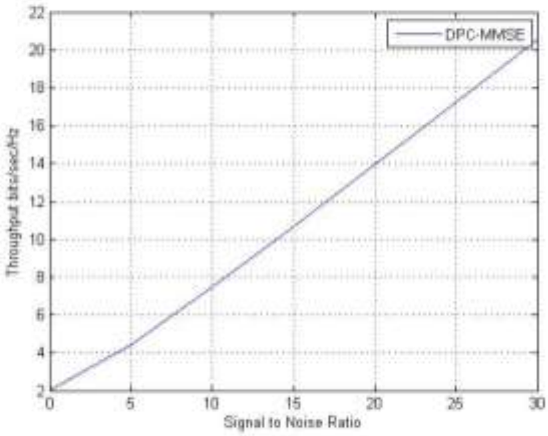

Figure 5 Throughput performances with MMSE equalizer

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In figure 5 plots between throughput and SNR. In this figure when increase SNR than throughput also increases. In above graph we can see that the maximum throughput 21 bits/sec/Hz at 30 dB SNR.

E) BER Performance for Different Algorithms

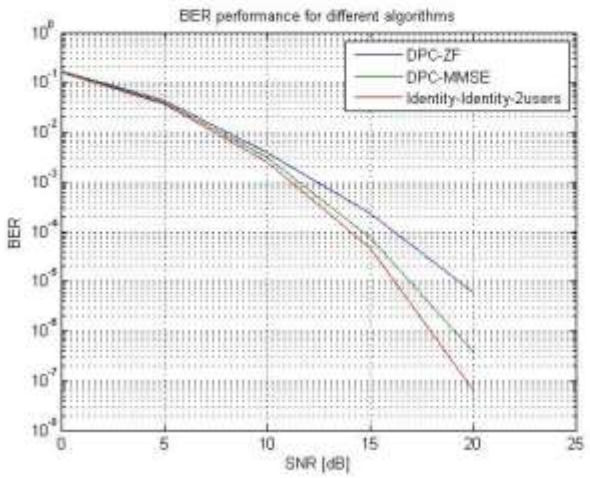

Figure 6 BER performances for different algorithms

In figure 6 BER curve plotted for different algorithms like DPC-MMSE and identity matrix. In the above figure 6 the x-axis shows SNR in dB and y-axis shows BER in Hz. In the above graph we can see that at point on y-axis at point $10^{-1.5}$ Hz the related SNR of the signal is 5 dB. In above graph the maximum value of BER is $10^{-0.8}$ for the initial value of SNR is 0 dB. Here the value of bit error rate (BER) is decreases exponentially when the value of SNR increases.

F) Throughput performance for different algorithms

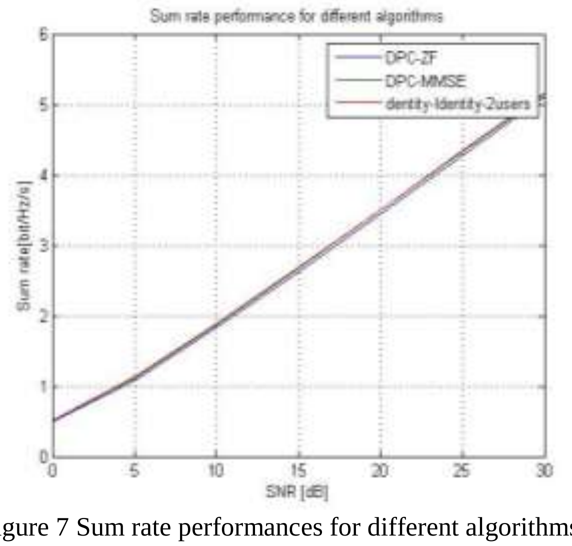

Figure 7 Sum rate performances for different algorithms

In figure 7 sum rate graph shows the performance of MU-MIMO with 2×2 (two users and two relays) for MIMO two way relaying system with two users and two relays. In the above figure 7 the x-axis shows SNR in dB and y-axis sum rate in bits/Hz/sec. in the above graph we can see that the minimum sum rate in 0.6 bits/HZ/per in 0 dB SNR and maximum sum rate in 5.2 bits/Hz/sec in a 30 dB SNR. Here the value of sum rate is increases exponentially when the value of SNR increases.

V. CONCLUSION

During the simulation of this projects work we have done analysis on an MIMO two way relay system and we observe that MIMO two way relay system faces a BER problem during the transmission we have also done simulation on

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MIMO two way relay system with pre-coding algorithms with different modulation technique. We observed that in place of putting DPC with ZF and MMSE equalizer we can try to minimize BER at the transmitter. In this project we are using DPC pre-coding technique as a BER reduction for MIMO two way relay system. In this pre-coding used we can minimize BER at the transmitter end. We also observed that as we increases the value of SNR, BER minimize but when increases the SNR, throughput also increases.

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BIOGRAPHIES

Devi Singh Meena has completed his B.E. in electronics & communication engineering in 2012 from RGPV University Bhopal, M.P. He is pursuing his M.E. in digital communication from IPS Academy, Indore. At present he is in 4th semester and final year of Master of Engineering.

Prof. Kavita Upadhyay is working as an Associate. Prof (electronics & communication) in IPS Academy, Indore (M.P.). He has received his B.E. and M.E. degree in Electronics & communication engineering. He has more than ten years of experience as Associate Prof.