Precoder Design for Improving the Performance in MIMO Systems

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Abstract*—Multiple Input and Multiple Output (MIMO) is a smart antenna technology which employs multiple antennas at both ends of the transmitter and receiver side in order to improve communication performance. It promises significant increase in data rate, link quality by mitigating fading effects through diversity effects. It have been applied to relay networks to provide high reliability and data rate and increase in coverage area. Relays which receive signals from the base station and forward to destination, thus destination is able to obtain another copy of the original signal with directly transmitted signal from source which leads to Joint diversity effects. So, In this paper it is proposed to achieve a Joint Diversity effect for MIMO Relay Co operative communications in order to improve the capacity of the system by having a optimal precoding technique in the transmitter side for two relay system.*

Keyword — *MIMO, Linear precoding, Relay, Amplify and Forward (AF), Decode and Forward (DF), Optimal Precoding.*

I. INTRODUCTION

Multiple Input Multiple Output (MIMO) is a multiple antenna technique that exploits the use of multiple signals transmitted into the wireless medium and multiple signals received from the wireless medium to improve the channel performance. It have the potential for providing high capacity, increased diversity and interference suppression and high spectrum efficiency without additional bandwidth or transmit power. The large spectral efficiencies associated with MIMO channels are based on the premise that a rich scattering environment provides independent transmission paths from each transmit antenna to each receive antenna. Multiple antennas are employed on both sides of the wireless links to provide parallel signal paths between transmitter and receiver to transmit same information through these paths, thus the receiver ables to obtain a multiple copies of the same information which ensures reliable communications. MIMO systems can also provide Spatial Multiplexing gain and Diversity gain. Spatial Multiplexing gain provides maximum transmission rate and it uses rich scattering or fading techniques. Diversity gain minimizes the probability of error.

Relaying is a technique addressed as a form of multiple-access channels. The single relay scenarios provide upper bounds for capacity considering for different strategies facilitation, full cooperation and partial cooperation. Over the last decade, there has been a renewed theoretic effort for investigating efficient relaying techniques. At the same time, practical deployment scenarios and throughput efficient usage of relays have been investigated, for wireless channels, relaying can provide diversity gains in addition to the path loss gains, the effect of which is referred to as 'relay diversity'. This effect can be realised from placing relays well separated, which will provide an independent multipath - fading loss (channel realisation) from each of the relay to the receiver. The channel realisation between a relay and the user receiver can be time varying. Therefore, even in the absence of channel knowledge at relay transmitter, outage probability can be reduced at the receiver end from combining the information which arrive from statistically independent channels .

II. SYSTEM MODEL

The concept of cooperative communications is to exploit the broadcast nature of wireless network, where the neighbouring nodes overhear the source's signals and relay the information to the destination.

As in System model, after receiving the signals resulting from the source, a third-party terminal acting as a relay and forwards their overhearing information to the destination so as to increase the capacity and improve reliability of the direct communication. The end-to-end transmission is clearly divided into two separate stages in the time domain broadcasting and relaying phase. In the broadcasting phase, i.e., broadcasting channel as seen from the source's viewpoint, all the receiving terminals including the relays and destination work in the same channel (time or frequency) as opposed to the second stage. In the relaying phase, i.e., multiple access channels as seen from the destination's viewpoint, the transmitting terminals (relay nodes) may operate in different channels to avoid co-channel interference.

System model operation depends on the relaying protocol used in our design Relaying protocols classified as AF and DF. In a Amplify and Forward system, it is realistic for relay terminals to amplify the signal from the source terminal without performing any sort of decoding. It multiplies the noisy version of the source's signal with the amplifying gain under a certain constraint, e.g., power constraint, and then transmits the resulting signal to the destination. As the relay simply retransmits the received signal from the source without any decoding manipulation, the non regenerative method reduces the hardware complexity of relay.

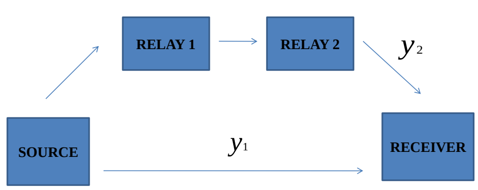

Fig.1. MIMO - Two Relay Networks.

We consider a MIMO Relay network, Where we are assuming that CSI is available at each node of a network with a direct link exist between the source and destination. Due to half duplex relaying the destination receives the data in two separate time slots. In first phase signal from the source will be transmitted to the destination. In the second phase the signals from the source to relay and relay to destination are combined and will be receiving as a single signal at the destination.

TABLE 1

Definitions for MIMO Relay System.

Parameter	Definition
N_s	Number of antennas are equipped in source
N_{r1}	Number of antennas are equipped in relay 1
N_{r2}	Number of antennas are equipped in relay 2
N_d	Number of antennas are equipped in destination
y_1	Signals Transmitted from source to destination i.e direct link
y_2	Signals Transmitted from source to relay,relay 1 to relay 2and relay 2 to destination

The received signal at the first slot which is the direct link from source to destination is given by

$$y_1 = H_d S x + v_d$$

Where S is the precoding matrix designed at the source by taking SVD of the channel matrix H_d from the source to destination of the order $N_d \times N_s$.

The received signal in the second slot, which is the combined signal of source to relay and relay to destination links which is given by

$$y_2 = H_r H_{s1} H_{s2} S L x + L M H_r H_{s1} H_{s2} S x + H_r L M v_s + v_r$$

Where L is the precoding matrix designed at the relay1 by taking SVD of the channel matrix H_{S1} from the source to destination of the order $N_{r1} \times N_s$.

Where M is the precoding matrix designed at the relay2 by taking SVD of the channel matrix H_{S2} from the source to destination of the order $N_{r2} \times N_s$.

The Optimal Precoding Algorithm is implemented for MIMO Relay networks to compute the Ergodic capacity with low complexity.

III. PERFORMANCE ANALYSIS

In this section the performance of optimal precoding is examined in terms of capacity. Rayleigh fading channel is assumed for the broadcast channel to analyze the performance. The capacity can be estimated for different transmit and receive antenna is given by

$$C = \log_2(\det(I_{N_s} + \frac{E_b}{N_o N_s} HH^H)$$

The capacity can be appraised from the precoding matrix and channel matrix. In this paper MIMO is considered and purveys high sum rate by varying signal to noise ratio with different transmit antenna and receive antenna. The capacity increases logarithmically for different number of transmit and receive antenna by using BPSK modulation.

IV. SIMULATION RESULTS

In this section simulation results of precoder design using optimal precoding and are illustrated. The simulation results are compared to for different number of antennas and different $(N_r X\, N_t)$ dimensions of MIMO systems. MIMO channels are considered to be uncorrelated and the elements of the channel are complex Gaussian random variable with zero mean and unit variance.

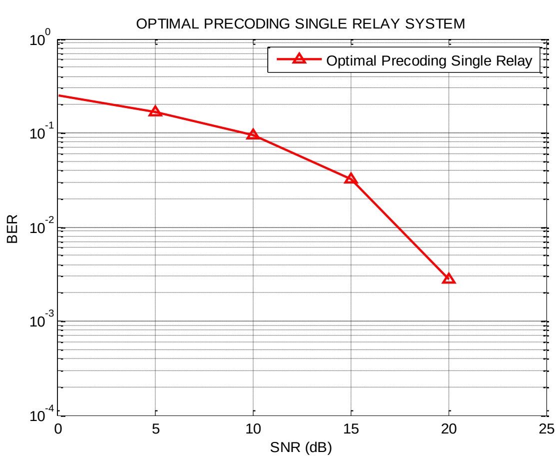

Fig.2. BER as a function of SNR for the single relay system using Optimal Precoding approach.

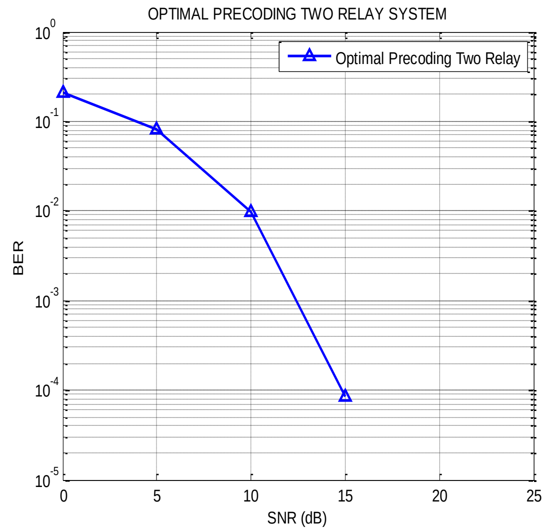

Fig.3. BER as a function of SNR for the Two Relay system using Optimal Precoding approach.

The above figure 3 also shows that the BER graph for optimal precoding provides less errors in low SNR value when compared to linear precoding method in figure 2.

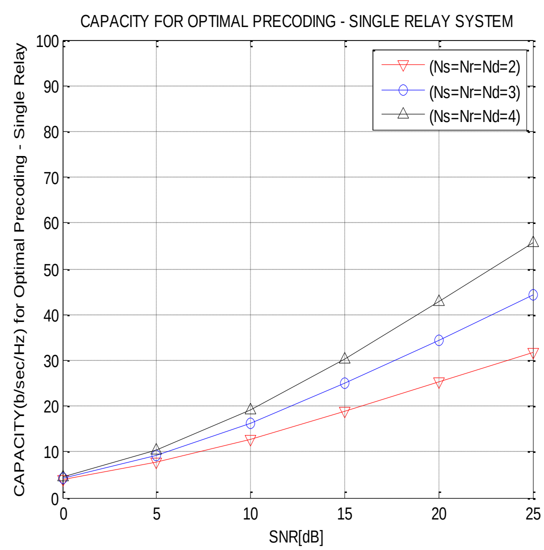

Fig.4. Capacity as a function of SNR for the single relay system using Optimal Precoding approach and compared the capacity for different number of antennas.

The above figure 4 shows that the capacity augments logarithmically for different antennas. The reason for the increase in capacity logarithmically is that the preceding matrix is designed in such a way that it nullifies the interference. Hence the capacity increases rapidly depending on signal to noise ratio.

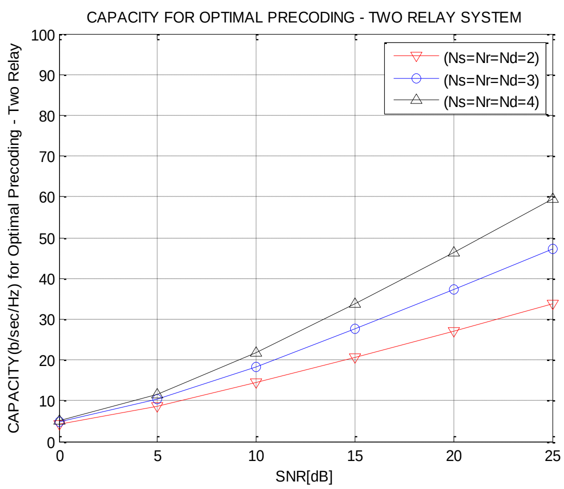

Fig.5. Capacity as a function of SNR for the two relay system using Optimal Precoding approach and compared the capacity for different number of antennas.

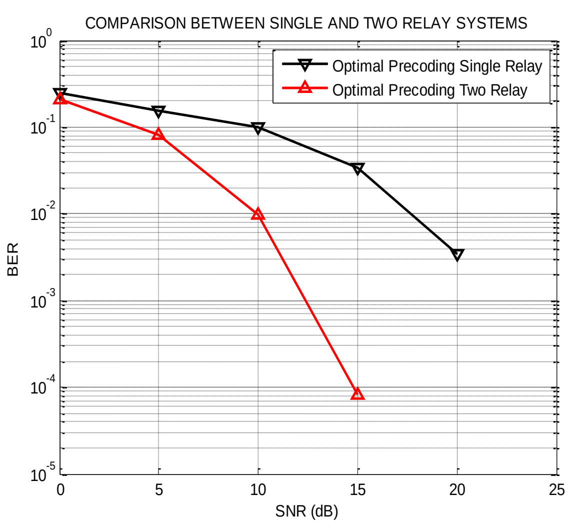

Fig.6. BER as a function of SNR compared for the single relay and two relay system using Optimal Precoding approach.

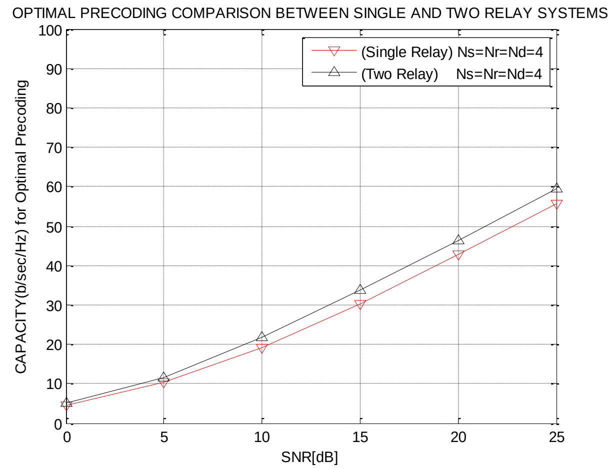

Fig.7. Capacity as a function of SNR compared for the single relay and two relay system using Optimal Precoding approach.

V. CONCLUSION

This Optimal Precoding technique for MIMO Two Relay networks is used to enhance the capacity at the condition of fading. In MIMO Relay networks CSI is an important factor, if every node in the network having the knowledge of CSI with a direct link exist between the source and destination and relay to destination.

VI. FUTURE WORK

In MIMO Relay networks, the performance of the relaying technique is mainly depend on the relaying protocols. Using the Optimal precoding technique this work can be implemented in MIMO Relay networks with Partial Decode and Forward (PDF) Relaying protocol which overcomes performance degradation factors i.e the noise amplification and the presence of decoded errors in AF and DF protocols, but in practical it is difficult to design a precoder at the source and relay having PDF relaying protocol with channel state information known to the transmitter. There by going to analyse the performance of the MIMO Relay networks employing the PDF protocol with the help of this proposed Optimal Precoding techniques.

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