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Rate Analysis of Multi-user MIMO Relay System with different Techniques

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ABSTRACT: In this paper we user a combination of multiple MIMO and relay system. We assume that we have an imperfect channel and feedback system. The achieved rate from the imperfect channel is analysed using different quantization methods. We plot graphs representing the achieved rate when various quantisation method is used and we are going to compare the rates achieved.

KEYWORDS: MIMO sytem, relay syetem, achieved rate, feedback system, scalar quantization, upper bound, CSI

I.INTRODUCTION

In multi user MIMO system, a base station antenna communicate with different antennas in user side. The advantage of using MIMO channel is that it increases the capacity and improves the the spectral effiency. These benefits of MIMO channels is achieved when we are able to get the channel state information(CSI) at the base station. Usually a feedback channel is necessary to carry the channel state information from receiver to base station. The relaying is a promising technique that can be used to solve the problems of reliability, coverage and spectral efficiency. When we use the MIMO relay system we can increase the capacity of the system as well as improve the coverage area.

The channel state information have to transmitted from the user side to the base system. Ideally if we think CSI obtained is perfect ie, the CSI received at the transmitter side is same as the CSI sent from the user. In practical case this is not true. There would have some kind of error final transmission of CSI. There are some cases of CSI that is to be considered. One when there is imperfect CSI at the receiver. This happens when receiver use pilot signal obtained from the transmitter to plot the channel. There is a large possibility that error could occur while estimating from the pilot signals. The second case is when transmitter obtains the CSI incorrectly. This again contributes error in the system. The third case is that estimation error happens at both transmitter and receiver ie, CSI at transmitter and CSI at receiver has error.

II.SYSTEM MODEL

Consider a relay MIMO downlink system. There is a base system and a receiver side. As we are using a relay MIMO system an intermediate relay system is also present. The signal send from base system takes a different path and reach relay system from where it is forwarded to the receiver side. Here in the receiver sidewe have some number of users. There are P base station antennas K relay station antennas and Q user antennas. The direct link from base station to user is neglected because of path loss. H denotes the channel from base system to relay system and G denotes channel from relay system to user. Also we assume that g_k is the channel vector between relay system and users. Here we assume the presence of noise in the channel. n and z_k denote the complex additive white guassian noises at the relay system and at the k^{th} user respectively. The number of antennas at the base system is assumed to be greater than or not less the number of antennas at Relay system. That means P>Q.

III. DISCUSSION

When we use no quantisation at all, a high data rate can be achieved but there will be a lot of errors in the signal received at the destination. In this case the set of input values transmitted will be so large creating large overheads. Those will be continuous and uncountable. Also in this case the accuracy of the output will be very much less. So by using quantisation, a small interval representing the entire uncountable data is taken. When quantisation is done at particular levels the effect of distortion can be minimised. Thus for more accurate results we need to use quantisation.

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In quantisation we represent large set of values using small set. Quantisation process consist of encoder mapping and decoder mapping. Encoder mapping process divides the range of values generated at the source into a number of intervals and each interval is represented by a distant codeword. In scalar quantisation all the source outputs for each particular interval is represented by codeword of that interval. The decoder generates a reconstruction value for each codeword generated by the encoder. Here the codeword represents an interval so it is difficult to know which value of the interval is actually generated by the source. It's the encoder's job to construct the interval that is to be transmitted and the decoder has to reconstruct the values in interval. At the encoder side the input values are divided into different interval, binary codes are assigned to these intervals. Scalar quantisation produces fixed length codewords.

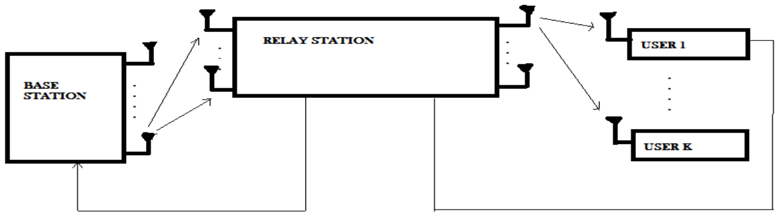

Fig 1 Model of sysetem

Zero forcing precoding is a spatial processing method. By this method the transmitter can cancel other interference signals. The performance of zero forcing beamforming depends on the knowledge of CSI. The performance of zero forcing precoding decreases with the imperfect CSI at the transmitter side. The base station can then use greedy algorithm for user selection. The algorithm first selects the user with the largest channel quantisation information. In the next step the Zero forcing sum rate is calculated and all users including the first user and additional user is then selected. Thus this process adds one user at a time till the last user in greedy fashion. Random vector quantisation increases the ease of simulation and analysis. Each user uses a quantisation codebook. Also each user's codebook is independently generated and rate is averaged over codebooks. The computational complexity is more in this case. Scalar quantisation provides rate slightly smaller than random quantisation. By taking the upper bound of random quantisation we get slightly better data rate.

IV. SIMULATION AND RESULTS

Here we assume that the number of base station antennas, relay system antennas and the number of users as equal ie, P=Q=K.

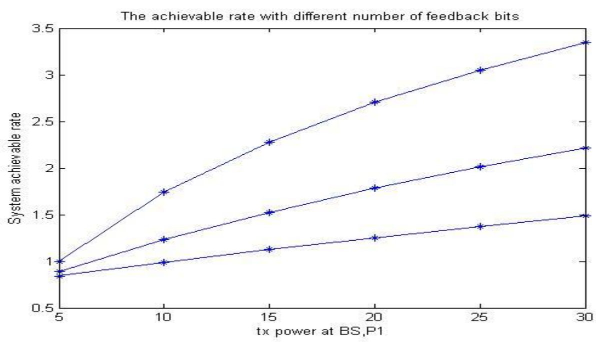

Fig 2 Achieved rate with different number of feedbacks

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For obtaining this graph we take base station antenna and relay station antenna as four ie P=Q=4, and that there are 4 users ie, K=4. As the number of feedback bits increases the performance approaches close to the perfect CSI case.

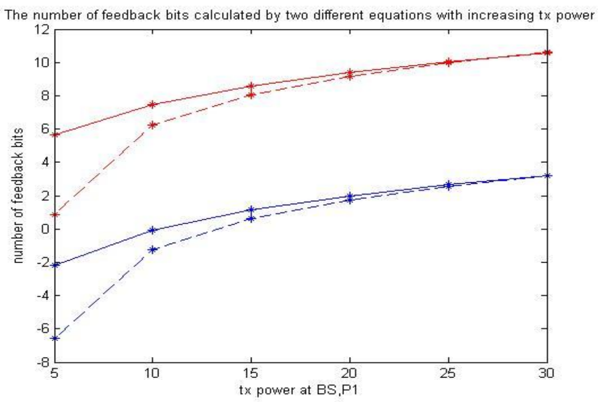

Fig 3 Feedback bits calculated using different scaled versions

We can see from the graph that the scaled and unscaled versions differs at the beginning and later on as the transmit power increases they almost become equal.

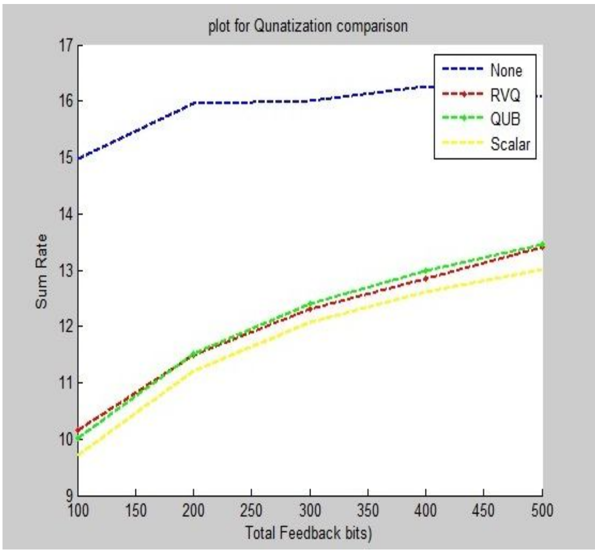

Fig 4 Rate achieved by using different quantisations

We can see that by using no quantisation one can achieve a high data rate but it will result in great loss. Scalar quantisation achieves the lowest rate but comes close to random quantisation. Here more accurate and high data rate is achieved by using random quantisation and when we take the upper bound of random quantisation

V. CONCLUSION

In this paper we investigate the data rate achieved when there is imperfect CSI on a MIMO relay feedback channel. There is a significant rate loss in case of imperfect CSI case than the perfect CSI. The perfect CSI is the ideal case and it is impossible to achieve as there will be some loss occurring during transmission. The data rate achieved for different

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quantisation is also studied. When no quantisation is used it leads to significant loss of data even though even though high rate is achieved. The random quantisation performs better than scalar quantisation and taking the upper bound of rate of random quantisation gives better rate.

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