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Power and Channel Allocation in Multi User and Multi Channel Using Joint Beam Forming in MIMO System Cognitive Radio Networks

[1]Chinnam Sandeep [2]G.Vishnu Vardhan
[1]M.Tech Student, [2]Assistant Professor
[1][2]Department of Electronics and Communication Engineering,
[1][2]Sir C.R.Reddy College of Engineering, Eluru.

Abstract: **We take into account multiple-input– multiple-output (MIMO) two-way relaying channels wherever a try of multi antenna users needs to exchange data with the assistance of a non-generative multi antenna relay. A low-complexity joint beam forming and power management theme is projected. The projected beam formers 1st align the channel matrices of the user try then decompose the aligned channel into parallel sub channels. 2 power management problems, i.e., power allocation and power management, addressed sum-rate optimizing power allocation is projected to assign power between all sub channels and nodes. Second, quality of service (QoS) satisfying power management is projected to reduce the whole transmission power within the network. Simulation results justify that the projected joint beam forming and power management theme delivers higher sum-rate performance or consumes lower transmission power next with existing schemes.**

Index terms**: Beam Forming, Convex Optimization, Power Allocation, Power Control, Two-way Relaying.**

I. INTRODUCTION

The relaying is a spectrally efficient technique to enable information exchange between two user's decode-and-forward amplify-and-forward, and Two-way relaying protocols, such as those based on estimate-and-forward relaying are able to fulfill two way information exchange in only two phases. Specifically, both users concurrently transmit in the same channel during the first phase, whereas the relay broadcasts the processed mixture to both users in the second phase. Each user utilizes the know-edge of the previously transmitted message, known as self interference, to decode the received mixture. In comparison of publication. This work was supported by the U.S. Army Research Laboratory and the U.K Ministry of Defense under Agreement W911NF-06 3-0001. The work of C. Y. Low was supported by University Technology Malaysia and the Ministry of Higher Education Malaysia. The work of Z. Ding was supported by the U.K. Engineering and Physical Sciences Research Counci under Grant EP/I037423/1. This paper was presented in part at the IEEE International Conference on Communications Kyoto, Japan, June 5–9, 2011. The review of this paper was coordinated by Prof. E. Bonek.C. Y. Leo is with the Department of Electrical and Electronic 2AZ, U.K., and also withthe Wireless Engineering, Imperial College London, London SW7 Communication Centre, Faculty of Electrical Engineering, University Technology Malaysia, 81310 Skoda, and Malaysia's. Ding is with the School of Electrical, Electronic and Computer Engineering Newcastle University, Newcastle upon Tyne NE1 7RU, U.K.K. K. Leung is with the Department of Electrical and Electronic Engineering, Imperial College London, London SW7 2AZ, U.K. Digital Object Identifier conventional one-way relaying consumes four orthogonal channel uses to complete the information exchange. Lower signal processing power when compared with regenerative relaying, i.e., DF and EF relaying. Attracted by the benefits of multi antenna inenhancing system capacity and reliability, subsequent works on non regenerative two-way relaying extend to a multi antenna scenario. References and considered sum-rate optimizing AF- based beam forming and power allocation at the relay, for the case where only the relay is equipped with multiple antennas. Reference generalized the scenario to include multiple pairs of single-antenna users and demonstrated that AF-based beam forming at the relay is able to address co channel interference and improve through

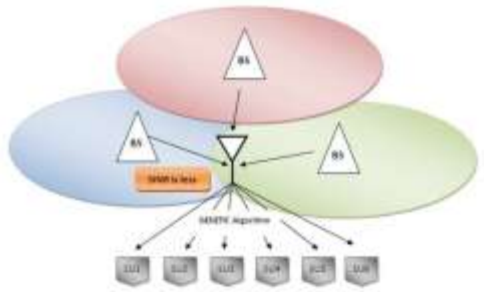


Figure1 GENETIC Algorithm using Single relay path

Meanwhile, and looked into the case with a single pair of multi antenna users and a non regenerative multi antenna relay. Reference proposed a sum-rate maximizing beam forming design at the relay subject to a fixed power constraint. However, the number of antennas required at the relay is twice the number of antennas needed at each user due to the zero-forcing criterion. Reference studied the joint design of the beam former at the relay and the decoder at the users to minimize the sum of the mean-square error (MSE) subject to an individual power constraint at each node. The possibility of beam forming at the users was not explored in the joint design of the transmit and receive beam formers in the multiple-input–multiple-output (MIMO) two-way relaying channels was studied in and . It was recognized in and that the sum-rate expression is not jointly concave with respect to the transmit and receive beam forming matrices, which complicates the optimization of the beam forming matrices. Reference proposed an iterative searching algorithm based on the gradient-descent method to find the locally optimal solution for the beam formers at the users and the relay satisfying individual power constraints with equality. The algorithm has to be extensively repeated with different starting points to increase the probability of finding the best locally optimal solution that corresponds to the globally optimal solution. Meanwhile proposed an alternate optimization (A-Opt) technique that combines searching algorithms and convex optimization techniques to find locally optimal beam formers at the

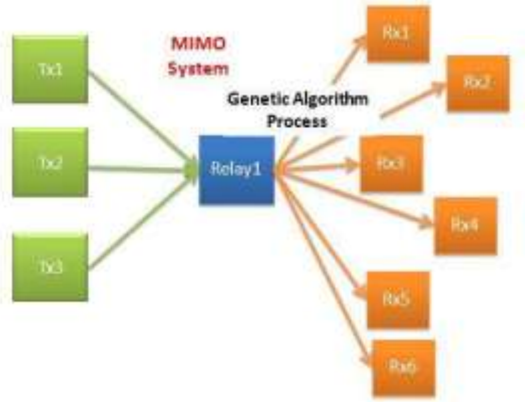


Figure2 GENETIC Algorithm Process

Users when the beam former at the relay is fixed, and *vice versa*, until convergence is reached. Similar to the algorithms that were proposed in to find locally optimal solutions have to be repeated multiple times to increase the probability of reaching the globally optimal solution. One major drawback of the algorithms that were proposed in and s the expensive computation cost involved in determining the beam-forming matrices. The problem dimension of the algorithms in and which quadratic ally grows with the number of antennas, significantly increases the computational complexity when the number of antennas is large. Another shortcoming is the high computation overhead involved following the fact that both and required extensive repetition of a local optimization procedure with different initial points to achieve the globally optimal solution. In addition to that, and only considered the case where each node is subject to a fixed individual power constraint. The possible performance gain of implementing joint power allocation (JPA) at all nodes subject to a total network power constraint remains unexplored.

Beam forming:

Beam forming is a general signal processing technique used to control the directionality of the reception or transmission of a signal on a transducer array. Using beam forming you can direct the majority of signal energy you transmit from a group of transducers (like audio speakers or radio antennae) in a chosen angular direction. Or you can calibrate your group of transducers when receiving signals such that you predominantly receive from a chosen angular direction. The physics and math are essentially the same for both the transmitting and receiving cases, so I will concentrate on the transmission case to explain the concept further. I should mention as well that there are a few general approaches to directing this signal energy, but by far the most common is having a slightly different signal go out of (or into) each transducer in your group; this is the approach I discuss here. Another interesting but less common approach is sending the same signal to all transducers but with varying information encoded by frequency in that signal, requiring a broadband signal - this is called using a "blazed array". However, I don't discuss that approach The JPA problem has been investigated in a one-way relaying scenario, e.g., in hand. However, the solutions cannot be directly applied to a two-way relaying scenario due to the fundamental difference in the transmission protocol. In two-way relaying, the relay receiver needs to account for the superposition of the transmissions from both users, whereas the transmit beam former at the relay needs to forward information to both users simultaneously. It was remarked in that channel decomposition for sub stream power allocation, i.e., water filling, is not possible in MIMO two-way relaying channels. Furthermore, the joint transmit and receive beam forming design in MIMO two-way relaying channels involves all three nodes in the network. In one-way relaying, only the source and the relay are involved in transmit beam forming; whereas the relay and the destination participate in receive beam forming. On the other hand, the capability of the MIMO system to support multiple parallel sub streams enables spatial multiplexing of several traffic types with various predefined quality of service (QoS). The QoS constraints can be target signal-to-noise ratios (SNRs), target data rates, target error rates, etc. The QoS requirement depends on the type of traffic. For instance, in multimedia applications, real-time video traffic requires a higher target data rate than real-time audio traffic. In certain applications, i.e., real-time control, real-time surveillance, etc., successful information delivery defined by QoS constraints is more important than that by power constraints. All these lead to the problem of fulfilling the QoS constraints with the lowest amount of power Reference studied the power control (power minimization) problem subject to SNR constraints for the MIMO one-way relaying channels, whereas investigated the joint beam forming and power control problem subject to per-user signal-to-interference-and-noise ratio constraints for the multiuser MIMO one-way relaying channels. Nonetheless, the power control problem with QoS constraints in the MIMO two-way relaying channels remains unexplored. In this paper, we consider a non regenerative two-way re-laying scenario consists of a pair of multi antenna users and a multi antenna relay, all equipped with M antennas. We propose a low-complexity transmit and receive beam forming design that

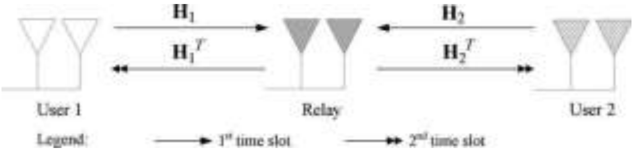


Figure2 Example of a two-way relaying scenario

Where each node is equipped with $M = 2$ antennas. The symbols above the arrows represent the channel matrices, whereas the directions of the arrows indicate the directions of data flows. Allows the use of single-input–single-output (SISO) decoders and enables JPA and joint power control (JPC) in the network. The proposed beam forming design based on sub channel align-meant enables us to investigate the following two power manage-meant issues: 1) JPA problem, which maximizes the sum rate subject to a predefined total power constraint within the network; and 2) JPC drawback, that minimizes the entire transmit power consumption within the network subject to predetermined QoS constraints, i.e., target knowledge rates. Such network power allocation and power minimization area unit vital in limiting the entire interference in-cured during a coverage space that's typically regulated by the au-thirty. To modify the facility allocation drawback to be expeditiously solved mistreatment umbel-like improvement techniques a depressed boundary comes. On the opposite hand, the facility management drawback within the sort of a geometrical program is reworked into umbel-like type soluble mistreatment umbel-like improvement techniques. The results show that the random add rate of the planned theme considerably outperforms baseline schemes. The results additionally reveal the performance gain of the planned theme over a comparable theme once SNRs of the nodes area unit asym-metrical. additionally, the results absolutely support the claim that the planned theme is a lot of energy economical in satisfying the QoS constraints compared with the baseline theme. Fixi, where F$i \in$ C$M \times M$ is the transmit beam forming matrix of user i, and x$i \in$ C$M \times 1$ is the information-bearing vector of user I systems of equations are functions of at least two variables. It can either be linear or non-linear, and to obtain a solution, the system should be non-singular and have a point in space where it coincides. A system of linear equations has the form: Which is represented in matrix-vector form as: Ax = y where x are unknown variables, N is the number of unknown variables, and a are constants, represented by the coefficient matrix A (String

Gilbert, 2007). The important information needed in genetic algorithm include objective function, and the representation scheme in a form of a coded string, containing information about the possible solutions. Evaluation of a possible solution is done after every set of genetic operations (Simon Marble and Sean Pascoe, 1999). Therefore, the simultaneous systems of equations can be solve using genetic algorithm if we can express it in form of an objective function, and a solution is said to be correct if it can satisfy all of the equations involving those variables.

II. SYSTEM MODEL AND PROTOCOL DESCRIPTION

Consider a scenario where two multi antenna users wish to exchange information with the help of a non regenerative multi antenna Relay. We are interested in the full spatial multiplexing case where all nodes are equipped with M antennas. This configuration commonly occurs in ad hoc and sensor networks where nodes have the same number of antennas and the relay is selected from idle users in the network. Fig. 1 shows an example of MIMO two-way relaying channels with $M = 2$. All channels undergo independent and identically distributed (i.i.d.) quasi-static Rayleigh fading and assume channel reciprocity. The receiver is corrupted by circularly

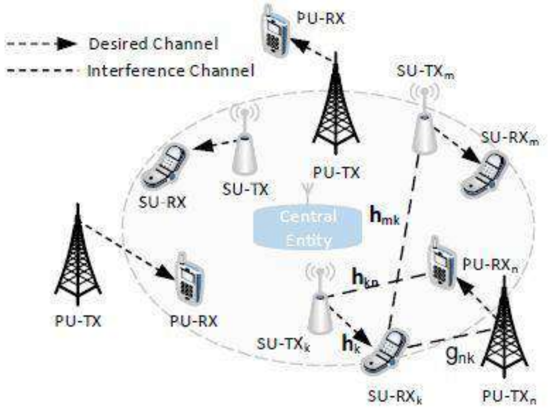


***Figure: System model and channel responses*.**

Symmetric additive white Gaussian noise. A half-duplex constraint is assume throughout this paper, and it is realized through time-division depleting. It is assumed that the relay has full knowledge of the channel state information (CSI) of both the relay-to-user channels, whereas each user knows his and his partner's user to-relay channels. The transmission protocol can be described in two time slots. Fig. 1 summarizes the transmission flow of the proposed protocol. In the first time slot, both users transmit linear pre coded information vectors to the relay, i.e., user i transmits $\mathbf{F}i\mathbf{x}i$,where $\mathbf{F}i$ $\mathbb{C}M\times M$ is the transmit beam forming matrix of user i, and $\mathbf{x}i \in \mathbb{C}M\times 1$ is the information-bearing vector of user i The transmission protocol can be descry genetic algorithms working with a fixed number of binary strings of fixed length.

III. GENETIC ALGORITHM

The genetic algorithm is a searching algorithm which can be applied to find out near optimal solution to an optimization problem. The termination condition for GA will be activated when the number of generations produced is beyond the predefined value Gnax .At each iteration, the complexity of GA results from three major operations, i.e., sorting, mutation and cross-over, which introduce complexity of
cross-over, which introduce complexity of $\mathcal{O}(\nu\log(\nu))$, $\mathcal{O}(K)$ and $\mathcal{O}(K)$, respectively. Beside the first generation, $(\nu-\rho)$ fitness values have to be determined at each generation. Thus, the overall complexity of GA can be computed as

$$\mathrm{G}_{max} \times \Big[\mathcal{O}(n\log(n)) + \lceil(\nu-\rho)/2\rceil(\mathcal{O}(K))$$

$$+ (\nu-\rho) \times t_T \times \mathcal{O}(\max\{\xi,\kappa\}^4\kappa|^{(1/2)}\log(1/\epsilon))\Big]$$

This algorithm is terminated under resulting outputs give the suboptimal channel allocation, Sum-rate and the beam forming Vector. terminated under resulting outputs give the suboptimal channel allocation, Sum-rate and the beam forming Vector

```
i=0;
Compute initial population B0 = (b1,0,...,bm,0); WHILE
stopping condition not fulfilled DO
BEGIN

FOR i := 1 TO m
DO select an individual b i,t+1 from Bt;
 FOR i := 1 TO m − 1
STEP 2 DO IF Random[0, 1] ≤ p
C THEN cross b i,t+1 with bi+1,t+1;
FOR i := 1 TO m
DO eventually mutate bi,t+1; t := t + 1
```

END

Obviously, selection, crossover (done only with a probability of p **C** and mutation are still degrees of freedom, while the sampling operation is already specified. As it is easy to see, every selected individual is replaced by one of its children after crossover and mutation; unselected individuals die immediately. This is a rather common sampling operation, although other variants are known and reasonable.

Genetic Algorithm Steps:-

Step: 1

Set that parameter based multiple base station (3 Base stations) 1 relay path and 6 destinations.

Step: 2

Each channel path we need to process on random variable of signals (channels)

Step: 3

Each channel path need to analysis on one by one loop on chromosome set

3 base station to 1 relay

Step: 4

Depend upon corresponding rate we need to choose best path; worst path using descending order condition

Step: 5

Found that path then we need to transmit maximum through put rate Crossover condition

Step: 6 optimal channel allocation analysis on relay path to destination we need to implement on decode forward relay path process.

IV. SIMULATED ANNEALING

The SA Based Algorithm has two major steps that is the generation of neighbor channel allocation and the determination of Sum-rate If S-max is the maximum number of iterations for convergence, the complexity of the algorithm can be computed as This algorithm is terminated under resulting outputs give the suboptimal channel allocation, Sum-rate and the beam forming Vector.

Simulated Annealing Steps:

Step:1

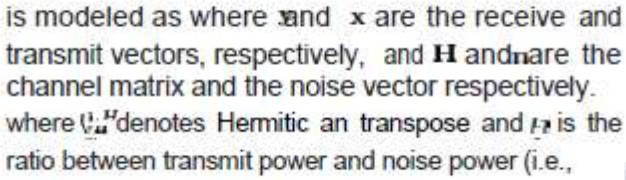
Robust probabilistic optimization method mimicking the solidification of a crystal under slowly decreasing temperature;

Step:2

Applicable to a wide class of problems. The fourth class of such methods will be the main this Genetic Algorithms The world as we see it today, with its variety of different creatures, its individuals highly adapted to their environment with its ecological balance .The product of a three billion years experiment we call evolution a process sexual and asexual reproduction, natural selection, mutation, and so on If we look inside the complexity and adaptability of today's creatures has been achieved by refining and combining the genetic material over a long period of time

IV. JOINT BEAM FORMING FOR MULTI ACCESS MIMO SYSTEMS

Considers multi access multiple-input multiple-output (MIMO) systems with finite rate feedback. The goal is to understand how to efficiently employ the given finite feedback resource to maximize the sum rate by characterizing the performance analytically. Towards this, we propose a joint quantization and feedback strategy: the base station selects the strongest users, jointly quantizes their strongest Eigen-channel vectors and broadcasts a common feedback to all the users. This joint strategy is different from an individual strategy, in which quantization and feedback are performed across users independently, and it improves upon the individual strategy in the same way that vector quantization improves upon scalar quantization. In our proposed strategy, the effect of user selections analyzed by extreme order statistics, while the effect of joint quantization is quantified by what we term “the composite Grossmann manifold”. The achievable sum rate is then estimated by random matrix theory. Due to its simple implementation and solid performance analysis, the proposed scheme provides a benchmark for multi access MIMO systems with finite rate feedback. The basic point in beam forming is, when you set multiple transducers next to each other sending out signals, you're going to get some kind of interference pattern, just like you see in a pond when you throw several stones in at once and create interfering ripples. If you select the spacing between your transducers and the delay in the transducers' signals just right, you can create an interference pattern that's to your benefit, in particular one in which the majority of the signal energy all goes out in one angular direction. To show this is true and what this looks like, I'm going to show a really simple example, using some sin waves being emitted from several point sources as seen below. In the expressions below S (theta r) is the signal strength (the color on the plots) as a function of azimuth and radius. It depends upon the signal function itself s (t). (Many apologies for the S and s confusion that came up with some readers, but the two are different functions.) Notice that for the example, the value used for t is simply distance from the source of the respective signal. So if we have, say, three sources interfering to create a beam pattern, we then have three s(t) functions which are summed. In MIMO systems, a transmitter sends multiple streams by multiple transmit antennas. The transmit streams go through a matrix channel which consists of all paths between transmit the antennas at the transmitter and receive antennas at the receiver the receiver gets the received signal vectors by the multiple receive antennas and decodes the received signal vectors into the original information. A narrowband flat fading MIMO system is modeled



is modeled as where $\mathbf{y}$ and $\mathbf{x}$ are the receive and transmit vectors, respectively, and $\mathbf{H}$ and $\mathbf{n}$ are the channel matrix and the noise vector respectively. where $(\cdot)^H$ denotes Hermitic an transpose and ρ is the ratio between transmit power and noise power (i.e.,

where denotes Hermitic an transpose and is the ratio between transmit power and noise power (i.e., transmit SNR).achieved through singular value decomposition of the channel matrix and the receiver. While it is often reasonable to assume that the receiver has perfect CSI through a pilot signal, assuming perfect CSI at the transmitter (CSIT) is typically unrealistic. In many practical systems, the transmitter obtains CSI through a finite rate feedback from the receiver. Note that a wireless fading channel may have infinitely many channel states, and a finite rate feedback implies that CSIT is imperfect. One expects performance degradation, and here we focus on the quantitative effect of finite rate feedback and the corresponding design. Single user MIMO systems with finite rate feedback proves beneficial. Single user systems are similar to multi access systems in the sense that there is only one receiver in both systems. The receiver knows the channel states perfectly and helps transmitters adapt their signals to maximize throughput. The essential difference between these two types of systems lies in the modes of antenna cooperation. In single user MIMO systems, all the transmit antennas are able to cooperate in sending a given message In multi access systems, different users have independent messages, and transmit antennas belonging to one user cannot aid the transmission of another user's message. Due to this additional constraint, the analysis and design of multi-access systems becomes more complicated. Still, we will borrow insight from single user systems to simplify the design of multi access systems. For single user MIMO systems, strategies to maximize throughput with perfect CSIT and without CSIT are derived and analyzed in .When only finite rate feedback is available, the focus has moved toward the development of suboptimal strategies as a simplification.

V. SIMULATION RESULTS

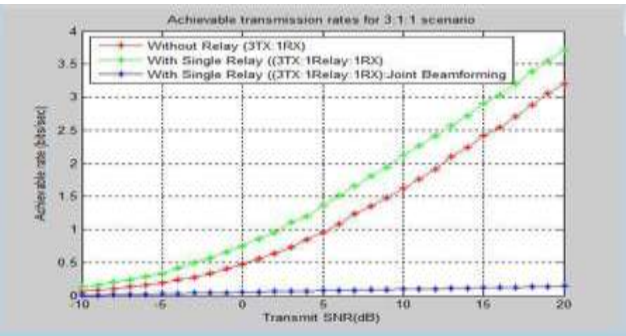


Figure5 Comparison output of two relays

The above simulation results shows Achievable rate for the given SNR values ranging from -10 to 20dB with output of two relays range from 3.3 to 3.9.

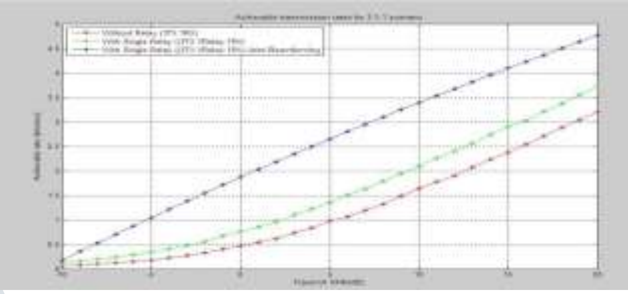


Figure6 MIMO joint beam forming (3TUX 1RX)

The above simulation results shows Achievable rate for the given SNR values ranging from -10 to 20dB with MIMO joint beam forming 3TUX 1RX without relay range from 0 to 3.4,with single relay range from 0 to 3.7 and with single relay joint beam forming range from 0 to 4.7.

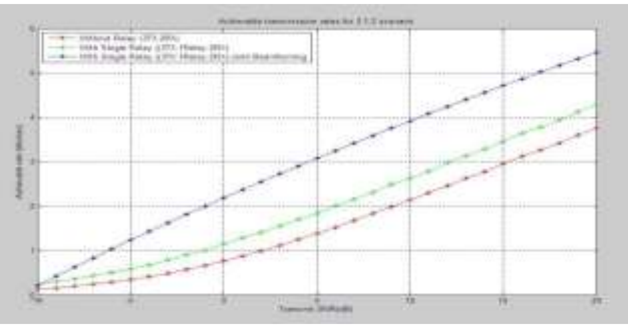


Figure7 MIMO joint beam forming (3TUX 2RX)

The above simulation results shows Achievable rate for the given SNR values ranging from -10 to 20dB with MIMO joint beam forming 3TUX 2RX without relay range from 0 to 3.8,with single relay range from 0 to 4.1 and with single relay joint beam forming range from 0 to 5.5.

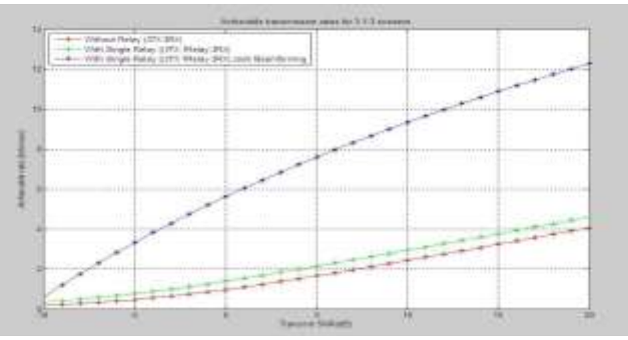


Figure8 MIMO joint beam forming (3TUX 3RX)

The above simulation results shows Achievable rate for the given SNR values ranging from -10 to 20dB with MIMO joint beam forming 3TUX 3RX without relay range from 0 to 4,with single relay range from 0 to 4.3 and with single relay joint beam forming range from 0 to 12.2.

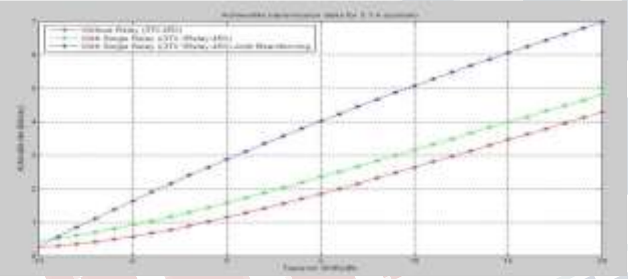


Figure9 MIMO joint beam forming (3TUX 4RX)

The above simulation results shows Achievable rate for the given SNR values ranging from -10 to 20dB with MIMO joint beam forming 3TUX 4RX without relay range from 0 to 4.4,with single relay range from 0 to 4.9 and with single relay joint beam forming range from 0 to 7.

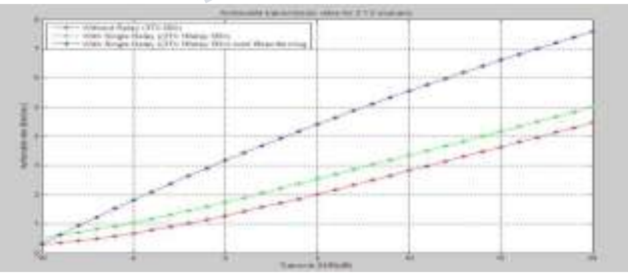


Figure10 MIMO joint beam forming (3TUX 5RX)

The above simulation results shows Achievable rate for the given SNR values ranging from -10 to 20dB with MIMO joint beam forming 3TUX 5RX without relay range from 0.3 to 4.5 ,with single relay range from 0.5 to 5 and with single relay joint beam forming range from 0.3 to 7.5.

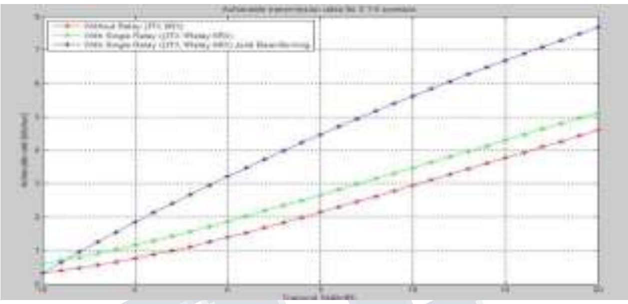


Figure11 MIMO joint beam forming (3TUX 6RX)

The above simulation results shows Achievable rate for the given SNR values ranging from -10 to 20dB with MIMO joint beam forming 3TUX 6RX without relay range from 0 to 4.8,with single relay range from 0 to 5.1 and with single relay joint beam forming range from 0 to 7.8.

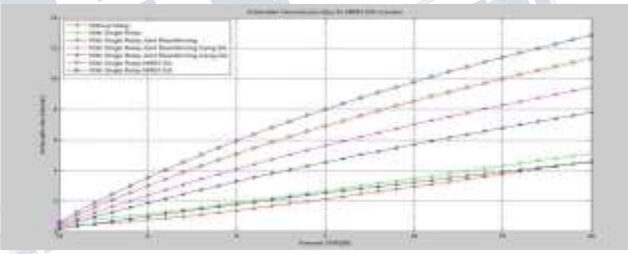


Figure 12: Comparison of MIMO Systems

The above simulation results shows comparison of Achievable rates of different systems. It shows that MIMO system will perform better than existing Zero Forcing Beam Forming (ZFBF) method and Joint Beam forming system using GA-MIMO will perform better than Joint Beam forming system using SA-MIMO.

Achievable Rate: $y = \sqrt{h}x + v$

Is as described in the previous section but with the subscripts i,j removed for brevity. Our objective is to maximize the average throughput by optimizing the rate allocation for both network and physical layer

$$Rate\quad r_k^n = \mathrm{B}\log_2[1+\mathrm{SNR}_k]$$

Where

$$\mathrm{SNR}_k = \frac{|w_k h_k|^2}{\sum_{m\in S_n, m\neq k}|w_m h_{mk}|^2 + Q_n|g_{nk}|^2 + \sigma^2}$$

$$\text{Achievable Rate C} = No.of\ Transmitters \times No.of\ Receivers \times r_k^n \times 100$$

Where
wk=kth SU-TX beam forming vector
hk= Channel response between the SU-TXk and the SU-RXk

VI CONCLUSION:

In this paper, a problem of joint beam forming, power and channel allocation is considered for multi-user multi-channel underlay cognitive radio networks.GA and SA-based algorithms have been applied to determine suboptimal channel allocations. Simulation results show that BPCA-GA can get close-to-optimal resolution with a price of high computation complexity. Whereas, BPCA-can significantly reduce the computational complexness with marginal performance degradation compared to BPCA-GA. Finally the Genetic algorithm is better than Simulated algorithm. Moreover, beam forming with interference tolerance capability introduced by our system model can achieve better performance than traditional (Zero Forcing beam Forming) ZFBF.

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