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# Optimal Spectrum Sharing with MIMO and Hybrid Multi-Relay Cooperative System and 1-D Filtering

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***Abstract – The optimality of the spectrum sharing network is highly sensitive to the fading effects of the wireless channels which call to integrate the relays to the system to reduce the power losses of the system. Use of relays makes system cooperative in nature and such will be called cooperative spectrum sensing networks, and with the application of relays the losses will be decrease. Here nakagami fading model is taken into consideration for best real life wireless scenarios. This analysis has been proved by many researchers, so here, the same concept has been integrated with the MIMO system followed by 1-D digital filtering make system more optimal in terms of outage. Simulation outcomes clearly show the optimality of the approach shown in this paper.***

***Keywords: MIMO, Cooperative Systems, Hybrid Multi-Relay, Outage probability, Spectrum Sensing, Nakagami Fading.***

## I. INTRODUCTION

Cooperative communications is a new way of communication that draws from the ideas of using the broadcast nature of the wireless channel to make communicating nodes help each other, of implementing the communication process in a distribution fashion and of gaining the same advantages as those found in MIMO systems. This results in a set of new tools that improve communication capacity, speed, and performance. It also reduce power consumption and hence improve battery life and extend network lifetime; increase the throughput and stability region for multiple access schemes; expand the transmission coverage area; and provide cooperation tradeoff beyond source–channel coding for multimedia communications.

To increase the data rates while also maintaining high reliability (lower probability of error) of the data sent over the communication link is the main objective of any mode of communication. However, in wireless communication networks, the channel suffers from unwanted yet inevitable effects (e.g. shadowing, pathloss, multipath fading etc.) which make it difficult to communicate reliably over the channel. To reduce such effects diversity can be used to transmit the different samples of the same signal over different independent channels. In this work, diversity is realized by using a third station acting as a relay.

Various diversities of the wireless channels are used as potential solutions to mitigate some of these channel impairments. Spatial diversity is used to mitigate the deleterious effects of fading via transmitting the signals from different locations, thereby allowing independently faded versions of the signal at the receiver. The multiple input multiple output (MIMO) system was proposed to generate spatial diversity by equipping the wireless device with multiple antennas. However many wireless devices are limited by size and hardware complexity to one antenna and MIMO is not realizable in these cases. Cooperative communications provides an alternative solution for this problem via enabling single antenna wireless devices in a multi-user environment to share their antennas and generate a virtual multi-antenna transmitter in order to achieve spatial diversity. The broadcast nature of the wireless channel is exploited in cooperative communications. The wireless devices which ’overhear’ the transmission between two entities meant to forward the overheard information and provide another independently faded version of the information at the receiver. Thus, each device in the network transmits its own information as well as cooperates in delivering the information originating from other devices.

In this work, combinations of several diversity relaying protocols and different combining methods are examined to see their effects on the performance. The optimal spectrum sharing with MIMO and Hybrid Multi-Relay Cooperative protocol is used in this system with 1-D Filtering. Proposed scheme achieves a good performance is then used to see the effect on the performance depending on the location of the relay.

## II. SPECTRUM SHARING

Since spectrum availability varies over time and space, and there may be a number of CR (cognitive radio) users attempting to access the spectrum at the same time, so their transmissions should be managed to avoid collisions in an overlapping portion of the spectrum. Spectrum sharing provides the ability to maintain the QoS of CR users without creating any interference to the licensed users by coordinating multiple accesses of CR users as well as allocating communication resources adaptively to the ever changing radio environment.

Therefore, spectrum sharing is carried out during the communication session and within the spectrum band, and includes much of the functionality of a medium access control (MAC) protocol. Based on architecture, spectrum allocation behaviour, spectrum access technique and scope, spectrum sharing can be classified into four categories.

*1. Classification based on architecture*

On the basis of architecture, spectrum sharing can be categorized into centralized and distributed. In centralized spectrum sharing, the spectrum allocation and access procedures are controlled through a BS. A distributed sensing algorithm can be utilized to forward the spectrum allocation measurements to the BS and then, a spectrum allocation map is generated. Moreover, the BS can lease portions of the spectrum to users in a limited geographical region, such as home, an office building, etc.

*2. Classification based on spectrum allocation behaviour*

Based on spectrum allocation behaviour, spectrum sharing can be classified into two categories: cooperative and non-cooperative. In cooperative spectrum sharing, the cooperative solutions are incorporated for interference measurements while taking into account the communication effect of one CR user on the other CR users. One of the most commonly used solutions is to form clusters to share interference information locally. This localized procedure can present an effective balance between a fully centralized and a distributed scheme.

*3. Classification based on spectrum access technique*

On the basis of spectrum access methodology, spectrum sharing can be classified as overlay spectrum sharing and underlay spectrum sharing. In the first category, the CR users access the network using spectrum holes that are not being utilized by the licensed users. The objective is to minimize the interference to the licensed users. In the second category, spread spectrum schemes such as code division multiple access (CDMA) and ultra wide band (UWB) are incorporated to achieve low interference levels.

*4. Classification based on scope*

Based on scope, spectrum sharing can be categorized into two types: intra- network and inter-network. In intra-network spectrum sharing, the resources are shared inside a CR network among its CR users, whereas, in inter-network spectrum sharing, the resources are shared among multiple coexisting CR networks as shown in Figure 2.1.

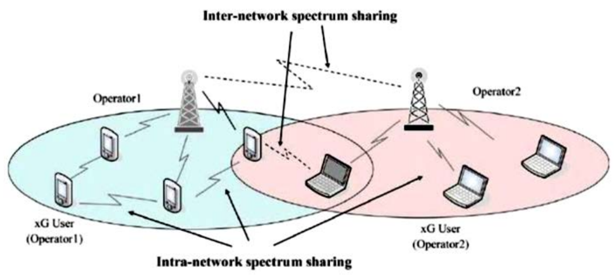


Figure 2.1 intra network and inter-network spectrum sharing.

## III. PROPOSED METHODOLOGY

Firstly in this work Matlab simulation environment has been created initially after that considers a dual hope relay and make Nakagami Fading model for spatial diversity system. Cooperative relay communication has been demonstrated to give better reliability against the multipath fading process. Consider a single source-destination combine imparting by means of a sum of R single antennas in a multihop parallel system appeared in Fig. 3.1. There are possible parallel relay paths are denoted by k with arbitrary number of relays in each path. Let path $n \in K, K = \{1, 2, .., K\}$, has a total $Nk - 1$ relays in series (i.e. total Nk hops in path k). The relays on a certain path transmit over different time slots. However the same time slots can be used by the relays on different parallel relay paths because the paths are far away from each other. Utilizing this MIMO and hybrid multi-relay phenomenon, a cooperative communication scheme is introduced that can guarantee higher quality of service (higher throughput, lower error or outage probability) in wireless networks. The channel target data rate has a nonlinear relationship with error or outage probability. An outage event generally defined as an event when a system fails to maintain reliable communication between the sources and sink. Since the received SNR/SINR characterizes the channel quality, outage probability can be characterized in terms of SNR and SNIR. The outage probability of a framework is consequently characterized as the likelihood that the instantaneous SNR or SINR falls beneath a predefined edge SNR and SINR. An optimal spectrum sharing with MIMO optimize outage metric in relay networks. It shows that the optimal route will achieve full diversity in a centralized network.

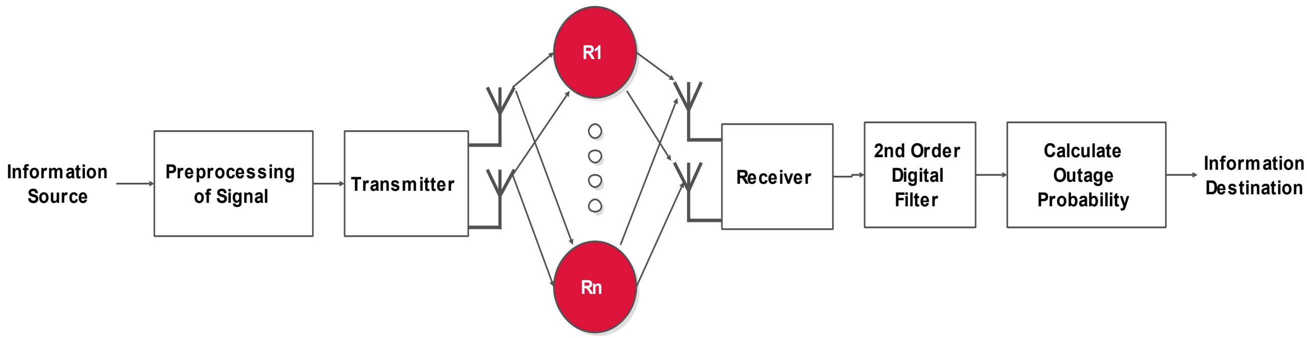


Figure 3.1. Block Diagram of Proposed Methodology.

The performance modeling is of proposed model has done for Nakagami fading channels in Matlab. Nakagami fading model gives the best approximation for multipath land mobile as well as indoor mobile environments. It also encompass other various wireless fading models such as Hoyt or Rician fading channels including the Rayleigh fading channels.

Figure 3.2 shows the flow of proposed algorithm in Matlab. To implement proposed model first simulation environment is created in Matlab. After creating simulation model in Matlab define a Nakagami fading model for wireless channel. Calculate DH channel matrix and power as well as channel and data index. Apply second order digital filtering on signals. Calculate outage probability. Compare and display results.

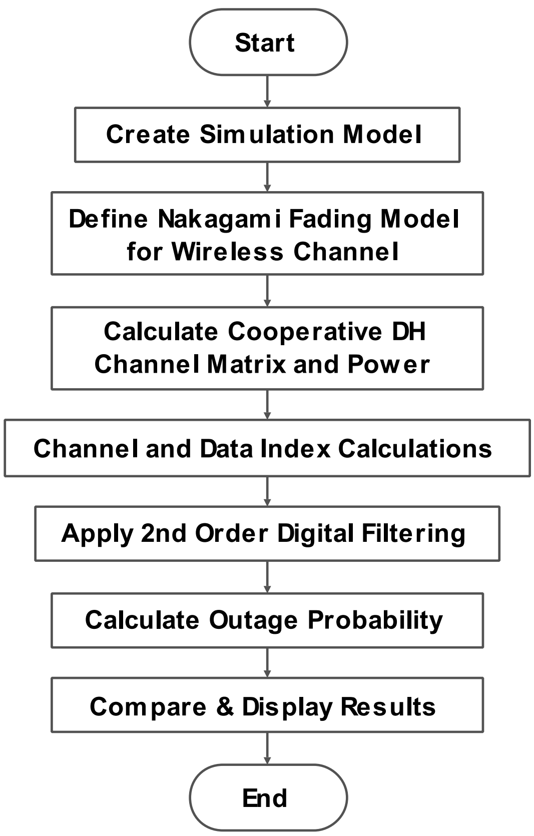


Figure 3.1. Shows Flow Graph of Proposed Methodology.

## IV. SIMULATION RESULTS

The antenna diversity based multi relay cooperative wireless system with consideration of Nakagami fading has been implemented on MATLAB. The simulation outcomes showed the system performance in terms of outage probability which is figure of merit in wireless cooperative communication system. The performance calculations can be done in using other figure of parameters like BER is the performance measure of the receiver and outage probability is a calculation of the channel, the channel capacity or throughput of information that can be analyzed via the communication channel affected by noise or signal fading letting to have smaller values of SNR. For a channel with the similar outage probability we could have two different BERs for two receivers.

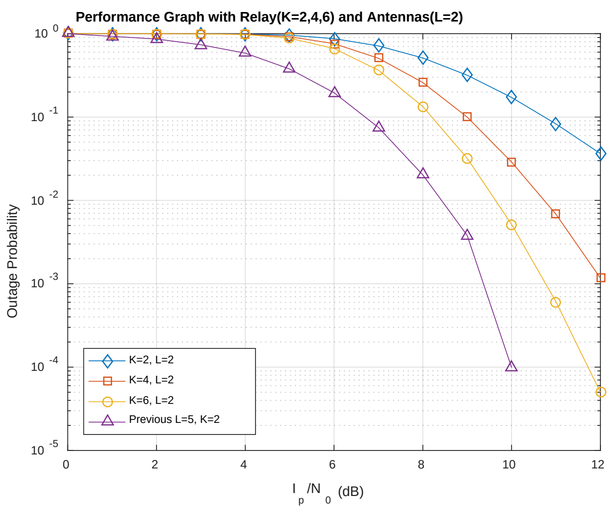


Fig. 4.1 Outage Probability of Cooperative Network with Spatial Diversity and K=2,4,6 Relays and L=2 Antennas

The complete simulation is performed using different system configurations as shown in the results below. Fig. 4.1 shows the outage probability of the spatial diversity cooperative relay system with single relay and multiple antennas (here we have taken two, four and eight antennas). The system is simulated under Nakagami-Fading environment.

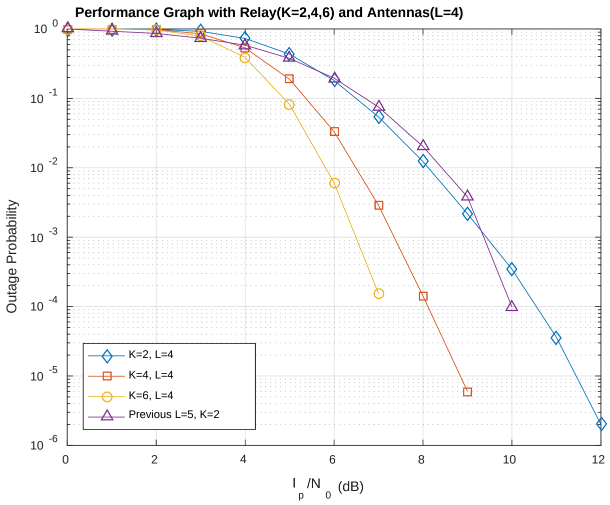


Fig. 4.2 Outage Probability of Cooperative Network with Spatial Diversity and K=2,4,6 Relays and L=4 Antennas.

From the comparison shown in the Fig. 4.1 it can be analysed that the outage probability will be decreases with the increase of number of antennas keeping the relays 2, 4 and 6 and 2 antennas for analysis.

Fig. 4.2 shows the outage probability of the spatial diversity cooperative relay system with 4 antennas (here we have taken 2, 4 and 6 relays). The system is simulated under Nakagami-Fading environment.

From the comparison shown in the result shown in Fig. 4.2 we can say that the outage probability will be decreases with the increase of number of relays keeping the antenna constant i.e. 4. The comparison from the previous results it is also clear that the additional relay increases the performance of the system, which significantly reduces the outage probability of the cooperative relay system.

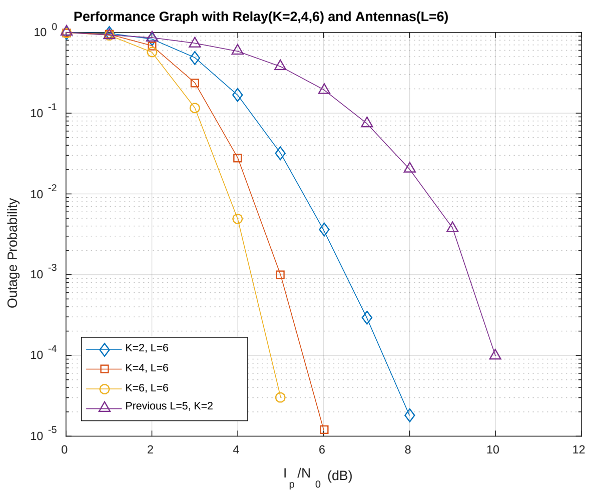


Fig. 4.3 Outage Probability of Cooperative Network with Spatial Diversity and K=2,4,6 Relays and L=6 Antennas.

Fig. 4.3 shows the outage probability of the spatial diversity cooperative relay system with 6 antennas and multiple relays (here we have taken 2, 4 and 6 relays). The system is simulated under Nakagami - Fading environment.

From the comparison shown in the result shown in Fig. 4.3 we can say that the outage probability will be decreases with the increase of number of relays keeping the number of antennas 6.

From the comparison shown in the result shown in Fig. 4.1 and Fig. 4.2 and Fig. 4.3, it can be defined that the outage probability are decreasing with the increase of number of antennas keeping as well as relays. The comparison from the previous results it is also clear that the additional relay increases the performance of the system, which significantly reduces the outage probability of the cooperative relay system.

## V. CONCLUSION AND FUTURE SCOPES

The proposed cooperative wireless communication system with the spatial diversity has been simulated with different number of hybrid relays system and the results have shown. Cooperative communication increases the reliability of signal transmission and extends the coverage of networks while reducing interference. The main idea of cooperative communication is to utilize the broadcast nature of the wireless medium and send replicas of information messages using different channels. When large numbers of relaying nodes use multihop paths to reach the destination, the data rate reduced in the network by a factor of N , where N is the number of hops. The rate does not improve even if a number of parallel paths are created as compared to MIMO systems, where the data rate increases with the number of antenna systems in the transmitter and receiver. From the simulated outcomes it can be concluded that the proposed multi relay multi antenna (MRMA) approach which has multiple antennas (L) and multiple relays (K), significantly optimize the performance of cooperative spectrum sharing system. The outcomes measured in terms of outage probability which should be as low as possible to make system more robust and efficient.

The location of the relay is important for system performance. The performance accomplished when the relay is at equal distance with sender and the receiver or marginally closer to the source is better when contrasted with when the relay is close to the destination. In general the relay should not be too far from the line between the two stations. As a scope of future work to design a robust system for better outage probability and noise resistance property compared to proposed work.

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