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Optimal Relay Selection in MIMO Empowered Cognitive Radio Ad-Hoc Networks

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ABSTRACT: Two emerging technologies MIMO and CR, both are basically parallel technologies but the fusion of these will provide a better network throughput. MIMO exploit the spatial degree of freedom and enables signal multiplexing technique in each node while Cognitive Radio (CR) exploits all the available channel frequency for transmission. But the problem in each node is that how they will select a channel or how it will effectively use the degree of freedom for higher network performance. So the proposed system will design a relay selection algorithm for finding the best relay nodes between source and destination. The relay nodes are chosen based on some criteria like energy of the node, best path from source to destination. The main objective of the relay selection algorithm is to maximize the weighted network throughput. The algorithm further support different transmission priorities reduce transmission delay and ensure fair transmission among nodes with equal probability for all the nodes in the networks. The performance of proposed algorithm can be studied based on some simulations and results will show that our algorithm is very effective and it will increase the network throughput in MIMO empowered cognitive radio networks. As part of this work we can provide security mechanism in the network for ensuring the fair transmission.

KEYWORDS: MIMO transmission, Cognitive radio, Degree of Freedom, Relay selection, Scheduling.

I. INTRODUCTION

The effective communication can be established through the connection between individual nodes. The communication can be of either wired or wireless. The Ad-Hoc wireless networks are decentralized networks. The term ad hoc indicates the meaning that these networks never relay upon a pre-existing infrastructure. Every nodes in the ad-hoc system participates in routing by forwarding data to other nodes. Dynamically identify the nodes and forward data. The principle behind ad hoc networking is multi-hop relaying in which messages are sent from the source to the destination by relaying through the intermediate hops or nodes Mobile ad-hoc is a collection of two or more devices or nodes or terminals with wireless communications and networking capability that communicate with each other without the aid of any centralized administrator. It is an autonomous system in which mobile hosts connected by wireless links are free to be dynamically and some time act as routers at the same time.

All nodes in a wireless ad hoc network act as a router and host as well as the network topology is in dynamically, because the connectivity between the nodes may vary with time due to some of the node departures and new node arrivals. The special features of Mobile Ad Hoc networks bring this technology with a great opportunity together with severe challenges. All the nodes or devises are responsible to organize themselves dynamically and the communication between the each other and to provide the necessary network functionality in the absence of fixed infrastructure. That maintenance, routing and management, etc. have to be done between all the nodes. This case called Peer level Multi Hopping and which is the main building block for Ad-Hoc Network. In the end, conclude that the Ad-Hoc Nodes or devices are difficult and more complex than other wireless networks.

The desirable goals in Ad-Hoc networks are mainly increasing network capacity and effectively using available bandwidth, along with enabling parallel communications among adjacent nodes. One way to achieve this is by using a multiple channel in communications, instead of a single channel. Utilizing the channel means channel capacity.

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MIMO[10] is a promising approach for the best channel utilization. A cognitive radio [1] offers an emerging idea to the

world of wireless technology. Cognitive radios are fully programmable wireless devices that can sense their environment and dynamically adapt their transmission waveform, channel access method, spectrum use, and networking protocols as needed for good network and application performance. Which provide a general purpose platform for programmable radio that will be a base for wireless communication development.

MIMO is a promising approach for multiple channel transmission. Space time coding is a promising approach which combines multiple antennas in the sender side with signal processing and coding techniques. The use of multiple antennas at both ends of a wireless link (multiple-input multiple-output (MIMO) technology) is an advanced method for achieving higher throughput. The corresponding technology is known as spatial multiplexing or BLAST and has an effective increase in spectral efficiency. Most of the previous work in the area of MIMO wireless has been limited to narrowband systems [8],[10]. Besides spatial diversity broadband MIMO channels, offers bigger capacity and frequency diversity. Receiver complexity in wireless environment can be reduces with the help of Orthogonal Frequency Division Multiplexing (OFDM). MIMO-OFDM will be an effective solution for future broadband wireless systems.

The use of MIMO technology in combination with OFDM, i.e., It is possible to increase the network capability by using MIMO and CR together. The goal is that to develop a distributed algorithm that can concurrently exploit the agility of CR and MIMO to benefit from both the opportunities of spare spectrum channels and spatial Degree of Freedom (DoF) for an overall higher throughput and lower delay in a multi-hop wireless network. Different channels can be utilized with different antennas. Thus the way a MIMO array of cognitive network can be created. This enhances the spatial gain. There is a tradeoff between the two options and how to assign transmission channels and antennas depend on many factors, including the network topology, the physical channel conditions, the node density, and the traffic patterns. Generally, here MIMO plays more roles when the available number of channels is small or the node density is high in a neighborhood. MIMO also could work better in a more severe channel condition.

The goal of the proposed system is to design a relay selection algorithm for finding the best relay nodes between source and destination. The relay nodes are chosen based on some criteria like energy of the node & best path from source to destination. The main objective of the relay selection algorithm is to maximize the weighted network throughput. The algorithm further supports different transmission priorities reducing transmission delay and ensuring fair transmission among nodes with equal probability for all the nodes in the networks. The performance of proposed algorithm can be studied based on some simulations and results will show that our algorithm is very effective and it will increase the network throughput in MIMO empowered cognitive radio networks.

The rest portions of the paper divided as follows: Section II reviews the body of related works, section III present the motivation and overview of our proposal, section IV briefly describes the proposed concept, and finally section V concludes this paper.

II. RELATED WORK

The studies and researches based on MIMO wireless transmission with Cognitive Radios for wireless multichannel transmission have been going on for the past few years. This section involves an extensive survey on different wireless multichannel transmission and their features. The nodes in the single channel transmission are periodically listen to the same channel while transmission in the single channel transmission. But the multichannel communication network nodes can switch among channels for maintaining parallel communication. Before the parallel communication happens, these channel would reach an agreement and this will coordinated by channel assignment mechanisms. The traditional multi-channel communication can be classified into two generalized categories such as SISO (Single Input Single Output), SIMO (Single Input Multiple Output), MISO (Multiple Input Single Output), and finally MIMO. Among these, MIMO has the more capability for carrying the data from transmitter to receiver.

In fixed channel assignment scheme, radio interfaces cannot change the operating channel during communication. Semi-dynamic scheme provides a fixed channel to either sender or receiver and nodes switch their interfaces to a

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selected channel for communication. Her switching between different frequencies take place. In the dynamic channel

assignment approach, nodes can dynamically switch among their channels in order to communicate with their neighbours and deliver the data. Therefore, every data transmission takes place after a channel selection.

Along with these MIMO capabilities, the introduction to dynamic sensing of wireless nodes for optimizing the channel capacity with Cognitive Radio while transmission discussed in [1], [7], [8] that is the concept of multichannel-multi interface wireless-communication. This concept mainly experimented with Wireless Sensor nodes (WSNs) [6], Ad-Hoc networks, Mesh networks [10] etc. The related works briefly explains different multichannel transmission with help of cognitive radio in large communication networks.

A Cognitive Radio [1],[2] which support dynamic channel sensing, having a single half duplex transceiver for every nodes. This helps in either the listening or the transmission, but only in a simultaneous manner. Cognitive Radio can intelligently sense the spectrum and can assign the adaptive frequencies to all the available channels. This can effectively reduce the amount of spectrum holes [1]. From this it is possible to define some cognitive task such as i)Radio scene analysis ii) channel state identification iii) dynamic spectrum management.

Cognitive Radio (CR) aims in signal Processing and radio technology which is capable of reconfiguring RF and switching to desired frequency bands. it is most powerful frequency agile device than the previous multi channel multi radio technology. Here multi-hope networking with CR nodes [7] are discussed. An array of frequency bands are allocated for each node in the case of this type of network. Array of bands are typically of unequal size. Bands can be subdivided into no: of sub bands for the effective sharing. Here characterizes the behavior of multi-hop cognitive radio network from multiple layers including different constraints such as scheduling, routing of packets and interferences. A mixed –integer non linear program (MINLP) [7] based on the objective that minimizing the required network-wide radio spectrum resource for a set of user sessions. A near optimal algorithm [7] is used for solving this MNLP problem.

Optimal channel selection can be done with the help of certain network parameters. Optimal opportunistic spectrum access (OSA) [8] is discussed here. OSA can be added to the transmitter end. Transmitter can't detect the complete state of channel. But it can be intelligently detected with the help of some parameters like energy as well as time. The main goal discussed here is to derive optimal strategies for determining which channels to probe, in what sequence, and which channel to use for transmission. A dynamic program that computes the optimal strategy within a finite number of steps, even when the state space is uncountably infinite. Here presents a more efficient, but suboptimal, two-step look-ahead strategy for each problem. These strategies are shown to be optimal for a number of cases of practical interest. This study examines their performance via numerical studies [8]. Here proposed an almost throughput optimal channel accessing scheme [9] for multi-hop cognitive networks. This study considers distributed learning process with low space and computation complexity.

Wireless adhoc networks are most promising approach for the effective communication between two nodes. One of the main advantages of this type of network is that many wireless devices can be connected. Which help to share the computing and resources to different devices. MIMO [11] is an emerging technology to meet the over increasing communication needs. Although MIMO technique itself can support diversity transmission when channel condition degrades, the use of diversity transmission often compromises the multiplexing gain and is also not enough to deal with extremely weak channels. This study illustrates a distributed and centralized algorithm [11] aims to exploit the use of cooperative relay transmission when direct communication is not possible. The scheduling scheme in here can efficiently invoke relay transmission without introducing significant signaling overhead as conventional relay schemes, and seamlessly integrate relay transmission with multiplexed MIMO transmission.

Reference [3],[4],[5] discuss some important and real world application of cognitive radio networks. Reference [3] discuss about a website which is popular in America. http://www.vanu.com/ which is a technical innovation to enable cellular coverage in areas such as it cannot be covered by existing technologies. First commercially available software radio network is developed under the guidance of VANU Inc. which lets wireless carriers to operate multiple standard on a single platform. Ie GSM,CDMA,iDEN
The aim of the survey is to collect maximum amount of data regarding with the two technologies MIMO and CR.

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[1] specifies the roll and importance of CR in today's wireless world. This specifies the capability of CR to explore the capacity of a spectrum band to a great extends. [2] Specifies the behavior of CR in the spectrum band. How the spectrum is divided among different channels and how these channels are utilized effectively. Rest of this survey mainly deals with MIMO network and their working architecture.

III. PROPOSED ALGORITHM OVERVIEW

In past years various form of relay selection algorithms are proposed. But these entire have a specific work area such as some of them is used for wired network, some other for wireless network such as ad-hoc networks etc. Our design framework is a MIMO empowered Cognitive Radio Ad-hoc network. This is a promising approach for the wireless communication. In this work we create each node as an intelligent node with some specific functionality. MIMO has the capacity for achieving spatial multiplexing to a great extends. And CR has the capacity for sensing the channel and white holes in a spectrum in an efficient manner. So the overall outcome of the system will increase surely. Our proposed algorithm is applied on this MIMO-CR framework. So that some of the nodes in between transmitter and receiver will act as a relay node.

The function of the relay node in this cellular communication is to pass the data packet from one node to other in a best and efficient manner. This relay node can be selected on some criteria's such as energy of the node , time, neighbour reachability and no of hops needed from source to destination. Here propose a jointly optimized relay selection scheme for both increasing the cooperative transmission and more stable cooperative spectrum sensing in MIMO-Cognitive Radio networks, aiming to reduce the computational burden of the selection procedure. Hence, we can select an optimum relay with only one selection algorithm for two tasks. The transmission and sensing performances of the proposed method are presented by means of computer simulations.

A. Diagrammatic Illustration

The diagrammatic illustration of the proposed concept is shown in fig 1.

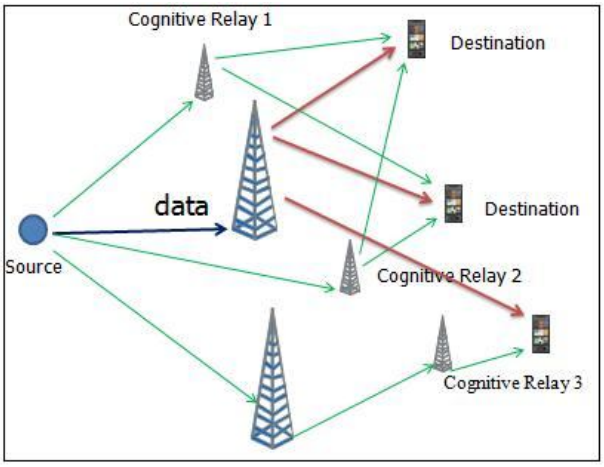

Fig 1: Proposed Concept

Here each node in the network can be considered as an intelligent MIMO-CR node. Our proposed algorithm will work in the following way. Ie we present our optimal relay selection scheme for both node to node communication and spectrum sensing in MIMO- Cognitive Radio networks. Our selection algorithm combines two steps; (i) choosing the best relay nodes for node to node transmission, (ii) choosing the best relay for spectrum sensing, and finally we combine these two task to perform a single task. Clearly, the selected relay will be sub-optimal for either transmission or spectrum sensing. In the above figure 1, we briefly explain our MIMO-Cognitive Radio network model with relay nodes. Based on the simulation results we can prove that our proposed method gives sufficient performance for both

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end to end communication, spectrum sensing and transmission tasks.

The most promising gain is that the selected relay yields sufficient error performance for transmission and sufficient probability of detection for spectrum sensing. Proposed method is more stable, robust to noise and low computational cost.

The "best relay" for transmission is selected based on following method.*

In the secondary network transmission, the best relay amplifies the *transmitted* signal and achieves the highest received instantaneous signal-to-noise ratio (SINR) at *destination*. For transmission, the best relay selection criterion is given as:

B_{relay} =Average (max (SINR (destination signal))---- (1)

The "best relay" for spectrum sensing is selected based on following criteria:*

The best relay to sense the spectrum is having the largest channel coefficient. For spectrum sensing, the best relay selection criterion is given by the following:

B_{relay} = arg max $[(|hPT-SRi|^2)/\sigma^2 SRi-PD]$ ------- (2)

SRi−PD - is the fading variances of the channels from transmitter to receiver. hPT−SRi Is the Complex Gauss fading coefficients for particular channel.

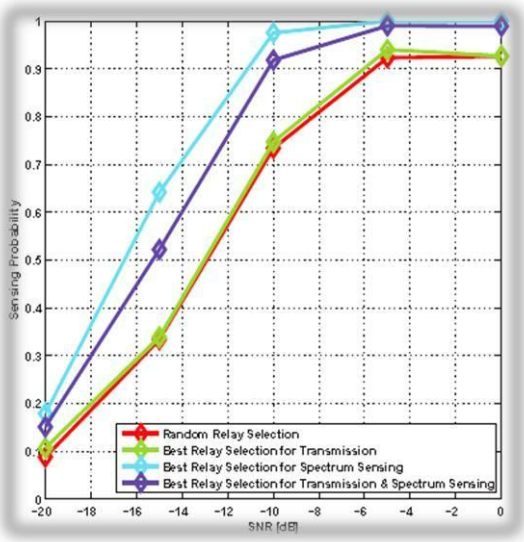

Fig. 2: Analysis outcome*

IV. CONCLUSION AND FUTURE WORK

The proposed algorithm for selecting the best relay nodes for end to end communication and spectrum sensing is a newer approach in case of a MIMO-CR network. As based on the simulation results it can be shown that the proposed algorithm will surely make the network to a more featured one. Ie by applying this algorithm, the overall performance including data rate, network throughput and efficiency can be increased. In conclusion, our algorithm selects a relay also at lower SNRs that performs sufficiently in terms of secondary network data transmission as well as spectrum sensing of the primary network with low processing complexity. The proposed algorithm includes the modification of the interfaces to distinguish between the different physical layer parameters supported by the different nodes. Security mechanisms can be added to this framework as a future enhancement. Analysis can be made to evaluate the network performance of proposed protocol. Simulations can be done by using network simulator-2 (NS-2).

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