Volume based channel sharing hybrid algorithm Multiuser MIMO-MRC Based Cognitive Radio Networks

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Abstract—In spectrum sharing environments of cognitive radio (CR), secondary users are permitted to share the primary user's spectrum only if limited interference to the primary user can be guaranteed. On the other hand, when multiple CR users share the same channel at one time, the total throughput of the CR networks can be maximized by allocating the common radio resource to the CR users with the best channel quality and the multiuser diversity gain can be obtained. In this paper we propose a fast CR user selection algorithm with low complexity and the multiuser diversity gain are analyzed. From the simulation results, this algorithm not only decreases the computational complexity of the scheduling algorithm but also retains large capability of the MIMO CR system.

Keywords-Cognitive radio; MIMO; multiuser diversity; spectrum sharing

I. INTRODUCTION

Cognitive radio (CR) is a promising technology to utilize spectrum resources efficiently in the future wireless communication systems [1, 2]. The main objective to design a CR network is to maximize the throughput while providing sufficient protection to the existing primary radio networks (PRs). There are spectrum sharing and other several basic operation models for CR networks. In spectrum sharing, the CR can transmit concurrently with PR only when it knows how to control the interference powers at PRs below a tolerable threshold [3]. On the other hand, in the dense multiuser networks, significant spectral efficiency improvement can be obtained by dynamically identifying and allocating the communication resources to the best or most reliable link. The improvements thus attained are referred to as multiuser diversity gain (MUD) [4, 5]. The conventional form of MUD is usually exploited in a wireless system with multiple independent fading communication links and the performance of such a resource allocation scheme relies on the peak channel conditions and improves as the number of user increases.

It is noted that MUD for the fading CR networks has been recently studied in [6-9]. In [6], MUD was analyzed for the fading CR multiple-access channel where the ratio between the CR transmit power constraint and interference power constraint goes to infinity. In [7], MUD was investigated for the fading CR parallel-access channel. In [8], a new kind of multiuser diversity, named multiuser interference diversity, is investigated in CR networks by exploiting the mutual interference between the CR and the existing primary radio links. In [9], the optimal gain achieved in a network with a central authority was obtained and a distributed spectrum access scheme that is proven to achieve the optimal throughput scaling factor was proposed.

All the work mentioned above, however, only considered the situation when the CR system consists of one CR user communicating to a CR base station in every time slot. In fact, the CR base station usually supports more then one CR user in a time slot. Suppose N CR users can be supported and K CR users want to transport, $N < K$, the best schedule algorithm is to search the C_K^N possibilities to find the group who has the maximum sum capacity. We should notice that every user can be regarded to be the co-channel interferences to the other users. However, this algorithm is quite complex, so the cost of operation to the base station has substantial increased.

In this paper, we propose a CR user group selection algorithm with low complexity to reduce the computational complexity. This algorithm introduces a technique for selecting users with the best channel state information as candidates to transmit the information. From the simulation results, this algorithm not only decreases the computational complexity of the scheduling algorithm but also retains large capability of the MIMO CR networks.

II. SIGNAL AND SYSTEM MODEL

Consider a spectrum sharing CR network coexisting with a PR network. One active PR link consisting of a PR transmitter with n_T transmit antennas and a PR receiver with n_R receive antennas is considered. We assume that the down link CR network consists of K desired mobile users and one base station in the presence of L co-channel users and additive noise. The CR base station employs n_T transmit antennas and each mobile user employ n_R receive antennas. We consider the block-fading model for all the channels involved and coherent communications; thus, only the fading channel power gains are of interest. It is assumed that the additive noises at all PR and CR receive terminals are independent circular symmetric complex Gaussian random variables each having zero mean and unit variance. Then, the received signal vector at the receiver of the desired CR user k in transmitter beamforming and maximum ratio combining MIMO-MRC systems can be written by channel matrix of the kth CR desired user, the element $h_{k\ 0,ij}$ represents the channel between the j th antenna of the where N is the number of users selected from K CR users. As for a scheduling algorithm, exhaustive algorithm can get the largest capability. But in the exhaustive scheduling algorithm, the whole C_K^N possibilities of the user groups need to be searched. We assume C_K^N is the number of scheduling in exhaustive algorithm, that is, the scheduling complexity. So this algorithm is quite complex and usually brings huge workload to a base station with multiple antennas, hence the cost of operation to a base station has substantial increased. We propose a fast user selection algorithm that selects users based on group. We first divide K users into M groups, K/M > N. Then we select N users in each group by exhaustive attack algorithm. After that, we select the users in the group with the highest sum capacity to transmit their signals.

On the other hand, it is obviously that sufficient protection to the existing primary radio (PR) network should be carefully considered while maximizing the throughput of the CR network. To protect the PR network, we define a threshold C_{pi} / C_p , where C_{pi} and C_p are the capicity of the PR receiver with and without the interference from the CR network. We first select N users in each group by exhaustive attack algorithm, then we check the C_{pi} / C_p related to this group. If the C_{pi} / C_p , the users in this group can be one of the candidate groups. Finally, the candidate group with the highest sum capacity can be allowed to transmit in PR network.

To examine the effects of interference, we assume that the cognitive network has a central decision-making entity fully aware of all cognitive users' instantaneous channel realizations. Some simulation results are shown to demonstrate the availability of the proposed algorithm. We assume that channels are static within a data block and vary independently among data blocks. For Monte Carlo simulations, simulated data of 50000 samples of fading channel are used. We consider a MIMO MRC system with n_R n_T 2 , SNR_{PR}=12dB for the PR user, SNR_{CR}=3dB for all the CR users.

Figure 1 and 2 show the throughout difference between exhaustive algorithm and proposed algorithm with different groups when 0.6 and 0.7 , respectively. From the Figure1, we can check that the gap between the proposed algorithm and other works is limited to sacrifice little system performance with low complexity. We find that the capacity gap between the exhaustive algorithm and the proposed algorithm with 2 or 3 groups are small. We also find that the capacity with 6 groups is smaller than that of with 2 or 3 groups. We can also find that the high value leads to less interference to the PR networks and low CR throughput.

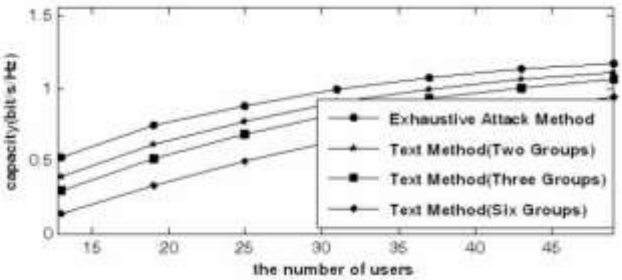

Fig.1 Comparison of channel capacity among the proposed algorithm and the exhaustive algorithm, =0.6.

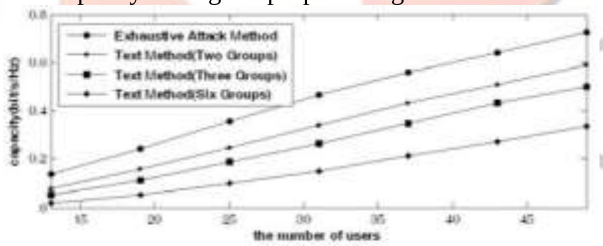

Fig.2 Capacity for proposed algorithm and exhaustive algorithm

In order to demonstrate the complexity of the proposed algorithm, the scheduling number of times, the complexity of the scheduling, is also compared in Figure 3. It is easily checked from the Figure.3 that the complexity of proposed algorithm is much lower than that of exhaustive algorithm.

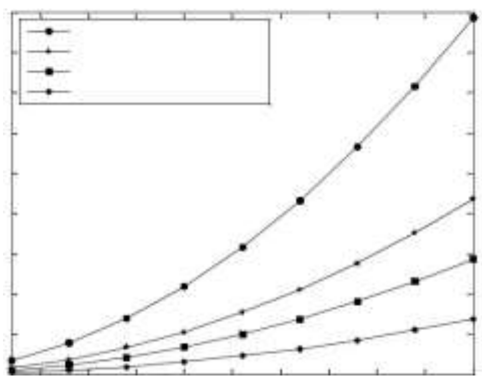

Fig.3 Comparison of selection complexity among the proposed algorithms and the exhaustive algorithm.

To further demonstrate the efficiency of the proposed scheduling algorithm, we define a factor *Q=Capacity /Complexity*, where *Capacity* is the throughput of the CR networks, *Complexity* is the number of scheduling in each algorithm. From figure 4, we can conclude that the proposed algorithm can achieve higher scheduling efficiency compared with the exhaustive algorithm.

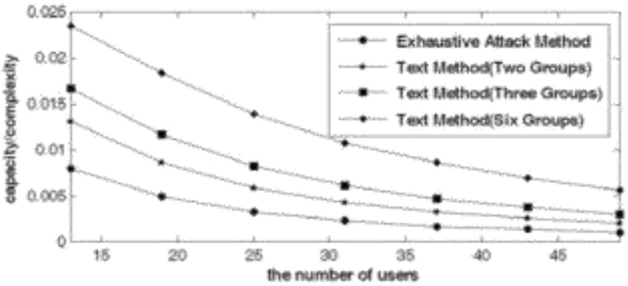

Fig.4 Comparison of Capacity/Complexity among the proposed algorithms and the exhaustive algorithm, =0.7

III. Conclusion

We propose an efficient algorithm to reduce the complexity of selecting desired users from amount of users in CR networks based on MIMO-MRC with co-channel CR users. A group scheduling technique is considered in this algorithm to select some CR users with the best sum capacity. Meanwhile, the interferences from these CR users to the PR networks are constrained under the threshold. The complexity is linearly increasing with the number of users when the total number of users is large. To check the simulation results, the tradeoff between the system performance and complexity is reasonable.

IV. Acknowledgment

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