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Design and Implementation of Power Allocation and Interference Minimization of Cognitive Radio Sensor Networks

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Abstract

The Cognitive Radio (CR) is an emerging technology in order to solve the spectrum scarcity problem in the future wireless communication networks. Spectrum Sensing is found to be one of the most complex and power intensive tasks in Cognitive Radio (CR). To improve the network performance Orthogonal Frequency Division Multiple Access is assumed as the multiple access technique for Cognitive Radio. Interference Cancellation is important problem in optimization strategies (MIMO) Multiple Input Multiple Output OFDM based cognitive networks. The power allocation using water filling algorithm to minimize unnecessary transmission power and reduce mutual interference to primary users(PU) and other secondary users(SU), an interference minimization and subcarrier power allocation approach for OFDM based Cognitive Radio Networks. Different from the other work, the optimization of power is introduced to maximize the energy with consideration of imperfect spectrum sensing techniques. Simulation result MATLAB shows that for every value of power levels energy will be improved. It also improves spectrum efficiency and throughput enhancement in the network.

Keywords: Cognitive Radio, Orthogonal Frequency Division Multiplexing, Multiple input Multiple output.

I. INTRODUCTION

The available electromagnetic radio spectrum is a limited natural resource and getting crowded day by day due to increase in wireless devices and applications. The issue of spectrum under utilization in wireless communication can be solved in a better way using Cognitive radio (CR) technology.

Cognitive radios are designed in order to provide highly reliable communication for all users of the network. MIMO, technology has been one of the most significant advances in wireless communications in recent years. MIMO technology makes use of antenna arrays, containing multiple antenna elements, at both ends of a communication link. On a single MIMO link, diversity and array gains can be exploited in order to significantly increase the link's capacity.

When multiple MIMO links are used concurrently on the same wireless channel, there is also the possibility to cancel interference between links. Interference cancellation provides increased performance benefits on top of diversity and multiplexing gains.

II. RELATED WORK

The energy-efficient power allocation schemes [1] for secondary users in sensing-based spectrum sharing cognitive radio systems. It is assumed that secondary users first perform channel sensing possibly with errors and then initiate data transmission with different power levels based on sensing decisions. The optimal power levels are identified in the presence of different levels of channel side information (CSI) regarding the transmission and interference links at the secondary transmitter, namely perfect CSI of both transmission and interference links, perfect CSI of the transmission link and imperfect CSI of the interference link, imperfect CSI of both links or only statistical CSI of both links. Through numerical results, the impact of sensing performance, different types of CSI availability, and transmit and interference power constraints on the EE of the secondary users is analyzed.

In paper [2], investigate the energy efficiency and throughput optimization problem of cognitive relay networks. To design sensing time and signal to noise ratio (SNR) to maximize the energy efficiency and throughput, since analytical and empirical studies have shown that sensing time and SNR are key factors for energy efficiency and throughput. optimal sensing time and optimal SNR can be jointly designed to maximize energy efficiency. Finally, simulation results to show that energy efficiency of cognitive relay transmission scheme can be significantly improved compared with that of direct transmission scheme in cognitive radio networks.

Inspired by the green communication trend of next-generation wireless networks, select energy-efficient throughput as optimization metric for jointly optimizing sensing time and working sensors in cooperative cognitive radio networks. Specifically, an iterative algorithm [3] is to obtain the optimal values for these two parameters. Specifically, the iterative algorithm is low complexity when compares to the exhaustive search method, and very easy to be implemented. Finally, simulation results reveal that the proposed optimization improves the energy efficient throughput significantly when the sensing time and working sensors are jointly optimized.

In paper [4] divide the sensors into a number of non disjoint feasible subsets such that only one subset of sensors is turned on at a period of time while guaranteeing that the necessary detection and false alarm thresholds are satisfied. Each subset is activated successively, and non-activated sensors are put in a low energy sleep mode to extend the network lifetime. Formulate such problem of energy-efficient cooperative spectrum sensing in sensor-aided CR networks as a scheduling problem, which is proved to be N P-complete. We employ Greedy Degradation to degrade it into a linear integer programming problem and propose three approaches, namely, Implicit Enumeration (IE), General Greedy (GG), and λ-Greedy (λG), to solve the sub problem. Among them, IE can achieve an optimal solution with the highest computational complexity, whereas GG can provide a solution with the lowest complexity but much poorer performance.

III. PROJECT OVERVIEW

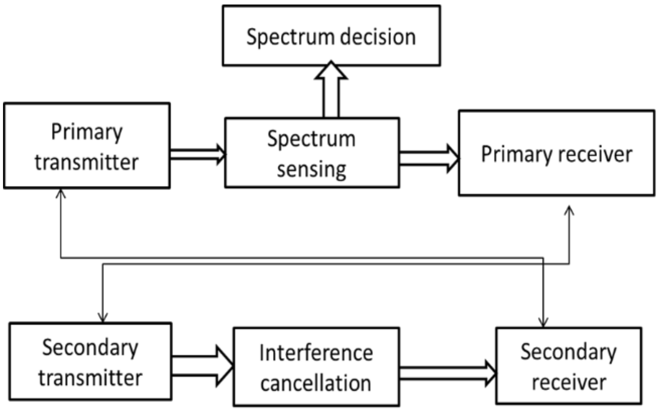

Fig.1. OFDM based Block diagram

The channels between various nodes are quasi-stationary and fixed over the duration of a number of blocks. Regarding channel knowledge assumptions at various nodes, that the primary terminals (transmitter and receiver) have perfect knowledge of its own channel, while the secondary terminals (transmitter and receiver) have perfect knowledge of all the channel transfer matrices. There are many cases where the assumption will be valid, for example, the channel reciprocity can be exploited to acquire channel state information (CSI) at the transmitters. Also, when the primary network subleases the spectrum for monitory purposes to the secondary network under a spectrum sharing arrangement, a degree of collaboration can be expected for acquiring CSI values.

A. ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

Orthogonal Frequency Division multiplexing is one of the latest modulation techniques used in order to combat the frequency-selectivity of the transmission channels, achieving high data rate without inter-symbol interference. The basic principle of OFDM is gaining a wide spread popularity within the wireless transmission community. Furthermore, OFDM is one of the main techniques proposed to be employed in 4^{th} Generation wireless system.

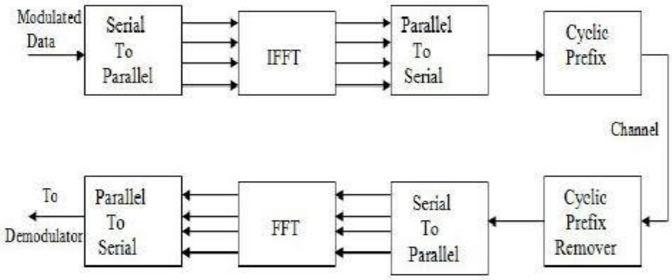

Fig.2. Block diagram of OFDM

B. WATER FILLING ALGORITHM

The proposed Water filling algorithm is a general name given to the ideas in communication systems design and practice for equalization strategies on communications channels. The process of water filling is similar to pouring the water in the vessel. The unshaded portion of the graph represents the inverse of the power gain of a specific channel. The portion representing the shadow represents ηthe power allocated or the water shows the maximum water level. The total amount on water filled (power allocated) is proportional to the Signal to noise ratio of the channel.

Power allocated by the individual channel is given by the Eq. 1, as shown in the following formula

$$Powerallocated = \frac{Pt + \sum_{i=1}^{n} \frac{1}{H_i}}{\sum channels} - \frac{1}{H_i} \qquad (1)$$

Where Pt is the power budget of the MIMO system which is allocated among the different channels and H is the channel matrix of the systems. The Capacity of a MIMO system is algebraic sum of the capacities of all channels and is given by the formula below.

$$Capacity = \sum_{i=1}^{n} \log_2(1 + PowerAllocated * H) \qquad (2)$$

To maximize the total number of bits to be transported. The result shows that the proposed water filling power allocation scheme is, as per the scheme following steps are followed to carry out the proposed water filling algorithm.

Algorithm Steps:

Step 1: We do not need to reorder the MIMO-OFDM sub channel gain realization in a descending order

Step 2: Take the inverse of the channel gains.

Step 3: Water filling has non-uniform step structure due to the inverse of the channel gain.

Step 4: Initially take the sum of the Total Power Pt and the Inverse of the channel gain .It gives the complete area in the water filling and inverse power gain.

$$Pt + \sum_{i=1}^{n} \frac{1}{H_i} \qquad (3)$$

Step 5: Decide the initial water level by the formula given below by taking the average power allocated (average water Level)

$$\frac{Pt + \sum_{i=1}^{n} \frac{1}{H_i}}{\sum channels} \qquad (4)$$

The power values of each sub channel are calculated by subtracting the inverse channel gain of each channel.

$$Powerallocated = \frac{Pt + \sum_{i=1}^{n} \frac{1}{H_i}}{\sum channels} - \frac{1}{H_i} \qquad (5)$$

IV. IMPLEMENTATION AND RESULT

MATLAB is used to simulate the proposed Interference cancellation. A multiple input multiple output channel technique is implemented based on cognitive radio system. The channel estimation method is used to evaluate the performance the system.

SIMULATION RESULT

NETWORK CREATION

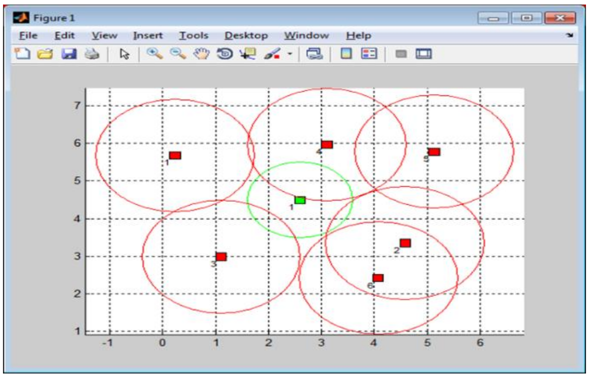

Fig. 3. Network Creation

From the fig (4.1) shows Network creation first to form the base station then to allocate the positions of primary and secondary user in the coverage area the maximum power a radio can transmit to the users. Initially, six primary user (transmitter) and one secondary user (receiver) in the network.

PRIMARY AND SECONDARY USERS

In order to evaluate the proposed scheme, we use a system with two users and two receivers each. This is a typical MIMO channel. The two users are sending signals to the receivers simultaneously.

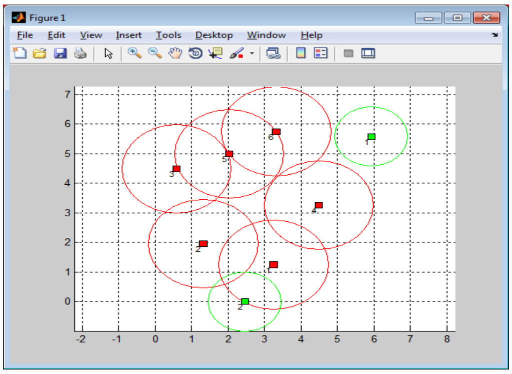

Fig.4. Primary and Secondary user

From the fig 4 shows that opportunistic spectrum access (OSA) mode, the secondary users access the spectrum when the primary user not use it concurrently.so the secondary users gradually increase.

CHANNEL GAIN

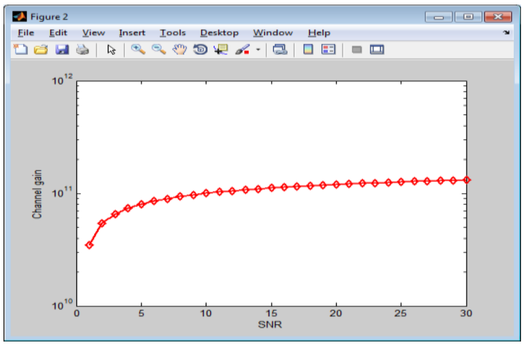

Fig. 4.3 Channel gain Vs SNR

From the figure (4.3) Channel gain against signal to nose ratio shows that the SNR has increased with the channel gain. The noise in the channel is removed by power allocation using water filling method. So the maximum transmission of channel information from transmitter to receiver.

CRN CAPACITY

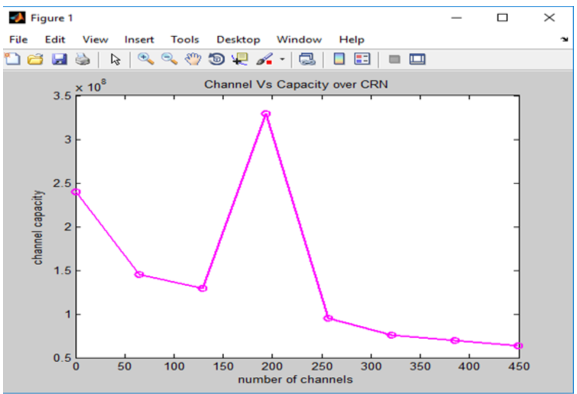

Fig.5 Channel Vs Capacity over CRN

From the above figure 5 shows that channel vs. capacity over CRN in this to increase the number of secondary users the channel capacity also increased. At the time interference occurred in the channels reduced the capacity.

CAPACITY VS SIGNAL TO NOISE RATIO

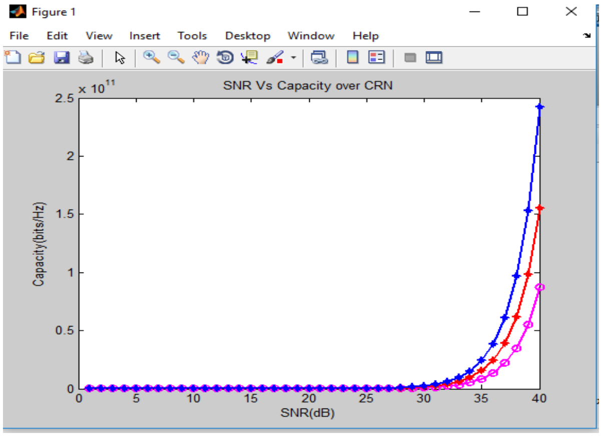

Fig.6. Capacity vs SNR

The above figure 6 shows that achievable rates for the CR network at 40 dB are 2.5x10^{11} bits/Hz/s. The achievable rates for the primary network with the cognitive relay network are higher than that of the primary network without a relay. This is because the interference cancellation technique not only annihilates interference at the primary destination, but it also assists the primary network to increase the effective channel gain.

PROBABILITY DETECTION

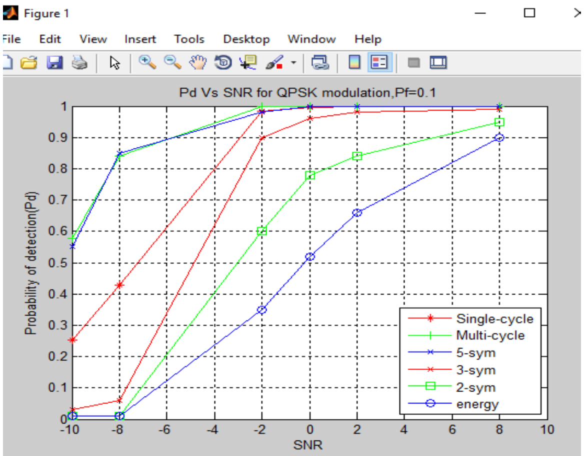

Fig.7. Probability detection Vs SNR

The performance for using different detection schemes is represented in figure (4.6).This result shows that the use of better detection scheme makes the performance for the MIMO cancellation method increase. In this Multi-cycle method is the best to reduce the error then compared to another method.

BIT ERROR RATE

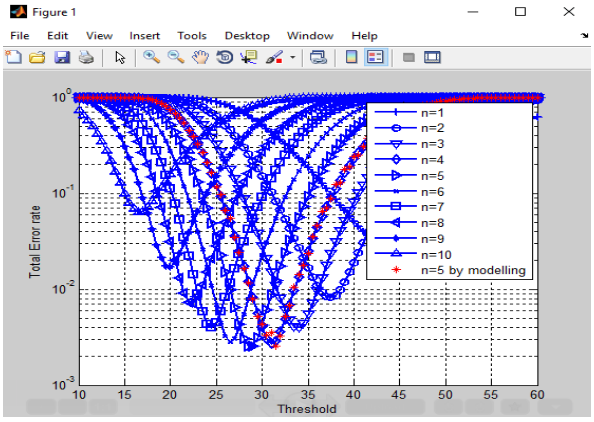

Fig.8. Energy detection

The above figure 8 shows that Cooperative spectrum sensing and adapting to the environment, a cognitive radio is able to fill spectrum holes and serve without causing harmful interference to the licensed user. We consider optimization of cooperative spectrum sensing with energy detection to minimize the total error rate.

V. CONCLUSION

Due to growing demand for high data rates and increased number of users, energy consumption of wireless systems has gradually increased. Cognitive Radio (CR) is promising solution for it which is effective. For optimal and efficient use of energy resources with the goal of reducing costs and minimizing the energy consumption of wireless systems is of paramount importance and energy-efficient design has become a consideration in wireless communications from the perspective of green operation. For that allocation of power to cognitive radio is even more important which can be done smartly as no other user can harm of it and transmission can be done easily in low energy level and cost. The approach is done by using the iterative water filling method in which Lagrange multipliers are used to reduce the computational complexity. It gives the result as some point the power get minimum but the energy efficiency is maximum and it become constant.

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