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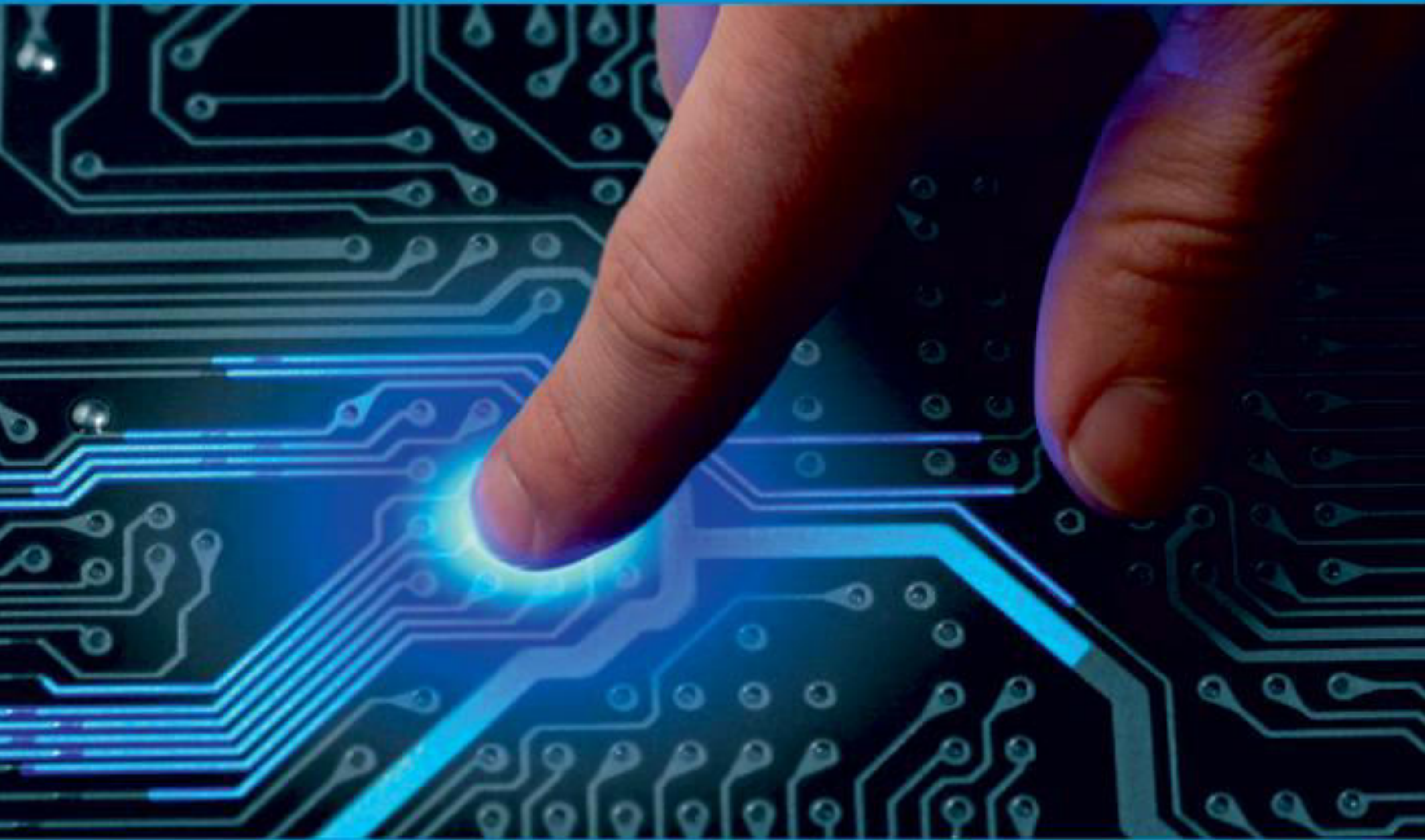

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Coordinated Multipoint Joint Transmission with Cognitive Radio Network for Performance Improvement In Advance Cellular Communication

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ABSTRACT: Cognitive radio (CR) has been proposed as a technology to improve the spectrum utilization efficiency by giving an opportunistic access of the unused/underutilized spectrum to unlicensed users. Meanwhile, coordinated multipoint joint transmission (JT) is another promising technique to improve the performance of cognitive radio network. In this paper, we propose a CR system with coordinated multipoint JT technique. An analytical model is developed for the received signal-to-noise ratio at a CR to determine the energy detection threshold and the minimum number of required samples for energy detection–based spectrum sensing in a CR network (CRN) with CoMP JT technique. The performance of energy detection–based spectrum sensing under the developed analytical model is evaluated by simulation and found to be reliable. It is formulated an optimization problem for a CRN with coordinated multipoint JT technique to configure the channel allocation and user scheduling for maximizing the minimum throughput of the users.

KEYWORDS: Cognitive, Joint Transmission, CRN, Energy, Throughput.

I. INTRODUCTION

Cognitive radio (CR) has been proposed as a technology to improve the spectrum utilization efficiency by giving an opportunistic access of the unused/underutilized spectrum to unlicensed users it is the key enabling technology that enables next generation communication networks, also known as dynamic spectrum access (DSA) networks, to utilize the spectrum more efficiently in an opportunistic fashion without interfering with the primary users. It is defined as a radio that can change its transmitter parameters according to the interactions with the environment in which it operates [3]. It differs from conventional radio devices in that a cognitive radio can equip users with cognitive capability and reconfigurability [4], [5].

Cognitive capability refers to the ability to sense and gather information from the surrounding environment, such as information about transmission frequency, bandwidth, power, modulation, etc. With this capability, secondary users can identify the best available spectrum. Reconfigurability refers to the ability to rapidly adapt the operational parameters according to the sensed information in order to achieve the optimal performance. Based on its abilities to detect and adapt to different radio environments, cognitive radio has been defined in various ways. Cognitive radio systems can mainly be divided into 2 categories: underlay and interweave. In underlay scheme, the SUs, ie, cognitive users access the spectrum while keeping the interference at the PU, ie, licensed user below a certain limit. On the other hand, in interweave scheme, the SUs access the spectrum while PU is inactive and the SUs use spectrum sensing technique to determine the inactivity of the PUs. The interweave scheme is the most suitable for the current spectrum management policies and legacy wireless systems. Spectrum sensing is one of the key functions in interweave CR network (CRN). For accurate detection of activity on a spectrum, accurate spectrum sensing techniques are required. While the concept of CR puts emphasis on better use of wireless spectrum and increasing total throughput, there is still

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growing need for improvement in the coverage of high data rates and an increase in user/system throughput.16 Cooperation among the base stations (BSs) in a network of small cells is one viable solution for this problem. Increasing the data rate of cell-edge users is also a concern in cellular networks. Coordinated multipoint (CoMP) transmission is currently being considered as an effective solution to both these concerns. In CoMP operation, multiple BSs coordinate with each other in such a way that the transmission signals from/to other points do not incur serious interference and exploit the benefits of distributed multiple antenna systems.
Both CR and CoMP transmission are highly promising paradigms for future cellular networks. Several researches have been conducted on CoMP transmission–based CRNs. These researches can be divided into 2 categories: underlay and interweave. Underlay CRN with CoMP transmission has been studied in this research under various aspects by limiting the interference to the PUs below a threshold.

II. SYSTEM MODEL DESCRIPTION

Assume that a PU transmitter exists, which is always transmitting with transmit power P^{pu} tx . The transmission power of the SU transmitters is equal and denoted by P^{su} tx. There are 2 secondary transmitters that can perform non coherent CoMP JT opportunistically on the licensed PU band. We assume that the SU transmitters coordinate among themselves and perform JT only when both of them detect the channel as idle. A typical system is shown in Figure 1, where PU TX and PU RX are the primary transmitter and receiver, respectively, and SU TX1 and SU TX2 are secondary transmitter 1 and secondary transmitter 2, respectively. The primary transmitter is placed at origin (0,0), and the positions of the other transmitters and receiver are shown in polar coordinates. We assume that the primary receiver moves about origin in a circle whose radius is the protected radius Rp. Protected radius (Rp) of the primary transmitter is the radius inside, which a primary receiver (PU RX) must be guaranteed reception, even when the SU transmitters (SU TXs) transmit using the same PU channel. In this region, primary receiver (PU RX) receives a minimum required signal-to-interference-plus-noise ratio (SINR) (γ_{dec}) to successfully decode its signal at its target rate.

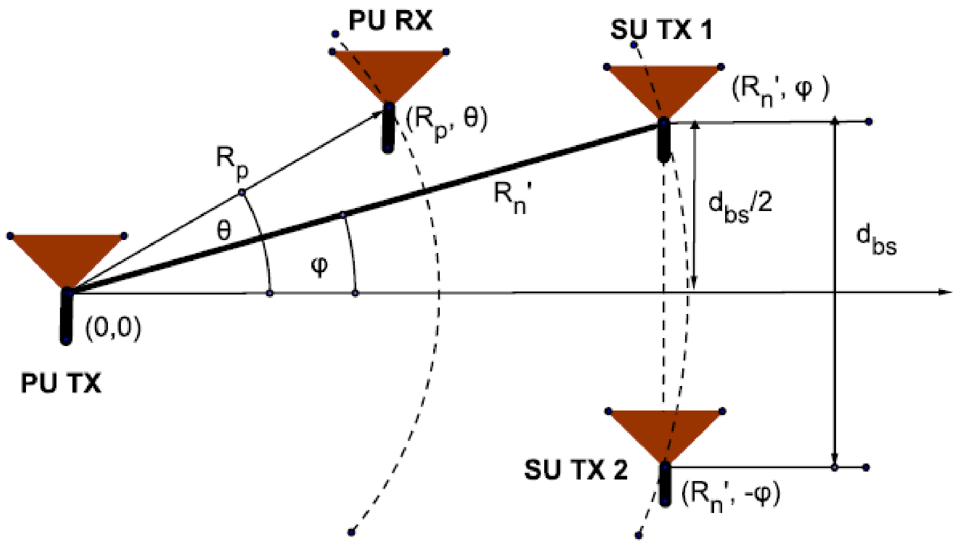

Figure 1: cognitive radio system with coordinated multipoint JT

At any instance, the position of the PU RX at the edge of the protected radius is given by the coordinates (*Rp*, θ). The secondary transmitters are placed at radius *Rn* with respect to the PU TX, and their coordinates are given by (*Rn*, ϕ) and (*Rn*, $-\phi$). We define *Rn* as the no talk radius for JT. The no talk radius is the distance within which the secondary transmitters must not perform JT using the channels being used by PU to facilitate a successful PU transmission. Thus, any SU situated inside no talk radius must detect an ongoing PU transmission accurately. The distance between the secondary transmitters is denoted as *dbs*.

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III. METHODOLOGY

Let consider a CRN consisting of 2 BSs *i* and *j* with CoMP JT technique. The set of BSs is given as $B = \{i, j\}$. The SUs are randomly distributed in the CRN. Each SU is associated with a BS that is nearest to it. The set of SUs associated with the BS $b \in B$ is given by *N′b*, the set of all the SUs *N* is given as $Ni \cup Nj$, and the total number of users is $|N| = N$. Let the set of SUs in the intersection area of the 2 BSs is denoted by *Nij*. The set of SUs in the BSs *i* and *j* that do not belong to the intersecting area are *Ni* and *Nj*, respectively. Now consider only downlink communications in the CRN, ie, the BSs transmit data to the SUs. The transmission power levels at the BSs are equal to *Psu tx* . The time is divided into small repetitive time frames with duration T_{frame}. Each frame is divided into 3 parts called *Ts*, *Ta*, and T_{tx}.

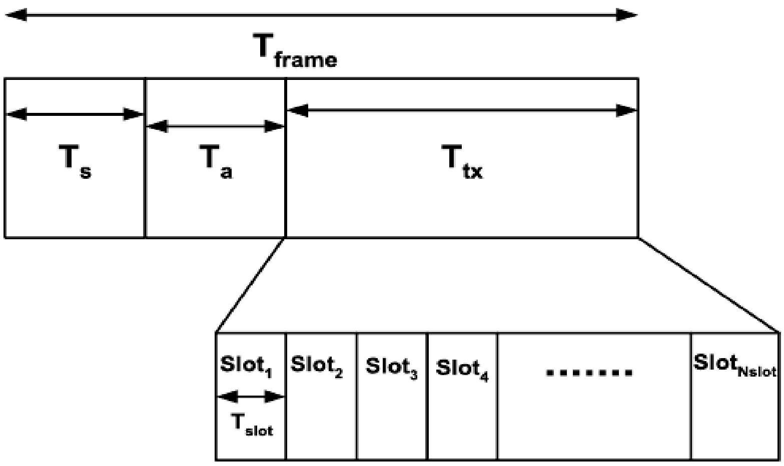

Figure 2: Distribution of time in each time frame T_{frame}

where *Ts* is the time taken by the BSs to perform spectrum sensing, *Ta* is the time taken for decision fusion, channel allocation, and scheduling, and T_{tx} is the time spent for data transmission. The time T_{tx} is further divided in N_{slot} slots each with duration T_{slot}. The free channels are allocated among the different users for the different slots of a time frame.

IV. SIMULATION AND RESULTS

Consider cognitive radio network which consisting of 10 PUs, 100 SUs, and 2 network. The PUs is randomly distributed over an area 1500×2500m2. The SUs are also randomly distributed in the coverage area of the 2 BSs. The number of SUs associated to a BS depends on the positions of the SUs. The distance between the BSs (*dbs*) is considered to be 600 m. The cell radius is taken to be 400 m, and the maximum overlapping distance across the center of the cells is 200 m.

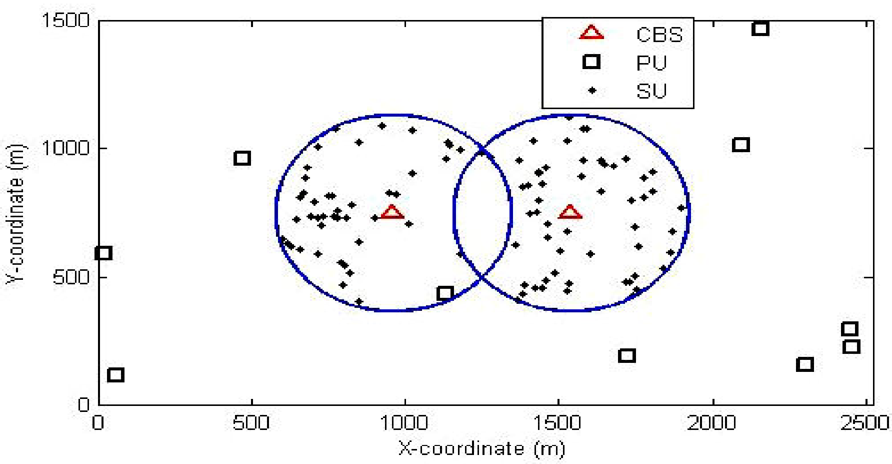

Figure 3: cognitive radio network model

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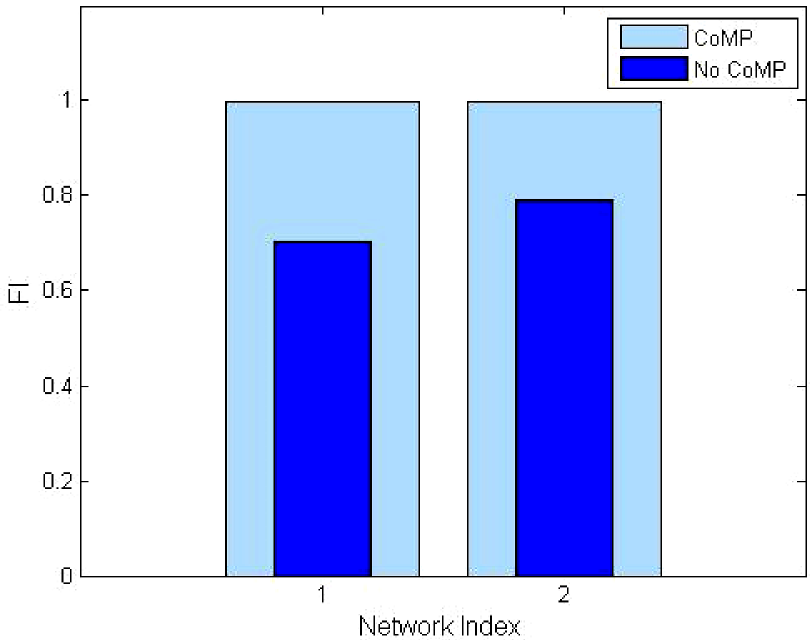

Figure 4: Fairness index in the different network instances

Perform simulation for the other network instances and then calculate the FI for each of the network instances. The FIs of the 2 instances with the proposed and baseline algorithms are depicted. The average FIs for the 2 CRN instances with baseline and proposed algorithms are found to be 0.7377 and 1, respectively. Thus, CoMP JT technique under the proposed algorithm solves the throughput unfairness problem in CRNs.

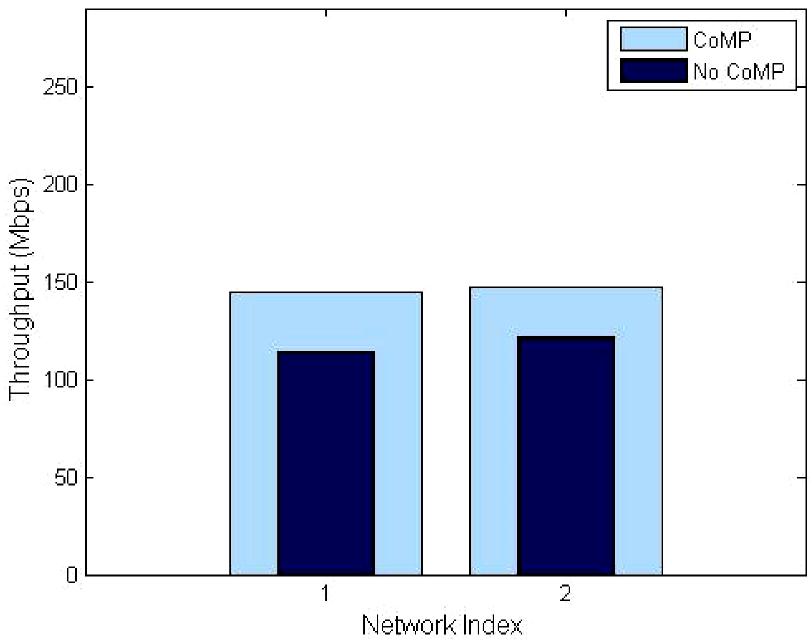

Figure 5: The total throughput of the users in the different network

CoMP JT–based CRN with respect to the traditional transmission based CRN. The average increment in the minimum throughput of the users is found to be 102.6876%. We know that there is a trade-off between throughput and fairness in wireless networks. The total throughput of the 2 CRN instances with and without CoMP JT technique is shown in Figure 5. We find that the total throughput in a CoMP JT based CRN is lower compared to that of a CRN without CoMP JT.

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V. CONCLUSION

This paper proposed a CR system with CoMP JT technique. We have provided analytical formulations to determine the design parameters of ED-based spectrum sensing in CoMP JT–based CRN. The performance of the spectrum detection is evaluated in probability of detection and probability of false alarm and found to be very effective. We have formulated an optimization problem to maximize the minimum throughput of the users in CoMP JT–based CRNs by optimal channel allocation and user scheduling. Because of complexity of solving the optimization problem using an optimization tool, We have found that the CoMP JT–based CRN under the proposed algorithm significantly improves the FI as well as max-min throughput compared to a CRN with traditional transmission. However, the total throughput in CoMP JT–based CRN is lower compared to a traditional CRN.

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