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Optimization Of Cooperative Spectrum Sensing With Transmit Diversity And Adaptive Diversity Scheme in Cognitive Radio

Shaminder Jeet Singh[1], Sandeep Kumar[2]

[1](M.Tech Student*), Electronics & Communication Engineering, PCET, Lalru Mandi
[2](A.P.) Electronics & Communication Engineering, PCET, Lalru Mandi

Abstract — *we have studied and analysed cooperative spectrum sensing in cognitive radio (CR) networks and techniques to optimize it.the analytic detection results show that the performance of cooperative spectrum sensing is limited by probability of reporting errors. To deal with this limitation a transmit diversity based cooperation spectrum sensing method is introduced.*

Moreover, we have studied an adaptive diversity scheme with best relay selection. Exact closed-form expressions of the outage probability of secondary transmissions ,referred to as secondary outage probability, ar derived under the constraint of satisfying a required outage probability of primary transmission (primary outage probability) for both the traditional non-cooperation and the proposed adaptive cooperation scheme over Rayleigh fading channel. In addition , we generalized the traditional definition of the diversity gain, which can notbe applied directly in coginitive radio networks since mutual interference between the primary and secondary users should be considered. We derive the generalized diversity gain and show that, with a guaranteed primary outage probability, the full diversity order is achieved using the mentioned adaptive cooperation scheme.

Keywords- *CR,PU,SU,BS,AP,SNR.*

I. INTRODUCTION

The remarkable growth of wireless servise over the last decade demonstrates tha vast and increasing demand for radio spectrum. However, the spectrum resource is limited and most has been licensed exclusively to users which can work with in a limited frequency band . recent studies by the federal communication commission (FCC) spectrum policy task force (SPTF) have demonstrated that the actual licensed spectrum is largely unoccupied most of the time. Another recent work on spectrum occupancy measurement showed that the average spectrum occupancy from 30 MHz to 3 GHz over six cities is 5.2% and that the maximum total spectrum is 13.1% in new York city.

In order t deal with the imbalance between spectrum scarcity and spectrum under utilization, coginitive radio (CR) has been proposed. By sensing and adapting to the environment, CR is able to fill in spectrum holes and serveits users without causing harmful interference to the lincensed user. One of the great challenges of implementing spectrum sensing is hidden terminal problem which occurs when the CR is shadowed, or degraded with high path loss while the primary users (PU) is still in operation. Cooperation spectrum sensing has been shown to greatly increase the probability of detecting the PU. Cooperative spectrum sensing refers to the spectrum sensing methods where local spectrum sensing information from multiple CRs are combined for PU detection. In a centralized CR networks , a common receiver plays a key role in collecting the local spectrum sensing information and detecting the spectrum holes. Usually, cooperative spectrum sensing requires two successive stages, sensing and reporting. The sensing channels between the PU and CRs are normally assumed as reyleigh fading with additive white Gaussian noise (AWGN), where as the reporting channels between there and common receiver are mostly assumed perfect (error-free). In practice, however, it is impossible for common receiver to receive decisions from interference or noise.

A secondary user (SU) and a primary user (PU) can access a licensed spectrum simultaneously as long the induced interference from SU to PU is below a threshold , i.e., the quality of service (QoS) of primary transmissions is not affected. Therefore, the transmit power of SU is constrained to guarantee the PU's QoS. However, when the QoS requirement is stringent, very low. Transmit power level is allowed for SU and thus the SU's thoughput is limited. Cooperative diversity, emerging as a new spatial diversity technique, can effectively combat channel fading enhance the throughput. The advantage of such cooperative diversity protocols proposed in come at the expense oa a reduction in spectral efficiency since the cooperative relay shall transmit on orthogonal channels. To overcome tha shortcoming of the inefficient spectral utilization, the relay-selection based cooperative diversity has been investigated in, where only the "best " rely is selected to forward and a source node's signal and thus only two channels (i.e., the best relay link and direct link) are required regardless of the number of relays. It has been shown that the cooperative diversity with best-relay selection can achieve the same diversity-multiplexing tradeoff as achieved by the traditional cooperation protocols where all relays are involved in forwarding the source node's signal. Notice that the research papers mentioned above address the conventional non-cognitive radio networks. Cooperation, in general, also has great potential to be used in cognitive radio networks. The authors have explored the application of cooperative diversity to spectrum sensing and shown that the sensing performance is improved by exploiting the user cooperation. A linear cooperative sensing framework has been proposed based on the combination of local statistics from individual cognitive users. The authors have considered a secondary transmitter to act as a relay for primary transmissions. It has been shown that the secondary link throughput can be improved in certain network topologies. More recently, papers have investigated the use of cooperative relay to assist the fulfillment of heterogeneous traffic demands in a secondary networks with an unbalanced spectrum usage, the main contributions of this correspondence are described as follows. First, unlike the previous research about relay selection in conventional networks, we investigate the adaptive cooperation diversity with best-relay selection in cognitive radio networks, where mutual interference between PU and SU are considered, second, an exact closed form expression of the secondary outage probability is derived under the constraint of satisfying a required primary outage probability. Finally, we proposed a generalized definition of the diversity gain in cognitive radio networks and show that the full diversity is achieved by the proposed scheme with a primary outage probability constraint.

II. COOPERATIVE SPECTRUM SENSING

Cooperative spectrum sensing refers to spectrum sensing methods where local spectrum sensing from multiple CR's are combined at a common receiver for PU (primary user) detection.

Local spectrum sensing methods using distributed CRs are limited in their effectiveness due to irregularities in the environment. Multipath fading and non line-of –sight (NLOS) condition can significantly reduce the probability of detecting whether or not a user is present in the frequency band at a single CR.

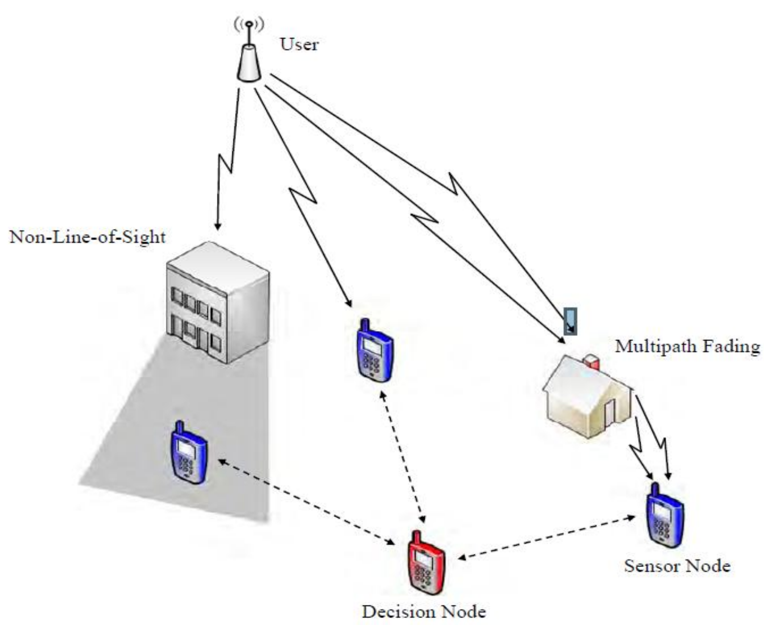

Figure 1: cooperative spectrum sensing under shadowing and multi path fading

Most damaging to the spectrum sensing process is the problem of hidden CR, which occurs when a particular CR suffers from NLOS condition or severe multipath fading as shown in figure 1. The two CR experiencing multipath and NLOS condition may not detect the presence of the user. However, if the CR's were to share their information with each other through a central decision node , a more accurate global result may be achieved such collaboration among the sensor nodes to overcome local environment effects is the essence of cooperation spectrum sensing.

We consider a CR network composed of K CRs (secondary users) and a common receiver, as shown in fig2. The common receiver functions as a base station (BS) which manage this CR network and all CRs.

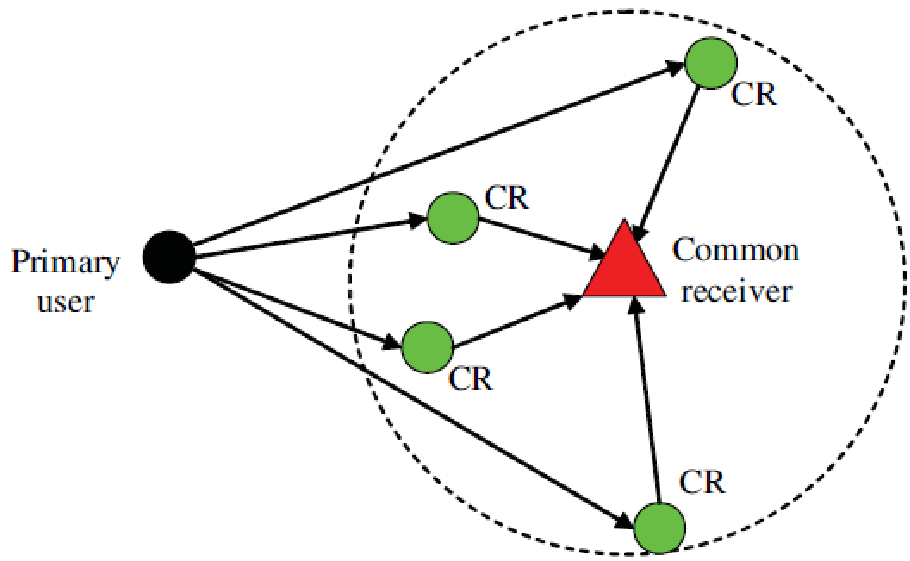

Figure 2: cognitive radio network in cooperation with a common receiver

To avoid causing harmful interference to a PU that is in operation, spectrum sensing is needed for the CRs. One of the great challenges of spectrum sensing is to detect the presence of the PU with little information about the channel and the signal transmitted from the PU. In such scenarios, one may choose the energy detector which measures the energy of the received signal in a fixed bandwidth W over an observation time window T. in the following, we focus on Rayleigh fading.

One of the most challenging issues of spectrum sensing is the hidden terminal problem, which occurs when the CR is shadowed or in severe multipath fading. In this case, the CR cannot reliably detect the presence of the PU due to the very low SNR of the received signal. The CR can then assume that the observed frequency band is vacant and begins to access this band without noticing the presence of the PU. To address this issue, multiple CRs can be coordinated to perform spectrum sensing cooperatively. Several recent works have shown that cooperative spectrum can greatly increases the probability of detection in fading channels. In general, cooperative spectrum sensing is performed as follows:

- **Step 1:** Every CR performs local spectrum measurements independently and then makes a binary decision;
- **Step 2:** All of the CRs forward their binary decision to a common receiver which is an AP in a wireless LAN or a BS in a cellular networks;
- **Step 3:** the common receiver combines those binary decisions and makes a final decision to infer the absence or presence of the PU in the observed frequency band.

III.TRANSMIT DIVERSITY

It has been shown that the use of multiple CRs improve the detection probability over realistic sensing and reporting channels. But performance is limited by the probability of reporting errors Pe which is due to imperfect reporting channels. We will employ transmit diversity to improve the performance of cooperative sensing by reducing Pe.

IV.ADAPTIVE COOPERATION SCHEME

A Consider a cognitive radio system with the coexistence of primary and secondary networks, as depicted in fig.3. in the primary networks, a primary transmitter (PT) sends data to a primary destination (PD). Meanwhile, in the secondary destination (PD) simultaneously with the primary transmission over the same channel.

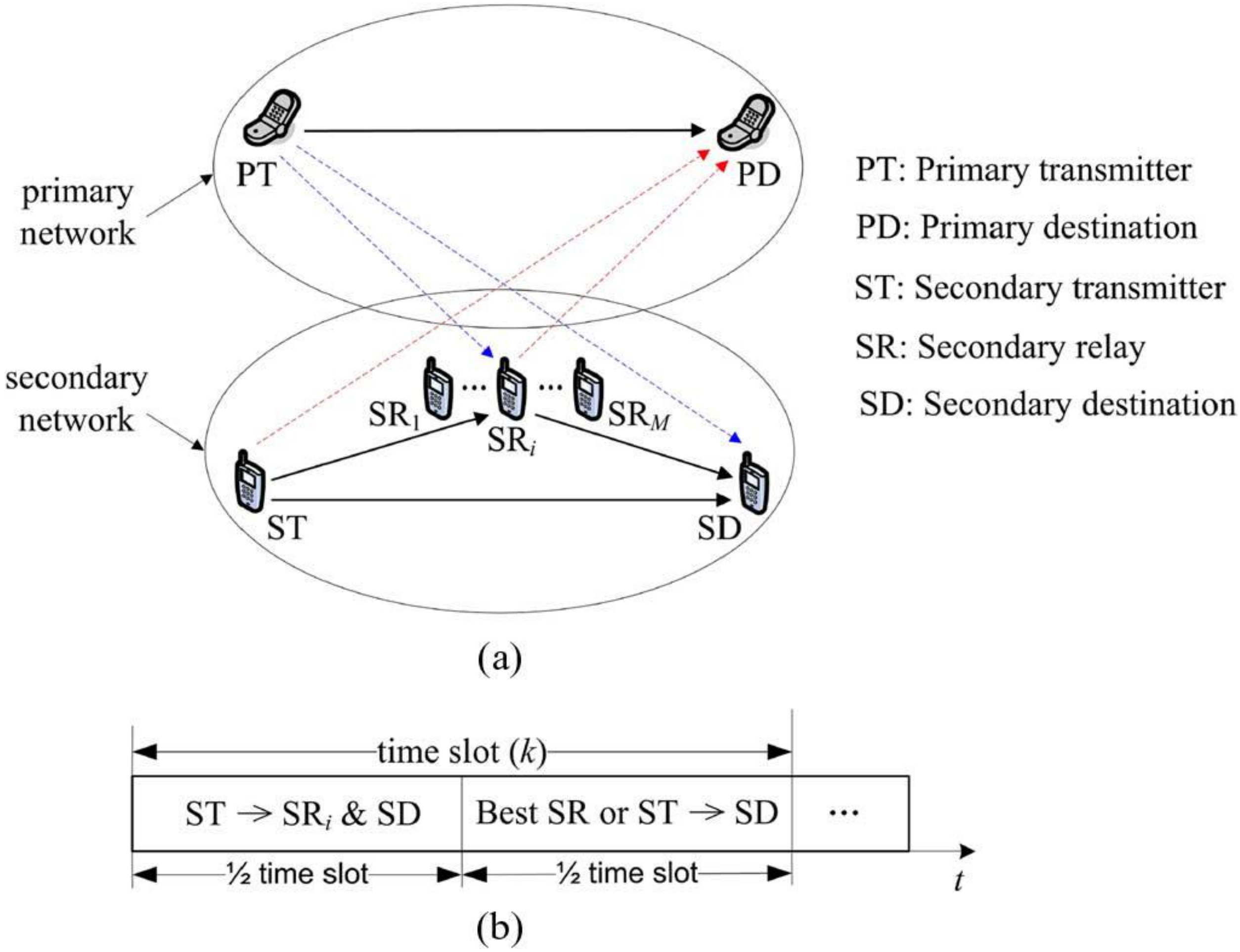

Figure 3. (a) cognitive radio system with coexistence of primary and secondary networks;

(b) illustration of the transmission process for the proposed adaptive cooperation with best-relay selection.

Notice that M secondary relays (SRs) denoted by R are available to assits ST's data transmissions and the decode-and-forward protocol is considered throughout this correspondence. As can be observed from Fig. 6(a), primary transmissions, the transmit power of ST should be limited for reducing the interference to PD.

Fig. 6(b) illustrates the transmission process of the proposed adaptive cooperation scheme, where each time slot is divided in to two half sub time-slots (sub phases). In the first sub phase, SB sends (broadcasts) its signal to SRs and SD. Then, all SRs attempts to decode the ST's signal and those SRs which decode successfully constitute a set D, referred to as a decoding set.

V.GENERALIZED DIVERSITY GAIN

We focus on the diversity gain analysis for the proposed adaptive cooperation scheme .as known, the traditional diversity gain where no interference is taken in to account. Hence it is not appropriate to apply the traditional definition directly in cognitive radio networks since mutual interference between PU and SU should be considered

It is known that the interference from a SU transmitter to a PU receiver can approach to zero if this interference is mitigated as much as possible when the secondary system utilizes an advanced signal processing technique, such as beam forming, on other hand, an interference cancellation approach may be employed at the SU receiver to reduce the interference from PU transmitter, which. However, cannot be cancelled out perfectly, i.e., the secondary outage probability floor will not be eliminated completely. Nevertheless, if the SU receiver has the ability to reduce such interference so that it approaches to zero, moreover, if the SU receiver is assumed to perfectly cancel out the interference from the PU transmitter, we can use the traditional definition to analyze the diversity gain achieved by the proposed adaptive cooperation scheme in cognitive radio networks.

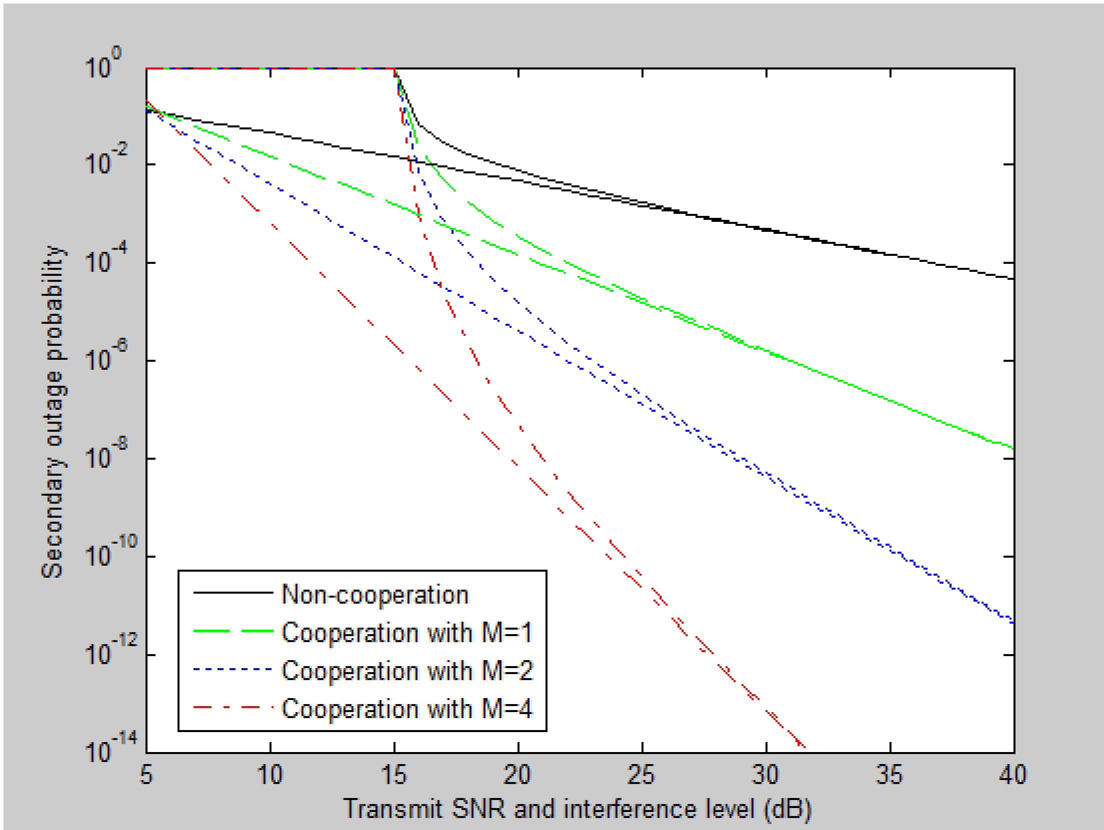

Figure 4: secondary outage Probability Vs. Transmit SNR(db) and Iterference Level (ST-PD)(db)

VI.CONCLUSION

In concluding remarks it is important to note that cooperative spectrum sensing with many CRs could increase the detection probability limits, robust cooperation spectrum sensing technique which apply transmit diversity with space –time coding into CR networks over fading channels is described.

In adaptive cooperation diversity scheme we have computed we have computed exact secondary outage probability under the constraints of satisfying a required outage probability. Further we have found that the full diversity order is achieved by the proposed adaptive cooperation scheme. The performance of the systems is studied with the help of MATLAB.

Ultimately, we have concluded that by employing some diversity and /or some coding scheme and/or some best relay selection algorithm, the spectrum efficiency in cooperative Cognitive Radio networks can be increased to a great extent without increasing the count of CRs.

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