Dual-hop Cooperation Protocol for Spectrum Sensing in Cognitive Radio Networks

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Abstract

In the upcoming 5G communication technologies, cognitive radio is going to play an important role in the effective utilization of the scarce frequency spectrum. In order to effectively utilize the available frequency, accurate spectrum sensing is required. In this paper, we propose a dual-hop cooperation protocol that can be used to improve the accuracy of spectrum sensing in cognitive radio networks. The problem of error in reporting the local decisions of secondary users to the base station has been addressed.

Keywords: cooperative spectrum sensing, cognitive radio network, 5G, energy detection, LDPC, fusion.

1. Introduction

Due to the increase in number of wireless communication technologies, the frequency spectrum available for utilization by these technologies has become scarce. But the devices operating in these allocated frequency bands do not always transmit information and therefore, it results in vacant frequency bands at a certain time instance or geographical location. Cognitive radio (CR) is a technique used to identify the vacant frequency bands known as spectrum holes.

Recent research work on cognitive radio uses detection techniques for spectrum sensing such as energy detection and cyclo-stationary feature detection [1]. Energy detection technique has been widely used for spectrum sensing because of its simplicity. However, the detection and final decision at the fusion center (FC) in the base station can be negatively affected due to correlated shadowing, multipath fading, and receiver uncertainty issues in the wireless network. Therefore, cooperative spectrum sensing has been proposed to mitigate these issues and improve the detection performance of the CR and in turn the utilization of the frequency spectrum [2]-[4].

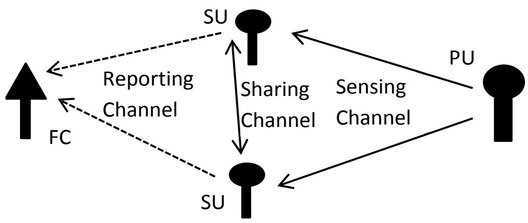

Fig. 1. The proposed cooperative CRN scenario.

In this paper, we focus on the reliable transmission of the detected signal to the FC. We propose a dual-hop cooperation protocol to perform cooperative spectrum sensing. Some initial results of the proposed dual-hop cooperation protocol for improved spectrum sensing in cognitive radio networks (CRN) are presented here. Further details will be presented in a future publication.

2. System Model

As shown in Fig. 1, a CRN consists of a licensed user or primary user (PU), an unlicensed user or secondary user (SU), and a base station, which contains a fusion center (FC). The role of SU is to sense the frequency spectrum, detect a spectrum hole in the network, and transmit this information to the FC. The FC then decides whether to allocate the available spectrum to the SU or not by gathering information from all or some of the SUs in the network.

We consider a CRN with N_{su} number of SUs. Each SU performs local spectrum sensing and makes a decision by using binary hypothesis test as follows,

$$H_0 : x_i(k) = n_i(k) \tag{1}$$

$$H_1 : x_i(k) = h_i s(k) + n_i(k) \tag{2}$$

where $i = 1, 2, ..., N_{su}$, and $x_i(k)$ is the received signal at SU i, at a time instant k. $n_i(k)$ is the

AWGN noise with mean 0 and variance 1, i.e., $n_i(k) \sim \mathcal{CN}(0,1)$. $s(k)$ is the transmitted signal by the PU, while h_i is the corresponding Rayleigh faded channel coefficient at the SU *i*.

The SUs in close proximity with each other make up a *cooperation region*. We assume that each SU in the network can receive the local sensing results from its neighboring SUs within the cooperation region, via identical and independently fading channels.

2.1 Dual-hop Cooperation Protocol

The proposed dual-hop cooperation protocol works as follows:

Step 1: Each SU performs local spectrum sensing by using energy detection FFT-averaging-ratio algorithm [14] and makes a binary decision about the presence or absence of the PU signal.

Step 2: All the SUs share this binary information with each other within the cooperation region.

Step 3: Each SU makes a cooperative data packet of the received information encodes the data with an LDPC code and transmits it to the FC.

Step 4: The FC receives this cooperative packet, decodes it, and makes a combined decision about the presence of PU in the observed frequency band of interest.

The FC performs fusion of the received sensing results by first combining the respective results of each sensor from the cooperative packet and then making a final decision from the obtained results by using the *majority vote* criteria as shown in Table 1.

3. Simulation Results

We assume a single PU in the area of interest, which is active for 50% of the time and N_{su} = 8. The LDPC code used by the SUs is *n*=12, *j*=3, and *k*=6. In this paper, we report the results on the probability of error in spectrum sensing, which is a summation of the probability of false alarm, P_{fa} (PU is absent but is detected as present) and probability of missed detection, P_{md} (PU is present but is detected as absent).

Fig. 2 shows the receiver operating characteristics (ROC) curves of the proposed cooperation scheme. These plots are obtained from the spectrum sensing results at the FC, averaged over 10000 sensing operations. These results compare our proposed

Table 1: Fusion of sensing results at the FC

	SU_1	SU_2	SU_3	SU_4
SU_1	1	1	0	1
SU_2	1	1	1	0
SU_3	0	1	0	1
SU_4	1	1	0	1
Result	1	1	0	1

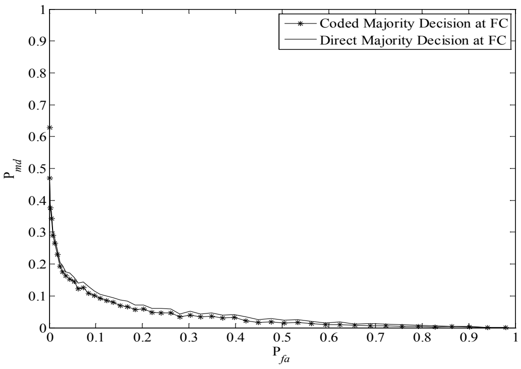

Fig. 2. ROC curves of the proposed cooperative CRN.

cooperation scheme with the direct reporting scheme (each SU sends its decision directly to the FC and the FC makes a combined decision). The result shows that our proposed cooperation scheme provides a better performance as compared to the traditional direct reporting scheme. The ROC curve of the coded majority decision is closer to zero in the optimal operation region where both P_{fa} and P_{md} are between 0 and 0.2.

4. Conclusion

This paper proposes a dual-hop cooperation protocol for spectrum sensing in CRN. We have proposed a cooperation mechanism to improve the spectrum holes detection. Our simulation results show a better performance in terms of sensing error rate and validate the effectiveness of our scheme.

Acknowledgment

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MSIP) (NRF-2015R1A2A1A05001826).

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