Interweave Cognitive Radio Network: Signal Detection

Pravin P.Magar, Megha N Pandey and Prof.Suman P.Wadkar

Abstract: in cognitive Radio SU intelligently detects the spectrum holes, and then opportunistically communicates over the vacant spectrum without causing any interference to the PU To let an SU efficiently communicate through the spectrum holes, an accurate sensing of the presence of the PU in the different frequency bands is required. Thus, advanced spectrum sensing techniques to detect spectrum holes over a wide bandwidth are crucial. It should be noted that there is no concurrent transmission of the SU and PU on the same spectrum, and the SU must vacate the spectrum as soon as the PU reoccupies it. Accordingly, the communication of the SU is forced to terminate if the SU cannot detect new spectrum holes to handover. An advantage of the interweave access is that an SU can transmit with maximum power once a spectrum hole has been detected without caring about interference to the PU. However, it is not easy to exactly detect the spectrum holes in a highly fluctuating radio environment. As such, a missed detection can make serious interference to the PU. In addition, in dense areas with high spectrum occupancy and hence small number of spectrum holes.

Keywords: CR-Cognitive Radio, PU-Primary User, Detection Probablity (PD), False Alarm (PF), SU-Secondary User.

I. INTRODUCTION

Hence to allocate resources to cognitive radio spectrum detection is very importantant.so that no spectrum should be repeated in the same area at same time. hence various signal detection techniques are used. as in interweave paradigm cognitive radio transmits information only if any frequency band is vacant. so to check the vacancy of any frequency the signal of the same frequency must be detected. by using various techniques. As below

A. Direct Signal Detection.

As the primary transmitter (PU-Tx) communicates with the primary receiver (PU-Rx), it uses a certain power level to transmit signals in a specific spectrum band. Thus, if the SU wants to know whether the PU is active or not, it needs to observe the radio signal in the spectrum band. Accordingly, the received signal y(t) at the SU can be given by.

$$Y(t) = \begin{cases} c(t)x(t) + n(t) & H1 \\ n(t) & H0 \end{cases} \qquad (1)$$

Where x (t), n (t), and c (t) denote the PU signal, additive white Gaussian noise (AWGN), and channel coefficient from the PU to the SU, respectively. The terms H0 and H1 are the two hypotheses which express the absence and presence of the PU signal, respectively. From the received signal y(t), the SU will make a decision between H0 and H1.

In order to examine the detection performance of the SU, the detection probability PD and false alarm probability PF, are typically used. More specifically, PD is the probability that the SU decision for hypothesis H1 is correct. On the other hand, PF is the probability that the SU decision is H1 while it actually should be H0.

B. Signal Energy Detection.

Energy detection is a low-complexity spectrum sensing technique which is applicable for wide-band spectrum sensing As the name suggests, the energy detector observes the average energy within M samples of the received signal, given by

$$Y = \frac{1}{M}\sum_{t=1}^{M} |y(t)|^2 \qquad (2)$$

By comparing the average energy Y with a predefined threshold λ, the decision of the energy detector may be expressed as

$$e = \begin{cases} H1, & if\ y > \lambda \\ H0, & if\ y < \lambda \end{cases} \qquad (3)$$

On this basis, the detection probability and false alarm probability are formulated, respectively, as

PD = Pr{Y > λ|H1}

PF = Pr{Y > λ|H0}

Besides the advantages of the energy detector such as low cost, easy implementation, short detection time, and no requirements of a priori information about the PU, it also faces some challenges. For example, the noise power may change over time and could be very high in some cases. As such, it is difficult to exactly detect the presence of a PU in real time. Furthermore, an energy detector cannot differentiate between a PU signal and other interference sources as it simply compares its received signal with a given threshold. Thus, the false alarm probability may be high

C. Matched Filter Detection.

Radio transmission techniques often use pilot signals, a preamble, or a training sequence to estimate channel state information (CSI). If an SU has such information about PU

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signals, then this can be used efficiently for the sensing process. More specifically, the SU senses the signals for a short time, and then compares the received signals with the available PU information. If the characteristics of the received signal and the information about the PU signal match, a PU occupies the spectrum. Otherwise, the spectrum is considered as being free. The main advantages of matched filter detection are short sensing time and high detection performance. However, if the PU information is provided incorrectly to the matched filter detector, the sensing performance degrades rapidly.

D. Cyclostationary detection

Cyclostationary detection is a special sensing technique that allows the energy detector to distinguish the PU signal from the interference and noise. Particularly, signals of wireless devices generally are modulated and generated following a periodicity. They can be recognized by Introduction analyzing the cyclic autocorrelation function of received signals, given as

$$R_Y^{(\alpha)}(T) = E[y(t+T)y^*(t-T)e^{j2\pi\alpha t} \quad (4)$$

where E[·] denotes expectation, _ stands for complex conjugate, and α represents the cyclic frequency. By using Fourier series expansion, can be rewritten in the form of a cyclic spectrum density (CSD) function as

$$s(f,\alpha) = \sum_{T=-\infty}^{\infty} R_Y^{\alpha}(T)e^{-j2\pi f t} \quad (5)$$

Since the primary signal is often modulated, the CSD function, S(f, α), exhibits peaks when the cyclic frequency, α, equals the fundamental frequencies of the transmitted signal. Otherwise, the CSD does not have any peak because the AWGN is a non-Cyclostationary signal. In practice, Cyclostationary detection can perform better than the energy detector as it not only can differentiate the PU signal, but also can detect in the low signal-to-noise ratio (SNR) regime. However, Cyclostationary detection demands long observation time and complex computation.

II PROBLEM FORMULATION

Even after using these methods of signal detection. Signal cannot be detected properly as every method is focusing limited parameters of signal detection. Few times signal may not be detected properly or false signal may be detected. or sometimes signal may not be detected due to some obstacle present between the primary Tx and secondary Tx. Hence in such cases secondary Tx may detect it as availability of spectrum any get access to that spectrum which may create problem to Primary user. to avoid such conditions some other type of signal detection methods are to be used Inspired by the above techniques, many recent techniques have been proposed to enhance the sensing performance, e.g., covariance-based sensing. Filter based sensing, fast sensing. Learning reasoning based sensing and measurement based sensing and modeling.

One of such method is cooperative sensing discussed below.

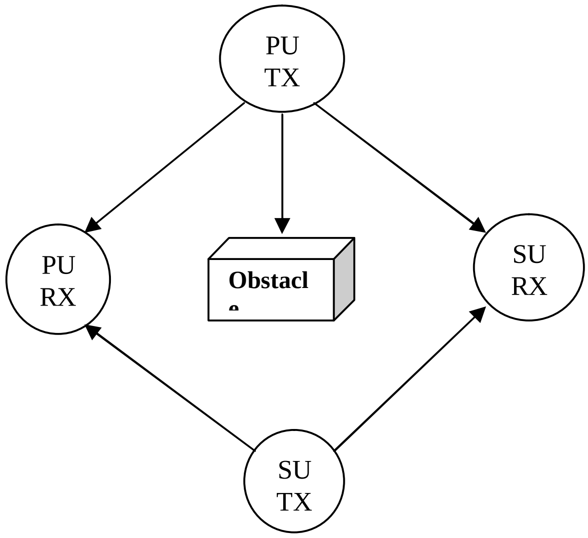

Fig 1: Hidden PU which cannot be detected by SU due to presence of obstacle.

E. Cooperative Spectrum Detection.

Noise, multi-path fading, and shadowing are natural characteristics of wireless Communications, which effect the received signal strength. For example, if a PU is far away from the SU, or the PU signal is blocked by a large obstacle, then the received signal may be very low at the SU. Accordingly, it is difficult to exactly detect the presence of a PU. Figure 2 illustrates a scenario in which the PU-Tx is hidden by an obstacle such that the secondary transmitter (SU-Tx) cannot detect the PU-Tx signal. Therefore, the SU-Tx may cause harmful interference to the PU-Rx, as it commences using the licensed spectrum to Communicate with the secondary receiver (SU-Rx).To overcome such problems, cooperative spectrum sensing has been proposed. It has been shown that the advantages of spatial diversity and independent fading channels of multiple users in cooperative networks can be used to enhance the detection probability and decrease the sensing time. An example scenario for cooperative spectrum sensing is shown

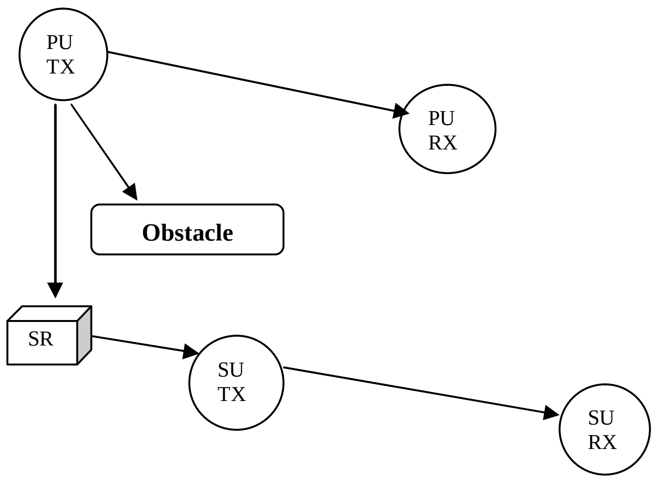

Fig 2: Use of SR, support SU to detect PU

The SU-Tx can detect the PU-Tx through the help of two secondary relays (SRs), SR1 and SR2.The basic structure of a cooperative spectrum sensing system includes a secondary base station (SBS) or an access point, and a number of SUs as Depicted in Figure.

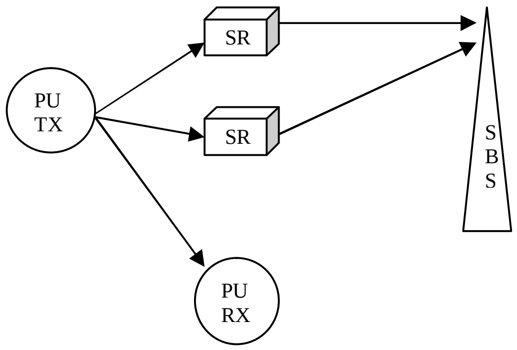

Fig 3: Cooperative Spectrum Sensing with SBS and SR

In this context, the SUs gather information about the PU-Tx and send this to the SBS through a common control channel. Based on the provided information, the SBS will process and make a decision about the presence or absence of a PU, and then send an announcement to the SUs Furthermore, to enhance the decision precision, the SBS can process the received information from the SUs by using a soft combination or hard combination technique as follows.

a. Soft combination

The SUs forward their original sensing information to the SBS. Then, the SBS is responsible for the calculation and making a final decision. A main advantage of soft combination is its high detection performance. However, it requires large overhead information to be exchanged between the SUs and the SBS. In addition, if there exist a large number of SUs joining the detection process, the SBS may take a long time to quantize information.

b. Hard combination

The SUs make their own decisions about the presence or absence of a PU-Tx in a specific spectrum, and send these to the SBS. As the SBS receives the decisions from the SUs, it will apply a specific rule such as AND rule, OR rule, or K-out-of-N rule to make a final decision. For example, N SUs independently detect the PU-Tx, where each SUn, n = 1… N, has its own decision dn, dn 2 {0, 1}. If the SBS receives a number of K decisions dn = 1, 0 < K<N, the SBS can broadcast an announcement to all SUs that the frequency band is being occupied by a PU. This is known as the K-out-of-N rule. Besides the aforementioned cooperative sensing schemes, the SUs can act as relays and apply amplify and-forward (AF) or detect-and-relay protocols to enhance the detection performance.

SIMULATED TEST RESULTS

Simulation by using Cooperative Sensing to verify results we can use cooperative sensing method by using AND rule. in the presence of Advance White Gaussian Noise. so by considering 10 Cognitive radio user we taken first reading and considering 5 Cognitive radio user second reading is taken. Simulated test results show probablity of false alarm (Pfa) v/s probablity of missed detection (Pmd) of spectrum by secondary cognitive radio user.

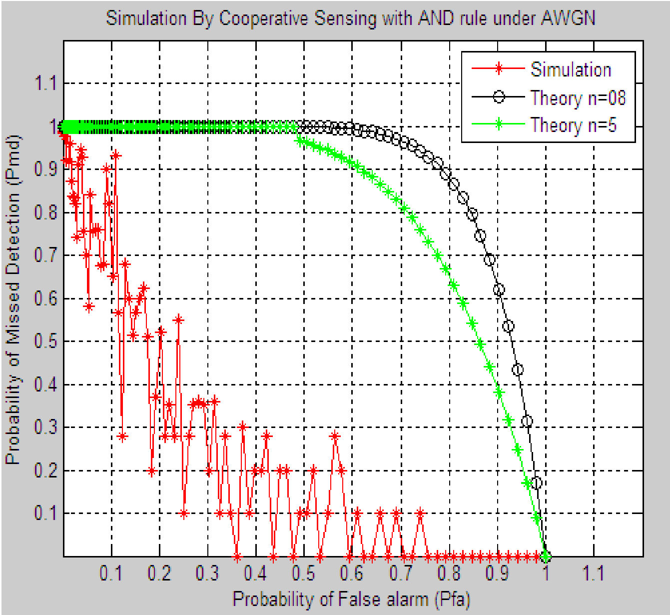

Fig: Simulated Test Results of Cooperative Sensing Method

CONCLUSION

Recent advances in cooperative communications allow different mobile users or terminals to cooperate and to share resources in a distributed manner. Cooperative communication not only increases the multiplexing gain but Also combats the detrimental effects of severe fading environments. Also while detecting the spectrum vacancy missed detection probablity (PD) and false alarm probablity (PF) plays important role in system QoS. Probablity of false alarm should be minimum because it may cause severe problem in primary user's communication. And probablity of missed detection will be the system to lose the opportunity to get access to free spectrum and it will adversely affect the data transfer rate of secondary user or cognitive user. Hence while designing such kind of detection methods value of false detection and missed detection must be carefully designed so that minimum interference must be created to primary user and maximum spectrum availability of spectrum should be there secondary users.

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