A Review on Spectrum Sensing Techniques in Cognitive Radio Network

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----------**ABSTRACT**----------
In recent years cognitive radio is the emerging area in wireless communication. Because of the growing demand on the wireless application has put the lot of constraints on the available radio spectrum usage. Using cognitive radio, spectrum efficiency will increase by making use of the spectrum holes. One of the major elements of cognitive radio applications are spectrum sensing. Sensing refers to detecting the unused spectrum (spectrum holes) and sharing it without harmful interference with other secondary users. In this literature we propose some spectrum sensing methods based on the basic sensing approach. And the challenges and the techniques of spectrum sensing are also discussed.

Keywords: **Cognitive radio, Spectrum Sensing, Spectrum Usage, Wireless Communication.**

1.INTRODUCTION

The electromagnetic spectrum is a natural scarce resource. The radio frequency spectrum involves the use of part of the electromagnetic spectrum. The radio frequency spectrum involves Electromagnetic radiation with frequencies between 3000 Hz and 300 GHz [1]. In the static allocation of the frequency band most of the space in spectrum in unused. Cognitive radio uses the dynamic allocation technique which is used in the efficient usage of spectrum holes.Spectrum sensing is an emerging part in Cognitive radio. Spectrum sensing is used in identifying the spectrum usage by the primary user .It deals with the opportunistic usage of frequency band that are not used by the primary user and allocating the unused space to the secondary user at that time. Primary users are the licensed users who have higher priority in accessing the spectrum space. Secondary users are the unlicensed users who have lower priority in accessing the spectrum space. Main functions of cognitive radio are Spectrum sensing, spectrum management, spectrum mobility and spectrum sharing.

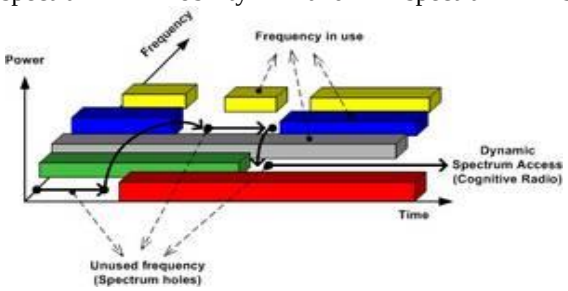


Fig.1 Illustration of Spectrum holes

There are several techniques used in spectrum sensing. They are given below.

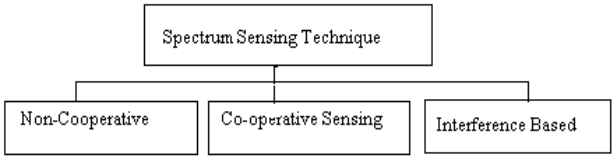


Fig. 2 Classification of Spectrum Sensing

2. NON-COOPERATIVE SENSING

In Cognitive radio non-cooperative technique is known as Transmitter detection in which the each cognitive radio has the ability to detect the presence and absence of primary user (PU) in the specified spectrum space. The following are the some of the methods in Non-cooperative sensing technique.

2.1 Energy Detector Based Sensing

Energy Detector Sensing is one of the approaches used in Non-cooperative sensing .Thismethod is also known as radiometry or period gram. It is the most common way of spectrum sensing because of its low computational and implementation complexities [10]. In this approach the receiver does not need any knowledge on the primary user. Hence the signal is detected by comparing the output of the energy detector with the threshold which depends on the noise floor. The decision on the occupancy of the band can be obtained by

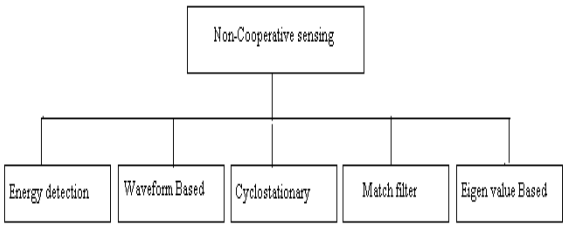


Fig.3 Classification of Non-cooperative Sensing

comparing the decision metric M against a fixed threshold $\lambda_{E.}$ This is equivalent to the distinguishing between the following two hypotheses:

H0: y (n) = w (n), (1)

H1: y (n) = s (n) + w (n) (2)

2.2 Waveform based sensing

Waveform based sensing is applicable to system with known signal pattern and it is also termed as coherent sensing. Such pattern includes preambles, midamble, pilot patterns and spreading sequence etc. A preamble is a known sequence transmitted before each burst and a midamble is transmitted in the middle of a burst or slot. Waveform based sensing outperforms energy based sensing in reliability and convergence time. The performance of the sensing algorithm increases as the length of the known signal pattern increases.

2.3 Cyclostationary Based Sensing

Cyclostationary feature detection is a method for detecting primary user by exploiting the cyclostationary features of the received signals. Signals have cyclostationarity features in the frequency domain that are not easily seen in the time domain [7]. Instead using power spectrum density (PSD) in the energy based detector, Cyclostationary based detector uses cyclic correlation function (CAF) to detect the signal present in the given spectrum.

2.4 Match Filtering

Match filtering is known as the optimum method for detection of primary users when the transmitted signal is known[10]. The short time to achieve a certain probability of false alarm or probability of misdetection is the main advantage of the matched filtering. Matched filter requires cognitive radio to demodulate the received signals. It requires the knowledge of primary user feature such as bandwidth, operating frequency, modulation, pulse shape and packet format.

The limitation in Match filtering is each CR should have the information of all primary users. One of the main advantages of match filtering is that it takes less time for high processing gain. The disadvantage is the larger power consumption and CR should need a dedicated receiver for every primary user.

2.5 Eigen value based Sensing

Eigen value based sensing uses the covariance matrix theory (CMT) for sensing the primary user [7]. It is different from the energy detection technique without any pre-knowledge of transmitted signal. Eigen value sensing uses sample covariance matrix because the received signal obtained after the channel is a series of samples.

λ_{max} maximum and λ_{min} minimum value are obtained by calculating the eigen value of covariance matrix. With the increased size of matrix, the rank of the co variance matrix reduces, thus leading to the overlap of some eigen value of the matrix.

2.6 Limitations of Non-Cooperative Sensing

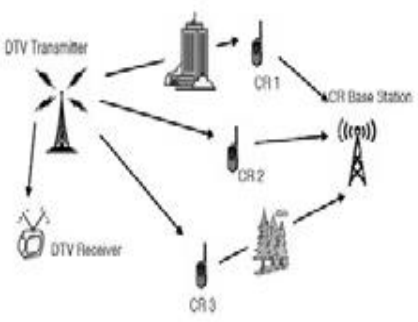
1. It suffers from multipath fading.
2. The received signal strength and the hidden terminal problem can lead to incorrect spectrum utilization.
3. Satisfactory performance can be achieved through longer observation time.

2.7 Some other Methods in Non-Cooperative Sensing

1. Wavelet detection.
2. Covariance detection.
3. Radio Identification based Sensing.
4. Hough transforms.

3. COOPERATIVE SENSING

In Cognitive radio cooperative technique is known as receiver detection technique. Cooperative sensing gives solution to the problems such as noise uncertainty, fading and shadowing [11]. It decreases the probability of misdetection and false alarm. And it is also capable of solving hidden primary user problem and it decreases sensing time. Cooperative sensing uses control channels to share the spectrum sensing result.



Cooperative spectrum sensing in cognitive radio (CR) networks: CR 1 is shadowed over the sensing channel and CR 3 is shadowed over the reporting channel.

Three important methods in Cooperative Sensing is given below

3.1Centralized sensing

In centralized sensing, a central unit collects sensing information form cognitive devices, identifies the available spectrum, and broadcasts this information to other cognitive radios or directly controls the cognitive radio traffic. The hard (binary) sensing results are gathered at the central place which is for reducing the probability of missed opportunity[6]. In the case of a large number of users, the bandwidth required for reporting becomes huge. In order to reduce the bandwidth, local observation of cognitive radios is quantized to one bit.

3.2 Distributed sensing

In the case of distributed sensing, cognitive nodes share information among each other but they make their own decisions as to which part of the spectrum they can use. Distributed sensing is more advantageous than centralized sensing in the sense that there is no need for a backbone infrastructure and it has reduced cost[8]. Only final decisions are shared in order to minimize the network overhead due to collaboration.

3.3 External sensing

External sensing is other technique for obtaining the spectrum information. An external agent performs the sensing and broadcasts the channel occupancy information to the cognitive radios [6]. The main advantages of external sensing are overcoming hidden primary user problem and the uncertainty due to shadowing and fading. External sensing algorithms solve some problems associated with the internal sensing where sensing is performed by the cognitive transceivers internally.

3.4 Advantage of Cooperative Sensing

Cooperative Sensing is not implemented in all applications, but the applicable improvements can be gained in the following system performance [1]:

1. Reduced false alarm rate.
2. Hidden node problem is sufficiently reduced.
3. Signal detection is more accurate.
4. Increased in agility.

3.5 Disadvantage of Cooperative Sensing

Some limitation in Cooperative Sensing also exists which leads to the development of antenna based sensing technique.

1. Control Channel
2. System Synchronization
3. Suitable geographical spread of cooperative nodes.
4. The increased number of terminals leads to a consequent increase in the cost.

3.6 Some Other Methods in Cooperative Sensing:

1. Collaborative Sensing.
2. Decentralized Sensing.
3. Cluster based Sensing.

4. INTERFERENCE BASED DETECTION

Interference based detection is one of the important method in cognitive radio since secondary storage is allowed only if it does not degrades the primary user (PU) Quality of service below a tolerant limit[3]. Each primary user has an interference temperature limit that defines tolerate to guarantee certain quality of service. Cognitive radio will measure the interference environment and adjust their transmission such that the interference to PU is not above the regulatory limits. The major drawback of the interference model is to measure the interference temperature at the primary receiver which is unfeasible.

5. CONCLUSION:

In this paper the most common methods for spectrum sensing and their limitations are explained. Advantage and Disadvantage of those methods have discussed. Among those methods co the Interference based sensing method is widely used in spectrum sensing .But in this method, the primary user's is not attaining feasibility in spectrum sensing.

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