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The Comparison of Non-Cooperative Spectrum Sensing Techniques in Cognitive Radio

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Abstract: *The Cognitive radio is the emerging wireless communication system. In the fundamental wireless communication system, the static allocation of spectrum is used and that directed to the problem called spectrum scarcity. Mitola was suggested the idea of cognitive radio in 1998. Spectrum sensing is an important and motivating issue in Cognitive radio. Spectrum sensing is the technique to find the primary user transmission in the assigned licensed spectrum band. In this paper the comparison of non-cooperative spectrum sensing techniques is done.*

Index terms- *Primary User, Secondary User, Spectrum Sensing, Energy Detection, Match Filter Detection, Cyclostationary Detection, Cognitive Radio.*

I. INTRODUCTION:

In cognitive radio(CR), the users that have been given the utmost priority on the use of the particular spectrum are identified as Primary Users(PU) and the users with the lower priority on the use of spectrum are identified as Secondary Users(SU). Our main motive is to make spectrum usable for the SUs without affecting interference to the PUs. This can be done if the SUs sense the PUs transmission before its own transmission. The secondary users check whether there is any active receiver within the range of the secondary user. If active primary user presence there then secondary user cannot transmit the signal because it will cause the interfering to the primary user. So to avoid the interference problem to the primary user it is required to continuously check the presence of any active primary receiver.
The secondary user's necessity to continuously check the activities of the primary users to find the spectrum holes. Spectrum holes are separate as the spectrum bands that can be used by the secondary user without producing interference to the primary users. This process of finding the spectrum holes is called the spectrum sensing. A cognitive radio may be furnished with different forms of cognitive capabilities i.e. a CR may sense the On/Off status of the PUs, or it can be measure the interference power level at primary receiver. Since a CR may be organized with different cognitive capabilities, it can access the radio spectrum in different ways. There are two spectrum access models we have [1]: 1) the opportunistically access model and 2) the concurrent spectrum access model. In the first model a CR user senses the spectrum to detect spectrum holes shown in fig 1. As it detects the one or multiple spectrum holes, it reconfigures transmission parameters (Ex., carrier frequency, bandwidth, and modulation scheme).

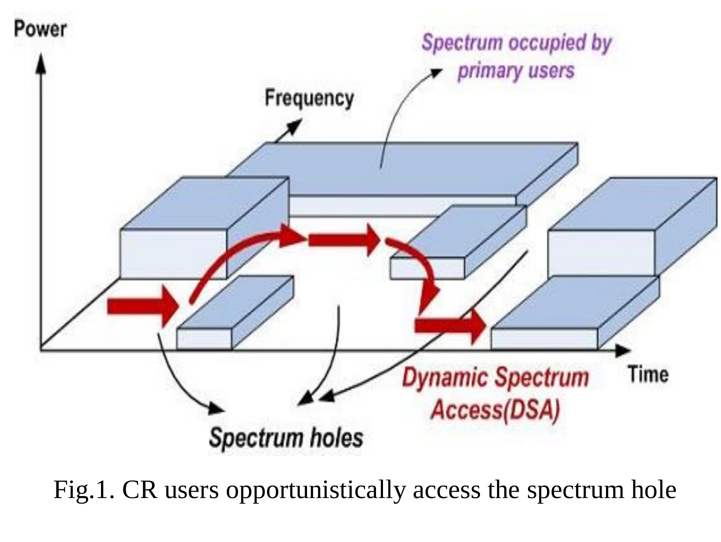

Fig.1. CR users opportunistically access the spectrum hole

The second model is shown in Fig. 2, in which both the CR user and an active PU can exist together till the interference caused by the CR transmitter to the primary receiver is below a tolerable limit. In this model, the CR transmitter should have the knowledge of interference power level at a particular location.CR users co-occur with active PUs under the interference power constraint.

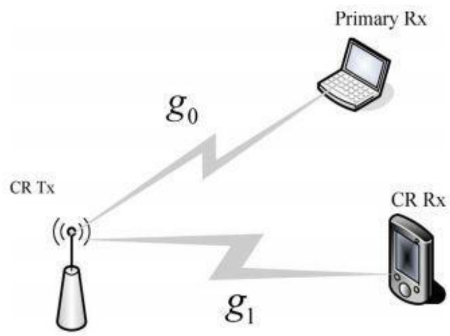

Fig.2. Concurrent spectrum access model:

II. SPECTRUM SENSING TECHNIQUES:

The different spectrum sensing techniques are there to detect the active primary users are presence or absence, such as energy detection matched filter detection and the feature detection etc. Nevertheless their performance is restricted through noise uncertainty, multipath fading and shadowing, which are important characteristics of the wireless channels [3-5].

Principle of spectrum sensing [1]:

The spectrum sensing principle shows in fig. 3. Here to sentinel the PU transmission we required the CR Tx to perform spectrum sensing and to check whether there is any active PU receiver in the coverage of the CR Tx. If there is any primary user transmission in coverage of CR Tx, then CR Tx cannot transmit because it will causes interference to the PU transmission.

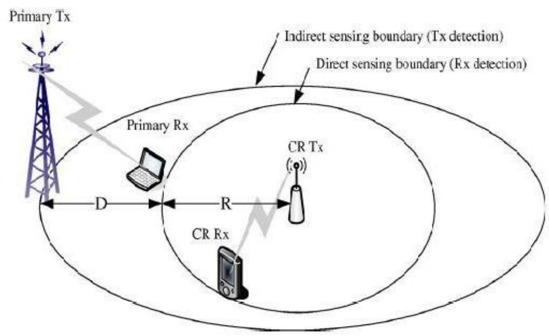

Fig.3. Principle of spectrum sensing

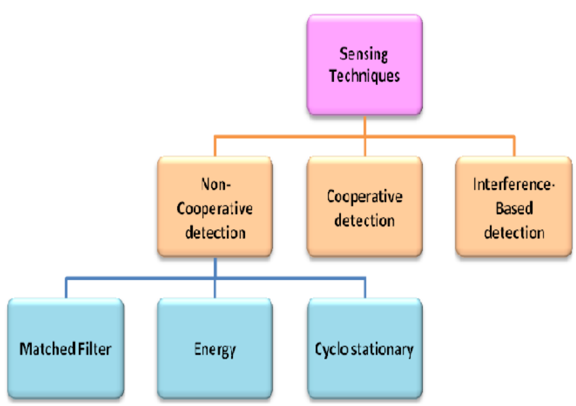

Fig.4. Spectrum sensing techniques

Non-cooperative Spectrum Sensing

Since it is difficult to sense the position of the primary receiver, so to detect the primary user transmission it is necessary to sense the signals sent by the primary transmitter. This is also called primary transmitter detection.

Energy Detection

If CR users have no information of the primary signals then ED can be used for spectrum sensing. ED is optimal detector if noise power is known to the CR user [2]. ED is very simple and easy to implement. It is the utmost common spectrum sensing technique. In energy detection, the occurrence of the signal is detected by measuring the signal in an observation time.

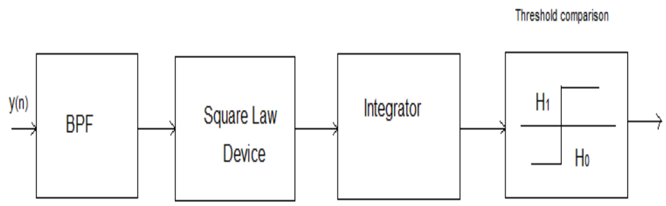

Fig.5. Block dia. of Energy Detection

The received signal is passed through the band pass filter and then through a square law device to calculate its energy. The average energy of the signals are calculated by integrating it over an observation time interval through an integrator. The integrator gives the final energy output. To detect presence of primary signal or not is compared with a predefined threshold i.e. binary decision is made. The threshold can be made fix or variable depending on the channel condition. ED is also called the BLIND DETECTION TECHNIQUE [9] because it doesn't count the structure of the signal.

Let Y be the energy from the integrator over the N samples. By comparing the Y with a threshold λ we can make the decision of the ED.

$$H_0 : y(t) = w(t)$$
$$H_1 : y(t) = h.x(t) + w(t)$$

where hypothesis H0 is "no signal transmitted", and H1 is "signal transmitted", y(t) is the received signal, x(t) is the transmitted signal, w(t) is the Additive White Gaussian Noise (AWGN) with zero mean and variance σ_n^2 and *h* is an amplitude of channel gain[10].

Advantages:

- Simple and less complex than other techniques
- No prior information of the primary signal required
- Easy to implement

Disadvantages:

- High sensing time required to achieving the preferred probability of detection using ED, it is not easy to distinguish primary signal from noise signal.
- Detection performance is limited with noise uncertainty
- Spread spectrum signals cannot be detected by ED

Matched Filter Detection

In this detection SNR of the received signal is maximized. The CR user wants to have the prior information of the primary signal transmitted by the primary user. Matched filter detection defines a correlation in which unknown signal is convolved with the filter whose impulse response is the mirror and time shifted version of a reference signal [6].

Block diagram of matched filter detection is shown below.

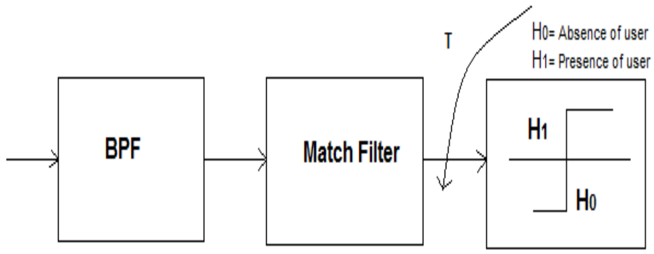

Fig.6 Block Diagram of Matched Filter Detection

Advantages:
- It requires less detection time.
- Matched Filter Detector is optimal detector in stationary Gaussian noise when information of the primary user signal is identified to the CR user [3].

Disadvantages:
- It needs priori information of the received signal.
- High Complexity

Cyclostationary Feature Detection:

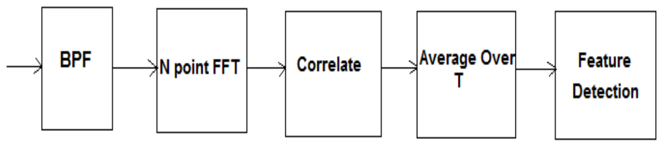

Fig.7 Block dia. of Cyclostationary Feature Detection

The modulated signals are generally cyclostationary in nature and this kind of feature of these signals can be used in this technique to detect the signal. The cyclostationary signals are having the statistical properties that differ periodically with time [7]. It is used to detect the presence or absence of primary users.

Advantages:
- Well performance at low SNR regions.
- No synchronization is required
- Improves the overall CR throughput
- Robust to noise uncertainties

Disadvantages:
- Highly complex method
- Long detecting time

Various non-cooperative spectrum sensing detections are compared bellow.

Characteristics	**Energy Detection**	**Matched Filter Detection**	**Cyclostationary Detection**
Sensing Time	High Sensing Time	Less Sensing Time	Long Sensing Time
Complexity	Less Complex	Very Complex	Highly Complex
Priori Knowledge	Not Required	Required	Not Required
Cost	Low Cost	Very High Cost	High Cost
Synchronization	Not Required	Required	Not required

Table1: Comparison of different non cooperative spectrum sensing detections

III. CONCLUSION:

The Radio spectrum is a very valuable resource for wireless communication. The use of wireless communication should be very powerfully. Cognitive radio system tells us the way how it can be used as per necessity. Through spectrum sensing, the radio spectrum can be used very efficiently. For this, the spectrum sensing should be fast and trustworthy. The basic three non-cooperative spectrum sensing can be valued for spectrum sensing and compared in this paper. Based on the comparison made, we can see that energy detection technique is most prevalent and most appropriate technique because it has low complexity, easy implementation, low cost and no priori knowledge requirement.

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