© 2014 IJEDR | Volume 2, Issue 4 | ISSN: 2321-9939

Assessment of Spectrum Sensing Techniques in Cognitive Radio Networks

1st Shiril Patel, 2nd Yogesh Kakdiya
1st PG Student, 2nd Asst.Prof
1st Electronic and Communication Engineering,
1st S.P.B.Patel Engineering College, Paten, India

***Abstract* - Cognitive radio is widely expected to be the next Big Bang in wireless communications. Spectrum sensing, that is, detecting the presence of the primary users in a licensed spectrum, is a fundamental problem for cognitive radio. In this paper spectrum sensing techniques are reviewed.**

***Index Terms* - Component Cognitive Radio (CR), Dynamic Spectrum Access (DSA), Primary User (PU), Secondary User (SU), Software Defined Radio (SDR)**

I. INTRODUCTION

The available electromagnetic radio spectrum is in scarcity and is getting utilized day to day . On the other hand it has been also found that the allocated spectrum is underutilized because of its static allocation which is the conventional approach of spectrum management and is very inflexible to operate in a certain frequency band. And, with most of the useful radio spectrum already allocated, it is difficult to find vacant bands to either deploy new services or to enhance existing ones. To overcome this situation, we need to come up with a means for improved utilization of the spectrum creating opportunities and ie Dynamic spectrum access [1-3]. The issue of spectrum underutilization in wireless communication can be solved in a better way using Cognitive Radio (CR) technology .Cognitive radios are designed in order to provide highly reliable communication for all users of the network, wherever and whenever needed and to facilitate effective utilization of the radio spectrum [1-2]. Cognitive radio: It is a radio that can change its transmitter parameters based on interaction with environment in which it operates. Cognitive radio includes spectrum sensing, spectrum management, and spectrum

- Spectrum sensing: Detecting unused spectrum and sharing the spectrum without harmful interference with other users.
- Spectrum management: Capturing the best available spectrum to meet user communication requirements.
- Spectrum mobility: Maintaining seamless communication requirements during the transition to better spectrum.
- Spectrum sharing: Providing the fair spectrum scheduling method among coexisting xG users.

II. COGNITIVE RADIOS

Cognitive radios is a new term in wireless communication technology which interacts with real time environment to dynamically alter its operating parameters such as transmit power, carrier frequency, modulation to acclimate itself with the environment whenever there is a statistical change in the incoming radio frequency with the sole purpose to take advantage of the available spectrum without causing interference to primary users.

Cognitive radio includes intelligent detection by a transreceiver, which checks that which communication channels are in use and which are not, and takes an instant decision of moving to vacant channels while avoiding occupied ones. This optimizes the use of available Radio-Frequency (RF) spectrum while minimizing interference to other users. The most basic form, CR is a hybrid Technology involving Software Defined Radio (SDR) It performs allocation identification and authorization of its user and adjusts output power and modulation characteristics it is to be noted that SDR cannot reconfigure by itself whereas CR can perform reconfigurability.

The Federal Communications Commission (FCC) ruled in November 2008 that unused portions of the RF spectrum (known as white spaces) be made available for public use .White space devices must include technologies to prevent interference, such as spectrum sensing and relocation capabilities [3-5]. The idea for CR was developed by Joseph Mitola at the Defence Advanced Research Projects Agency (DARPA) in the United States. Full cognitive radio is sometimes known as “Mitola radio.” software. The CR is viewed as the key enabling technology for future mobile wireless services anywhere, anytime and with any Device [7-8]

III. SPECTRUM SENSING

Spectrum sensing is the ability to measure, sense and be aware of the parameters related to the radio channel characteristics, availability of spectrum and transmit power, interference and noise, radio’s operating environment, user requirements and applications, available networks (infrastructures) and nodes, local policies and other operating restrictions. It is done across Frequency, Time, Geographical Space, Code and Phase. Spectrum sensing is the very task upon which the entire operation of cognitive radio rests. To allow reliable operation of cognitive radios, we must be able to detect precisely the spectrum holes at the link level (that is certain frequency bands are not used for transmission at certain times), which gives spectrum sensing a critical role.

In practice, the unlicensed users, also called secondary users (SUs), need to continuously monitor the activities of the licensed users, also called Primary Users (PUs), to find the spectrum holes (SHs), which is defined as the spectrum bands that can be used by the SUs without interfering with the PUs. This procedure is called spectrum sensing. There are two types of SHs, namely temporal and spatial SHs, respectively. A temporal SH appears when there is no PU transmission during a certain time period and the SUs can use the spectrum for transmission. A spatial SH appears when the PU transmission is within an area and the SUs can use the spectrum outside that area. To determine the presence or absence of the PU transmission, different spectrum sensing techniques have been used, such as matched filtering detection, energy detection, and feature detection. However, the performance of spectrum sensing is limited by noise uncertainty, multipath fading, and shadowing, which are the fundamental characteristics of wireless channels [9-11]

A. Principle of Spectrum Sensing

Fig. 1 shows the principle of spectrum sensing. In the fig. the PU transmitter is sending data to the PU receiver in a licensed spectrum band while a pair of SUs intends to access the spectrum. To protect the PU transmission, the SU transmitter needs to perform spectrum sensing to detect whether there is a PU receiver in the coverage of the SU transmitter.

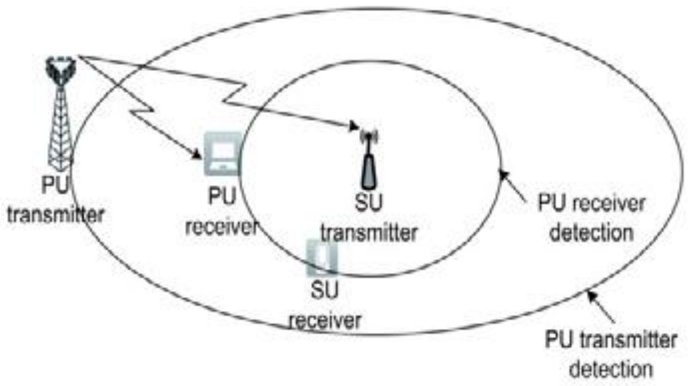

Fig. 1: Principle of Spectrum Sensing

IV. SPECTRUM SENSING DETECTION METHODS

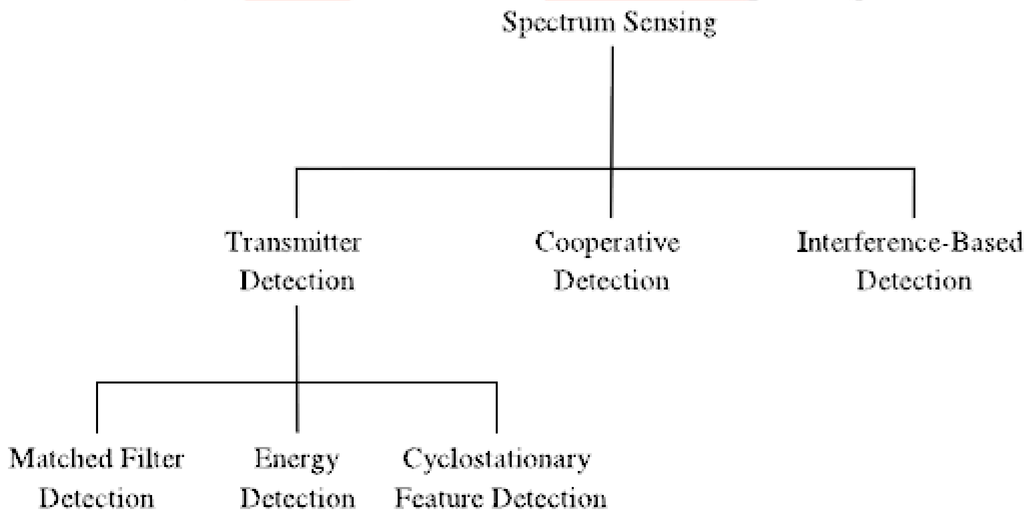

Fig. 2: Features that cognitive radios can incorporate to enable a more Efficient and flexible usage of the spectrum.

1. **Frequency Agility -** The cognitive radio is able to change its operating frequency for its adaptation to the environment.
2. **Dynamic Frequency Selection -** The cognitive radio senses signals from nearby transmitters to choose an optimal environment to work in.
3. **Adaptive Modulation -** The transmission characteristics and waveforms can be reconfigured to exploit all opportunities for the usage of spectrum in an efficient way.
4. **Transmit Power Control -** The transmission power is adapted to full power limits when necessary on the one hand and to lower levels on the other hand to allow greater sharing of spectrum.

V. TECHNIQUES

1. Primary Transmitter Detection

Energy Detection

It is a non coherent detection method .Under this technique the primary signal based on the sensed energy is detected. It is simple to implement and also while using energy detection we do not require the prior knowledge of primary signal.Also Energy

Detection (ED) is the most popular sensing technique in cooperative sensing The block diagram for the energy detection technique is shown in the fig. 3.

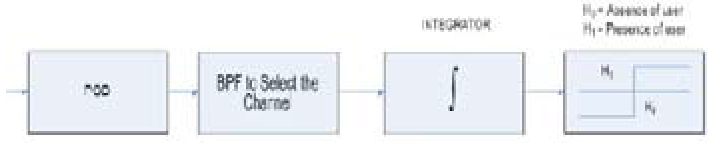

Fig. 3: Energy Detector Block Diagram

In this method, signal is passed through band pass filter of the bandwidth W and is integrated over time interval. The output from The integrator block is then compared to a predefined threshold. The comparison of input signal and threshold signal is used to discover the existence or absence of the primary user. The threshold value can set to be fixed or variable based on the channel conditions. We also call Energy detection technique as BLIND SIGNAL DETECTION because it ignores the structure of the signal and estimates the presence of the signal by comparing the energy received with a known threshold derived from the statistics of the noise. While analyzing we reduce signal detection to a simple identification problem, as a hypothesis test,

$$y(k) = n(k)\ldots\ldots\ldots\ldots\ldots\ldots\ldots H_0$$

$$y(k) = h * s(k) + n(k)\ldots\ldots\ldots H_1$$

Where y (k) is the sample to be analyzed at each instant k n (k) is the noise of variance σ_2 Let y (k) be a sequence of received samples k E {1, 2….N} at the signal detector, then a decision rule can be stated as,

$$H_0 \ldots if \varepsilon < v$$

$$H_1 \ldots if \varepsilon > v$$

Where the estimated energy of the received signal and v is chosen to be the noise variance σ_2 Disadvantages associated to ED i) High sensing time taken to achieve a given probability ii) Detection performance is subject to the uncertainty of noise power. iii) Using Energy Detection technique it is difficult to distinguish primary signals from the CR user signals .iv) CR users need to be tightly synchronized and refrained from the transmissions during an interval called Quiet Period in cooperative sensing. v) ED not suitable to detect spread spectrum signals.

Matched Filter Detection

Fig. 4: Block Diagram of Matched Filter

A matched filter (MF) is a linear filter designed to maximize the output signal to noise ratio for a given input signal. In matched filter detection the secondary user has a priori knowledge of primary user signal is needed Matched filter operation is equivalent to correlation in which the unknown signal is convolved with the filter whose impulse response is the mirror and time shifted version of a reference signal. The operation of matched filter detection is expressed as:

$$Y[n] = \sum_{K=-\infty} h[n-k]x[k]$$

Where 'x' is the unknown signal (vector) and is convolved with the 'h', the impulse response of matched filter that is matched to the reference signal for maximizing the SNR. is known to the cognitive users.

Cyclostationary Feature Detection

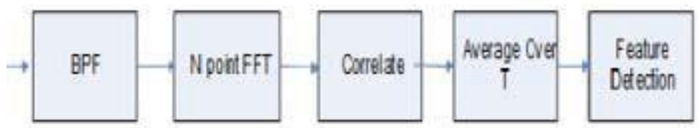

Fig. 5: Block Diagram of Cyclostationary Feature Detection

Cyclostationary feature detection exploits the periodicity in the received primary signal to identify the presence of Primary Users (PU). The periodicity is commonly embedded in sinusoidal carriers, pulse trains, spreading code, hopping sequences or cyclic prefixes of the primary signals. Due to the periodicity, these cyclostationary signals exhibit the features of periodic statistics and spectral correlation, which is not found in stationary noise and interference.

Cooperative Techniques

If multiple CR users cooperate in sensing the channel we need high sensitivity requirements. Various topologies are currently used and are broadly classifiable into three regimes according to their level of cooperation Cooperative sensing techniques:

– Centralised Coordinated

- Decentralised Coordinated
- Decentralised Uncoordinated

Why do we require Cooperation in CR?

- Plummeting sensitivity requirements: channel impairments like multipath fading, shadowing and building penetration losses, impose high sensitivity requirements inherently limited by cost and power requirements.
- Employing cooperation between nodes can drastically reduce the sensitivity requirements up to -25 dBm,
- Reduction in sensitivity threshold can be obtained by using cooperation scheme. It is seen that with this technique the detection time is reduced as compared to uncoordinated networks [9].

Other Approaches: Multi -Taper Spectrum Sensing and Estimation

Multi Taper spectrum estimation (MTSE) has proposed by Thomson (1982) before the CR concept was introduced. The last N received samples are collected in a vector form and are represented as a set of slepian base vectors. The main idea of this method is that the Fourier transforms of Slepian vectors have the maximal energy concentration in the bandwidth fc-W to fc +W under finite sample size constraints. By exploiting this feature, CR user can easily identify the spectrum opportunities in given band. As MTSE uses multiple prototype filters and is better for small sample spaces sincethe computational complexity increases with large number of samples.

Filter Bank Based Spectrum Sensing

Filter bank based spectrum estimation (FBSE) is regarded as the simplified version of MTSE which uses only one prototype filter for each band and has been proposed for multi-carrier modulation based CR systems by using a pair of matched Nyquist filter. FBSE uses the same concept of maximal energy concentration in the bandwidth fc -W to fc +W. By exploiting this information, CR user identifies the spectrum occupancy and hence the spectrum opportunities. MTSE is better for small samples whereas FBSE is better for large number of samples [7].

Wavelet Based Detection

It is widely used technique in image processing for edge detection applications. Tian and Giannakos (2006) have proposed this approach in spectrum sensing where wavelets are used for detecting edges in the power spectral density (PSD) of a wideband channel. The edges in power spectral density are the boundary between spectrum holes and occupied bands and hence it helps to find vacant bands. Based on this information CR can identify the spectrum opportunities.

Random Hough transform based detection

It is also widely used for pattern (such as lines, circles) detection in image processing applications. Challapali et al. (2004) have proposed to perform Random Hough transform of received signal r(n) to identify the presence of radar pulses in the operating channels of IEEE 802.11 wireless systems.

Radio Identification Based Detection

These techniques are used in the context of European Transparent Ubiquitous Terminal (TRUST) project (Farnham et al., 2000) which is based on several extracted features such as transmission frequency, transmission range, modulation technique etc. Once the features are extracted from the received signal, CR users exploit those features and can select suitable transmission parameters for them. [13- 15]

VI. CONCLUSION

Spectrum is a very valuable resource in wireless communication systems and it has been a major research topic from last several Decades. Cognitive radio is a promising technology which enables spaces. Considering the challenges raised by cognitive radios, the use of spectrum sensing method appears as a crucial need to achieve satisfactory results in terms of efficient use of available spectrum and limited interference with the licensed primary users. As described in this paper, the development of the cognitive radio network requires the involvement and interaction of many advanced techniques, including distributed spectrum sensing, interference management, cognitive radio reconfiguration management, and cooperative communications. Furthermore, in order to fully realize the CR system in wireless communications for efficient utilization of scarce RF spectrum, the method used in identifying the interference and/or spectrum sensing should be reliable and prompt so that the primary user will not suffer from CR system to utilize their licensed spectrum. We presented the different signal processing methods by grouping them into three basic groups and their details in turn. We have also presented the pros and cons of different spectrum sensing methods, and performed the comparison in terms of operation, accuracies, complexities and Implementations. There exists number of issues to be addressed in terms of primary signal detection time, hardware requirements and computational complexities. Taking into consideration the applicability the energy detection technique is preferred the most as It is most common way of detection because of its low computational and implementation complexities [6]. In energy detection approach, the receivers do not need any knowledge on the primary users' signals as in matched filters and other approaches. In this method, the signal detection is performed by comparing the output of energy detector with a given threshold value.

REFERENCES

[1] Danijela Cabric, Artem Tkachenko, Robert W. Brodersen, "Spectrum Sensing Measurements of Pilot, Energy, and Col-laborative Detection", Military Communication Conference