A Review on Techniques to Sense the Spectrum for Cognitive Radio Networks

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Abstract - ***Radio spectrum is the most valuable resource in wireless communication. In recent past the growth of wireless devices and multimedia applications has led to increase in spectral usage causing spectral congestion problem. Cognitive radio provides tempting solution to this problem by making best use of the frequency band which is not heavily occupied by licensed users hence improving the spectrum utilization. In this paper various spectrum sensing techniques, such as energy detection, cyclostationary detection, matched filter detection methods are discussed and compared with one another.***

Key Words: *— cognitive radio, spectrum hole, spectrum sensing, PU, SU*.

1. INTRODUCTION

The major challenges in the design of wireless network are the use of frequency spectrum. With the drastic increase in communication applications in various countries, almost all of the spectrum has been fully allocated resulting in the spectrum congestion problem. From the recent report of Federal Communication Commission (FCC) about 15 to 85% of spectrum is not utilized [1]. Utilization of the frequency band can be improved by introducing Secondary User (SU) which will continuously detect the presence of PU called **spectrum sensing**, and utilize licensed band when Primary User (PU) is absent. Secondary User (SU) will transmit their information without disrupting licensed user (PU), such an opportunity is called **spectrum hole** and the device that detect these holes are called **Cognitive Radio** (CR) [4].

Cognitive radio is widely as one of the promising technology for future wireless communication. According to Federal Communication Commission (FCC) "Cognitive radio :A radio or system that senses its operational electromagnetic environment and can dynamically and autonomously adjust its radio operating parameters to modify system operation, as maximize throughput, mitigate interference facilitate interoperability, access secondary markets."[12]

2. SPECTRUM SENSING

Spectrum sensing or PU detection is an important function for cognitive radio. It can be defined as process of finding spectrum holes by sensing radio spectrum around cognitive radio receiver. Temporary usage of unused frequency bands by CR is commonly known as spectrum holes. Spectrum holes are of two types, temporal spectrum holes and spatial spectral holes.

A spectrum hole which is not occupied by the PU during the time of sensing is temporal spectrum hole, hence can be used by SU at that time slot. Band which is unoccupied by PU at some spatial areas is spatial spectrum hole, therefore it can be occupied by SU as well as outside this area

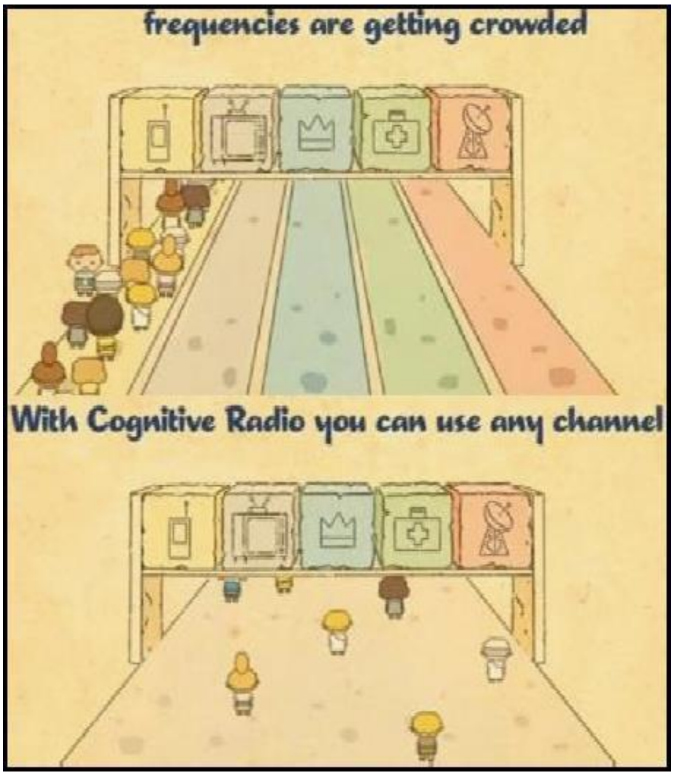

Fig-1: Frequency utilization in CR [5]

CR hops to another spectrum holes if the band is used more by PU as shown in figure. 2

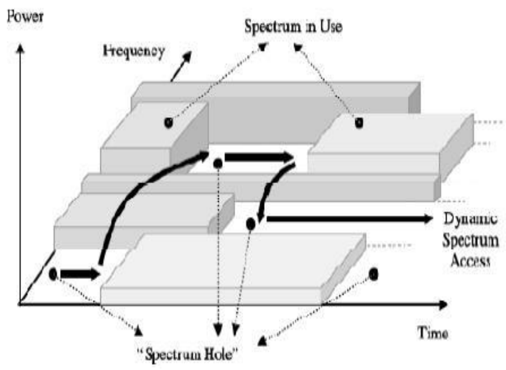

Fig- 2: Spectrum holes [7]

To enhance the detection probability diverse spectrum sensing techniques can be used as shown in figure. 3

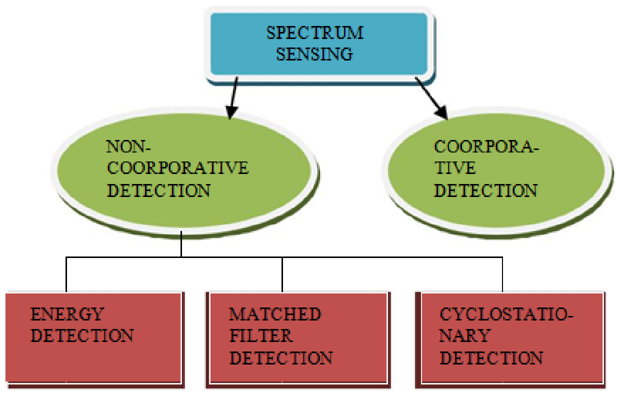

Fig- 3: Spectrum sensing techniques

2.1 Corporative Spectrum Sensing (CSS)

Due to generally facing many problems such as fading, shadowing, Signal-to-Noise Ratio (SNR) etc, only depending on single SU will not give sufficient sensing results during short sensing time. Therefore many ways of CSS have been proposed to obtain better results than single user sensing.

In CSS scheme trust factor of each user is considered to improve the global sensing performance of CRN. It is based on decision fusion, all of the collaborative SUs perform local sensing and make binary local decision individually and transmit their local binary decision to the Fusion Centre (FC) where data fusion rule will be performed to make global decision on presence and absence of licensed users (PU) activities. Simulations result show that the proposed method can obtain better detection performance than the traditional decision fusion ways and does not need any information of PU's signal and noise in advance.

2.2 NON CORPORATIVE DETECTION TECHNIQUE

In Non corporative detection technique individual radios works locally and independently to carry out their own detection of unused frequency band and occupancy of spectrum [10]. Three methods have been discussed in the following subsections under non cooperative detection.

2.1.1 Matched filter detection*:* Matched filter is one of the favorable methods for detection of licensed user (PU) and is used when the transmitted signal is known. It requires accurate information of the PU signaling features which are operating frequency, bandwidth, pulse shaping, order and modulation type [11] so that CR can demodulate transmitted signal. Advantage of matched filter are; it requires less sensing time to achieve good detection performance due to coherent detection and can also work with very low SNR. This technique is not applicable in case where transmit signal by PU's are unknown to SU's [9].

2.1.2 Energy detection*:* Energy detection is a mechanism to detect signal using an energy detector (also known as radiometer) to specify the absence or presence of signal in the band. Energy detector based method is common way of sensing the spectrum because of its low computational time and implementation complexities [11]. It is very simple and practical method as receiver does not need any information about PU's signal to be detected, so it is widely adopted. The signal is recognized by comparing the threshold which depends on the noise floor with the output of energy detector [8] However there are some limitations of this technique which includes inability to differentiate interference between signal from a user signal and noise, it is also not effective for those signals whose signal power has been scattered over a wideband.

2.1.3 Cyclostationary based sensing: Cyclostationary detector utilizes the cyclostationary feature of the signals for spectrum sensing. If mean and autocorrelation of cyclostationary are a periodic function then a signal is said to be cyclostationary. [6]. Feature detection refers to sunder out the features from the received signal and perform detection based on the extracted feature [2], [3]. Cyclostationary detection is better option than energy detector in case where energy detection is not so effective. It performs better than energy detector because of its noise rejection ability as noise is totally random and does not show any periodic behavior.

Cyclostationary detector can differentiate noise from licensed user (PU) signal and can also be used for detecting weak signal at a very low signal-to-noise ratio region. Cyclostationary detection technique is best used when we have no prior knowledge about licensed user signal. The disadvantage of this method is the complexity of calculation and long sensing time.

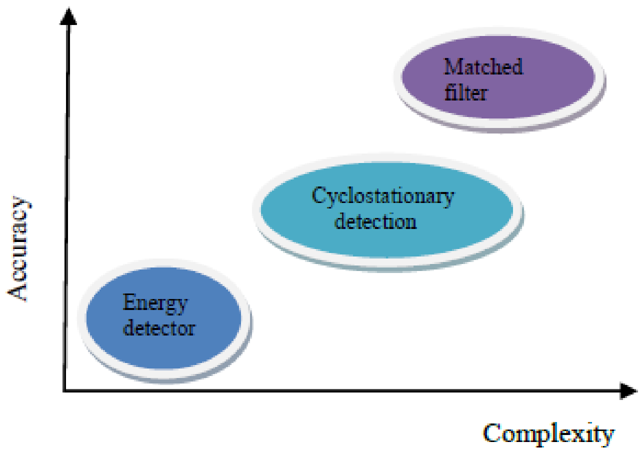

Fig-4: Sensing methods in terms of their complexity and Sensing accuracy

3. CONCLUSION

In this paper, cognitive radio network related to spectrum sensing technique is proposed and also various spectrum sensing methods are reviewed. Cognitive radio technologies are being developed in order to fully utilize unused frequency band increasing the efficiency of spectrum usage. The important feature of cognitive radio is sensing on which it works. Three techniques have been described above for spectrum sensing and are also compared. The graph in figure 4 shows different sensing method in terms of their sensing accuracy and complexity. Cognitive radio technology will be applied to many real systems in the future.

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