# A Review On Spectrum Sensing For Cognitive Radio Networks

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**Abstract**— Cognitive radio is the emerging technology for supporting dynamic spectrum access. To detect the presence of the primary users in a licensed spectrum is a fundamental problem for cognitive radio. In cognitive radio networks, the performance of the spectrum sensing depends on the sensing time and the fusion scheme. These schemes are used when cooperative sensing is applied. In this paper, spectrum sensing techniques such as energy detection, matched filtering detection, cyclostationary detection and waveform based sensing methods are discussed. Energy detection is most commonly used in local spectrum sensing. This paper gives the overview about comparison between different methods. It helps to find the better method of spectrum sensing.

**Keywords -** Cognitive radio, spectrum sensing, dynamic spectrum access

## I. INTRODUCTION

The radio spectrum is naturally limited resource needed for wireless communication systems. With the explosive growth in communication applications, in several countries, most of the available spectrum has fully been allocated, which results in the spectrum scarcity problem. From the report of the Federal Communications Commission (FCC) it was shown that the conventional fixed spectrum allocation rules have resulted in low spectrum usage efficiency in almost all currently deployed frequency bands. The fixed spectrum access (FSA) policy has traditionally been adopted to support various wireless applications and services in a non-interfering basis, which assign each piece of spectrum with certain bandwidth to only one or more dedicated users[1]. That means only the assigned (licensed) users have the right to use the allocated spectrum and other users are not allowed to use it. Therefore to allow the radio spectrum to be used more efficiently, dynamic spectrum access (DSA) has been proposed as an alternative scheme. Cognitive radio is the emerging technology for supporting dynamic spectrum access.

Cognitive radio, a paradigm introduced by J. Mitola, has emerged as a promising technology for maximizing the underutilized frequency bands. In this paper, we use the definition adopted by Federal Communications 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, such as maximize throughput, mitigate interference, facilitate interoperability, access secondary markets*." [8]. Hence, one main aspect of cognitive radio is related to autonomously exploiting locally unused spectrum to provide new paths to spectrum access[5].

In dynamic spectrum access, some part of spectrum can be allocated to particular users, which are called licensed or primary users (PUs). That means they have higher priority in using it. For that the secondary users are required to continuously perform spectrum sensing, that is, detecting the presence of the primary users. The secondary users (SUs), which have not the license for that spectrum, can also access the allocated spectrum when the PUs are not fully utilizing it. The spectrum can also be shared with the PUs as long as the PUs can properly be protected[1]. Whenever the primary users become active, the secondary users have to detect the presence of them with a high probability of detection and vacate the channel or reduce transmit power within certain amount of time. Thus the radio spectrum can be reused opportunistically and the spectrum utilization efficiency can significantly be improved[1].

## II. SPECTRUM SENSING

In this paper, our attention is on the particular task on which the very essence of cognitive radio depends is spectrum sensing. It is defined as the task of finding spectrum holes or spectrum white space by sensing the radio spectrum in the local neighborhood of the cognitive radio receiver.

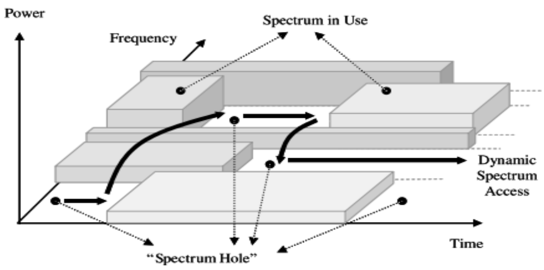


***Fig. 1. Spectrum hole concept[4]***

The term, spectrum holes stands for those sub-bands of the radio spectrum that are underutilized at a particular instant of time and specific geographic location. The task of spectrum sensing involves the following subtasks: 1) detection of spectrum holes; 2) spectral resolution of each spectrum hole; 3) estimation of the spatial directions of incoming interferes; 4) signal classification[2]. In this paper many spectrum sensing methods are viewed including the energy detection (ED) , matched filtering (MF) detection , cyclostationary detection (CSD) , and some newly emerging methods such as radio identification based sensing, waveform based sensing. These methods have different requirements for implementation. For example, matched filtering and cyclostationary detection require both source signal and noise power information; ED and waveform based sensing methods require only noise power information; Eigen value-based sensing method does not require any information about source signal and noise.

## III. VARIOUS SPECTRUM SENSING METHODS

(1) Energy Detection is the most common way of spectrum sensing because of its low computational and implementation complexities[6]. It is a very simple method in which the receivers do not need any knowledge on the primary user's signal. The signal is detected by comparing the output of the energy detector with a threshold which depends on the noise floor[9]. The main challenge with the energy detector based sensing is the selection of the threshold for detecting primary users. The challenging task for this method is include inability to differentiate interference from primary users and noise and poor performance under low signal-to-noise ratio values.

(2) Cyclostationary Spectrum Sensing performs better than Energy detection because of its noise rejection ability. This occurs because noise is totally random and does not exhibit any periodic behavior. When we have no prior knowledge about primary user's waveform then best technique is cyclostationary feature detection. The disadvantage of cyclostationary spectrum sensing is its high complexity which results in high cost.

(3) The waveform-based Sensing method is only applicable to systems with known signal patterns Such patterns include preambles, midambles, regularly transmitted pilot patterns, spreading sequences *etc.* A preamble is a known sequence transmitted before each burst and a midamble is transmitted in the middle of a burst or slot. In the presence of a known pattern, sensing can be performed by correlating the received signal with a known copy of itself[9]. Waveform-based sensing requires short measurement time.

 

(4) Matched-filtering is known as the optimum method for detection of primary users when the transmitted signal is known. Matched-filtering requires cognitive radio to demodulate received signals. So for that it requires perfect knowledge of the primary users signaling features such as bandwidth, operating frequency, modulation type and order[6].

(5)In radio identification based sensing by identifying the transmission technologies used by primary users we can obtain a complete knowledge about the spectrum characteristics. Such an identification enables cognitive radio with a higher dimensional knowledge as well as providing higher accuracy[7].

## IV. COMPARISON OF VARIOUS SENSING METHODS

The figure shows the comparison of different sensing methods in terms of their sensing accuracy and complexities. Waveform-based sensing is more robust than energy detector and cyclostationarity based methods. Energy detector based sensing is limited in terms of accuracy. The advantage of energy detection method is its less complexity which result in low cost. Energy detector based sensing methods perform better than cyclostationary based methods when the noise is stationary. Cognitive radio needs receivers for all signal types, the implementation complexity of sensing unit is impractically large [6].

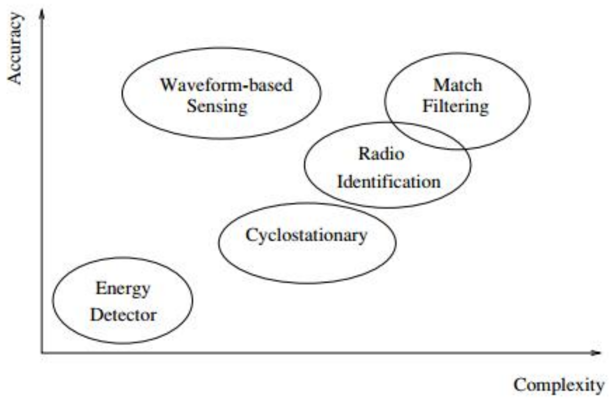


***Fig. 2. Sensing methods in terms of their sensing accuracy and complexities.[5]***

## V. CONCLUSION

Cognitive radio arises to be a tempting solution to spectral crowding problem by introducing the opportunistic usage of frequency bands that are not heavily occupied by licensed users since they can't be utilized by users other than the license owners at the moment. It offers a solution by utilizing the spectrum holes that represent the potential opportunities for non-interfering use of spectrum. In this paper, various spectrum sensing techniques have been studied. Cooperative spectrum sensing for cognitive radio networks is recently being studied to simultaneously minimize uncertainty in primary user detection and solve hidden terminal problem. In cooperative spectrum sensing, each secondary user requires some information in order to achieve the vacant spectrum sensing.

## REFERENCES

[1] Y.C.Liang, K.C.Chen,Geoffrey Ye Li, Petri Mahonen, "Cognitive Radio Networking and Communications: An Overview", IEEE Transactions on vehicular technology, vol. 60,no 7, sept 2011
[2] Simon Haykin, David J. Thomson, Jeffrey H. Reed, " Spectrum Sensing for Cognitive Radio", Proceedings

of the IEEE, vol. 97, no. 5, May 2009

[3] Hang Su, Xi Zhang, "Energy-Efficient Spectrum Sensing for Cognitive Radio Networks", IEEE ICC, 2010.

[4] I. F. Akyildiz, W.-Y. Lee, M.C. Vuran, S. Mohanty, "NeXt generation/ dynamic spectrum access/cognitive radio wireless networks: a survey", Computer Networks, vol. 50, no. 13, pp. 2127–2159, 2006.

[5] T. Yucek, H. Arslan, "A survey of spectrum sensing algorithms for cognitive radio applications", IEEE Communications Surveys Tutorials, vol. 11, no. 1, pp. 116–130, 2009.

[6] D. Cabric, S. Mishra, and R. Brodersen, "Implementation issues in spectrum sensing for cognitive radios," in Proc. Asilomar Conf. on Signals, Systems and Computers,vol.1,Pacific Grove,California, USA, Nov. 2004, pp. 772–776.

[7] T. Y ucek and H. Arslan, "Spectrum characterization for opportunistic cognitive radio systems," in Proc. IEEE Military Commun. Conf., Washington, D.C., USA, Oct. 2006, pp. 1–6.

[8] Federal Communications Commission, "Notice of proposed rule making and order: Facilitating opportunities for flexible, efficient, and reliable spectrum use employing cognitive radio technologies," ET Docket No. 03-108, Feb. 2005.

[9] H. Tang, "Some physical layer issues of wide-band cognitive radio systems," in Proc. IEEE Int. Symposium on New Frontiers in Dynamic Spectrum Access Networks, Baltimore, Maryland, USA, Nov. 2005, pp.151–159.

[10] Miia Mustonen, Heli Sarvanko, Atso Hekkala, Oulu,Finland,"Cognitive radio: An intelligent wireless communication system" , march 2009

[11] Mahmood A. K. Abdulsattar Zahir A. Hussein "Energy Detector with Baseband Sampling for Cognitive Radio: RealTime Implementation", Wireless Engineering and Technology, vol. 3, pp.229-239,2012