Comparative Study of Spectrum Sensing methods

A. NASSER[1,2,3], A. MANSOUR[2], K.C. YAO[1], H. CHARARA[3], M. CHAITOU[3]
[1]LABSTICC, UBO, 3 Rue des Archives, 29238 Brest, France
[2] LABSTICC, ENSTA Bretagne, 2 Rue François Verny, 29200 Brest, France
[3] Lebanese University, Faculty of Science, Lebanon

Email: abbas.nasser@univ-brest.fr, mansour@ieee.org, koffi-clement.yao@univ-brest.fr, h_charara@hotmail.com, Mohamad.Chaitou@gmail.com

Abstract: **Spectrum Sensing is the main part in the Cognitive Radio system. In fact many researches have been realized the last decade, and several techniques have been proposed to perform the Spectrum Sensing. This manuscript deals with this subject by presenting the most used techniques, by categorizing them as Cooperative and Blind, according to their requirements.**

***Index Terms*—Cognitive Radio, Spectrum Sensing, Cooperative techniques, Blind techniques.**

I. Introduction

Cognitive Radio (CR) was introduced by Mitola in [1], in order to improve the distribution of the frequency spectrum to satisfy the growing evolution in wireless applications. Therefore, the major goal of CR is to identify the non-presence of Primary User (PU) which has the legal right of transmission [1] [2]. In case of absence of PU, the CR can allocate the unused band to a Secondary User (SU). The SU should stop his transmission if PU starts to be active, in order to avoid any interference. In fact, many techniques have been introduced in order to estimate the opportunity of free bandwidth; those techniques could be classified as: Blind and Cooperative. The cooperative techniques need a priori information about the PU to do the sensing of the channel, while the blind techniques do not.

II. Techniques of Spectrum Sensing

A. Cooperative techniques

The Wave Form (WF) and the Cyclo-Stationary Detection (CSD) methods are the most widely used in the cooperative techniques [2].

A.1- Wave Form consists of the evaluating the projection R of the received signal on a known pilot used by PU [2][3][4].The quantity R should be compared to a threshold to make a decision about the presence of PU.

This method is very accurate and efficacy at very low SNR, but requires the knowledge of the pilot of the PU, which is not available for all cases. In addition SU should be synchronized with the PU [4] [2].

A.2- Cyclo-Stationary Detection method detects the presence of PU by examining the cyclo-stationary features of the received signal [2] [5] [6]. The Cyclic Spectral Density exhibits a peak if the cyclic frequency is equal to the fundamental frequency of received signal. This technique can work in a noisy environment even at weak SNR. With this method, the SU should know the cyclic frequencies of PU.

B. Blind techniques

The Energy Detection and the Blind Source Separation are also used in Spectrum Sensing; those techniques do not require any a priori information.

B.1- Energy Detection (ED) is the most generic technique in the context of Spectrum Sensing due to its simplicity [2] [5] [7] [8]. The ED is based on the computation of the energy E of the received signal and then comparing E to a pre-defined threshold. Nevertheless, this method is very sensitive to the estimation

of noise variance [2] [8] [9]. The ED do not work at low SNR, where the measured E is weak and cannot achieve the spectrum sensing of certain type of signals such as spread spectrum signals[2] [3] [10].

B.2- Assuming that the PU's and the SU's signals are statistically independent, the BSS techniques can be applied for spectrum sensing [9] [11],these techniques can separate the signals without a priori information about them. Recently applied in the context of spectrum sensing [11], the BSS algorithms are based on the measure of the Gaussianity of mixed signals, received on an array of sensors. Such methods present a major advantage, which is the capability to scan the channel even if SU is active, while the other methods (ED, CSD and WF) are not capable [12] [11]. The main drawback of this method is that several sensors are needed to form a detector.

III. CONCLUSION

In this paper, a state of art of spectrum sensing is presented; we categorize the techniques used in spectrum sensing as Cooperative and Blind. The cooperative methods can be accurate, but require a priori information about PU, which cannot be always possible, because the CR should deal with a great diversity of signals. In other hand, the Blind methods are simple, and do not require the knowledge of signal's features, but ED is very sensitive to the noise variance estimation error, while BSS require only that the SU's and PU's signals are independent. So, the BSS can be a good method to perform Spectrum Sensing.

REFERENCES

[1] I. Mitola and J. Maguire, Cognitive radio: making software radios more personal, IEEE Personal Commun. Mag., vol. 6, no. 4. pp 13-18. August 1999 .

[2] T. Yucek and H, Arslan, A Survey of Spectrum Sensing Algorithms for Cognitive Radio Applications, Communications Surveys & Tutorials, IEEE , Vol. 11, 2009

[3] D. Cabric, A. Tkachenko and R. W. Brodersen, Spectrum Sensing Measurements of Pilot, Energy, and Collaborative Detection, Military Communication Conference MILCOM 2006, 2006.

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

[5] S. Shankar, C. Cordeiro, and K. Challapali, Spectrum agile radios:utilization and sensing architectures, Proc. IEEE Int. Symposium on New Frontiers in Dynamic Spectrum Access Networks Meryland, USA :, Nov. 2005.

[6] P. Qihang, Z. Kun, W. Jun, and L. Shaoqian, A distributed spectrum sensing scheme based on credibility and evidence theory in cognitive radio context, Proc. IEEE Int. Symposium on Personal, Indoor and Mobile Radio Commun., Helsinki, Finland , Sept. 2006.

[7] Y. Yuan, P. Bahl, R. Chandra, P. A. Chou, J. I. Ferrell, T. Moscibroda, S. Narlanka, and Y. Wu, KNOWS: Cognitive radio networks over white spaces, Proc. IEEE Int. Symposium on New Frontiers in Dynamic Spectrum Access Networks. Dublin, Irland , Apr. 2007.

[8] F. Digham, M. Alouini, and M. Simon, On the Energy Detection of unknown signals over fading channels, Proc. IEEE Int. Conf. Commun, Washington, USA , Vol. 5, May 2003,

[9] Yi Zheng, Xianzhong Xie, Lili Yang, Cooperative Spectrum Sensing Based on Blind Source Separation for Cognitive Radio, Changchun, First International Conference on Future Information Networks, China, 2009.

[10] T. Yücek and H. Arslan, Spectrum characterization for opportunistic Cognitive Radio System, Proc. IEEE Military Commun. Conf., Washington, USA , Oct. 2006.

[11] S. S. Ivrigh, S. M.-S. Sadough and S. A. Ghorashi, A Blind Source Separation Technique for Spectrum Sensing in Cognitive Radio Networks Based on Kurtosis Metric, International Conference on Computer and Knowledge Engineering, Mashhad, Iran, Oct. 2011.

[12] A. MANSOUR, A. K. BARROS, and N. OHNISHI, Blind Separation of Sources: Methods, Assumptions and Applications, IEICE TRANS. FUNDAMENTALS, Vol. E83-A, August 2000,