Chapter 3
Iterative Optimization of Energy Detector Sensing Time and Periodic Sensing Interval in Cognitive Radio Networks

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ABSTRACT

In this chapter the authors propose a new approach for optimizing the sensing time and periodic sensing interval for energy detectors in cognitive radio networks. The optimization of the sensing time depends on maximizing the summation of the probability of right detection and transmission efficiency, while the optimization of periodic sensing interval is subject to maximizing the summation of transmission efficiency and captured opportunities. Since the optimum sensing time and periodic sensing interval are dependent on each other, an iterative approach to optimize them simultaneously is proposed and a convergence criterion is devised. In addition, the probability of detection, probability of false alarm, probability of right detection, transmission efficiency, and captured opportunities are taken as performance metrics for the detector and evaluated for various values of channel utilization factors and signal-to-noise ratios.

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INTRODUCTION

Demands on high data rate applications are increasing and consequently demands on spectral resources are increasing as well. Several studies, initiated recently by the US regulator Federal Communications Commission (FCC), have shown that the frequency spectrum is underutilized and inefficiently exploited: some bands are highly crowded, at some day hours or in dense urban areas, while others remain poorly used. Regulators worldwide are beginning to recognize that the traditional way of managing the electromagnetic spectrum, called Fixed Spectrum Access (FSA), in which the licensing method of assigning fixed portions of spectrum, for very long periods, is inefficient (Wellen, Wu, & Mahonen, 2007).

Among the efforts taken, by regulators worldwide, in order to achieve better usage of spectrum is the introduction (promotion) of secondary markets. In a secondary usage context, the spectrum owned by the license owner (also called primary user) can be shared by a non-licensee referred to as a secondary user. Besides the promotion for secondary markets, we are currently experiencing rapid evolutions of Software Defined Radio (SDR) techniques. Such techniques allow reconfigurable wireless transceivers to change their transmission/reception parameters, such as the operating frequency that can be modified over a very wide band, according to the network or users' demands. The efforts taken by regulators in order to make better usage of spectrum, in particular the promotion for secondary market, together with the rapid evolution of the SDR techniques, have led to the development of opportunistic Cognitive Radio (CR) systems. The term Cognitive Radio was first introduced by Mitola in 1999. CR generally refers to a radio device that has the ability to sense its Radio Frequency (RF) environment and modify its spectrum usage based on what it detects (Mitola, 1995).

In cognitive radio environments the primary users are allocated licensed frequency bands while secondary cognitive users can be dynamically allocated the empty frequencies within the licensed frequency band, according to their requested Quality of Service (QoS) specifications. Spectrum sensing is commonly recognized as the most fundamental task in cognitive radio based on dynamic spectrum access due to its important role in discovering the spectrum holes (Haykin, 2005). To achieve this goal the unlicensed user should monitor the licensed channels to identify the spectrum holes and to properly utilize them. The concept of spectrum hole or spectrum opportunity imposes a multi dimensional spectrum awareness (Yucek & Arslan, 2009) since a spectrum hole is a function of frequency, time and geo-location. Besides, considering noise existence all over the radio spectrum, then spectrum hole is a function of the received power as well since a received power equal to the noise floor means spectrum hole. The concept of spectrum holes is as demonstrated in Figure 1.

The detection of the existence of the primary user is a fundamental task to be performed by the Secondary User (SU); the following three approaches have been proposed for achieving this task (Ghasemi & Sousa, 2008):

- **Database Registry:** The PU activity information is obtained through an accessible database by the SUs.
- **Beacon Signals:** A beacon signal is sent via standardized channel to tell which channels are occupied by the PUs.
- **Spectrum Sensing:** The SU is responsible for checking the PU signal existence and accordingly finding the spectrum holes.

The database registry and beacon signals approaches require supporting positioning in SUs and implies cost burden on the PUs since they are responsible for providing information about spectrum availability. Moreover, Internet connection is necessary to adopt database registry and standardized channel is needed for beacon

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