Chapter 5
Review of Spectrum Sensing Techniques in Cognitive Radio Networks

Ala Eldin Omer
American University of Sharjah, UAE

ABSTRACT

Most frequency spectrum bands are licensed to certain services to avoid the interference between various networks, but the spectrum occupancy measurements show that few portions of this spectrum are fully efficiently used. Cognitive radio is a future radio technology that is aware of its environment, internal state, and can change its operating behavior (transmitter parameters) accordingly. Through this technology the unlicensed users can use the underutilized spectrum without causing any harmful interference to the licensed users. Its key domains are sensing, cognition, and adaptation. The spectrum sensing problem is one of the most challenging issues in cognitive radio systems to detect the available frequency bands. This chapter introduces the concepts of various transmitter detection techniques, namely energy detection, matched filter detection, and cyclostationary feature detection. The chapter also discusses other sensing techniques that are introduced to enhance the detection performance of the conventional energy detector. Additionally, the introduced sensing techniques are implemented using extensive MATLAB simulations and their performances are evaluated and compared in terms of sensing time, detection sensitivity, and ease of implementation. The implementation is based on BPSK and QPSK modulation schemes under various SNR values for AWGN noisy channel with Rayleigh fading.

INTRODUCTION

Recent advances in wireless communication and the extensive development of new wireless services and applications have led to a transition from the conventional voice-only communications to multimedia-based applications. Consequently, spectrum resources are facing huge demands with needs for higher data rates. However, this interest is impeded by the shortage of radio spectrum, due to the legacy method of static assignment of the radio spectrum to licensed users. With providing each new service with a

DOI: 10.4018/978-1-5225-5354-0.ch005

unique fixed frequency band in a traditional allocation way, most of the primary spectrum has become fully assigned, accordingly, it has become very difficult to allocate the newly expanded services within the existing spectrum. Due to present government polices of static assignment, unlicensed users are restricted from accessing the licensed spectrum instead they turn to share several frequency bands that are interference-prone and heavily-populated. Therefore, the radio spectrum scanning measurements investigate a huge scarcity in certain frequency bands with only partial occupation most of the time, while the rest of the spectrum is being heavily and fully used (Haykin, 2005).

The researches in spectrum utilization have shown that the main cause of spectrum scarcity problem is the underutilization of frequency bands in the fixed spectrum policy in which the wireless spectrum (i.e. frequency carriers) are leased to some operators for a long period of time up to several years. Therefore, an urgent need is emerged for new innovative and developed techniques that can exploit the available spectrum more efficiently. Researchers have been motivated to find new wireless communication technologies to overcome the radio spectrum scarcity and meet the increasing demand for the wide range of wireless service. Cognitive Radio arises to be an enticing solution to the inefficient utilization and spectral congestion problems that allows the secondary users to opportunistically exploit the less occupied frequency bands by the licensed users in the network (Haykin, 2005) ((FCC), November 2002).

Cognitive Radio (CR) networks have been introduced by researches to overcome the spectrum scarcity problem. It provides an efficient usage of the underutilized radio spectrum through dynamic spectrum access methodology. CR has different system models and cognitive functionality levels. The first CR standard using TV bands is IEEE 802.22 Wireless Regional Area Networks (WRAN), in which the medium access is controlled by a base station (BS). 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 the system operation, such as maximize throughput, mitigate interference, facilitate interoperability, access secondary markets. ((FCC), November 2002)

Generally, Cognitive radio architecture consists of: primary user, secondary user, and shared channel. The licensed spectrum is a shared resource between primary and secondary users with higher priority for the primary users in accessing the channel. Therefore, when a primary user is detected, the secondary users have to vacate the channel in a timely manner to avoid any possible interference. In order to reduce secondary users connection loss and primary users interference, the secondary users need to avoid the channels with high occupancy probability within a given time period. Therefore, the secondary users should be able to evaluate the channel(s) availability through predicting the traffic pattern of the primary user(s).

The Cognitive Radio technology will enable the unlicensed user to determine the available portion of the spectrum to be used by detecting the presence of primary user(s) (Spectrum Sensing), select the best available channel based on the user requirements (Spectrum Management), coordinates the access to the channel with other unlicensed users (Spectrum Sharing) and change to some other frequency channel whenever the primary user is detected (Spectrum Mobility) (Akyildiz, Lee, Vuran, & Mohanty, 2006).

Being the focus of this chapter, spectrum sensing is the most important motif for establishing the Cognitive Radio and it is concerned about being aware of the spectrum usage and presence of licensed users in a geographical area in specific frequency band(s). This awareness can be obtained by local spectrum