Chapter 8
Advanced Spectrum Sensing Techniques

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ABSTRACT

Spectrum sensing plays an important role in cognitive radio networks. Based on the bandwidth considered for spectrum sensing, it can be classified into narrowband and wideband spectrum sensing. Traditional spectrum sensing methods are devised for narrow band as it focuses on narrow frequency a range that is the channel bandwidth is lesser than the coherence bandwidth of the channel. To provide more spectral opportunity to cognitive user and to increase the throughput, cognitive radio network needs techniques that exploits spectral opportunities over a wide frequency range. Wideband spectrum sensing techniques aim to sense a channel bandwidth that exceeds the coherence bandwidth of the channel. Narrowband sensing techniques cannot be directly employed to perform wideband spectrum sensing as they make a single binary decision. In this chapter, the advanced spectrum sensing techniques and their taxonomy are discussed in detail.

INTRODUCTION

The main aim of spectrum sensing is to provide more spectrum access to Cognitive Radio (CR) users. Based on the bandwidth sensed, spectrum sensing can be classified into Narrowband and Wideband (Abdelmohsen Ali, & Walaa Hamouda, 2017). Narrowband spectrum sensing algorithms focuses on narrow frequency range i.e. the channel bandwidth taken for spectrum sensing is lesser than the coherence bandwidth (Bountouris, 2013). Due to rapid fluctuating nature of wireless environment, the spectral opportunities provided by narrowband sensing techniques that enable continuous spectrum access to CR users undergo difficulty to meet out the demand of CR users. Hence, there arises a need for advanced spectrum sensing techniques. Wideband spectrum sensing techniques focuses on wide frequency range i.e. the channel bandwidth sensed is greater than the coherence bandwidth (Sun, Nallanathan, Wang, & Chen, 2013).

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LIMITATIONS IN NARROW BAND SENSING

Time consumption involved in sensing is considered as one of the major limitation of Narrowband sensing. It limits the local observations which lead to incomplete sensing information. The traditional narrowband spectrum sensing techniques are Matched filtering, energy detection, Cyclostationary detector and covariance based detector (Sun, Nallanathan, Wang, & Chen, 2013). Matched filtering technique (Jaiswal, Kumar Sharma & Singh, 2013) correlates the known reference signal with the received signal to detect the presence of Primary User (PU). However, it requires prior knowledge of PU signal and need to maintain synchronisation. In energy detection technique (Digham, Alouini, & Simon, 2007), the received signal energy is compared with a threshold to detect the presence of PU. When compared to the previous technique it does not require any prior information about PU. However due to the stochastic nature of wireless channel, it is cumbersome to differentiate PU from CR user. Cyclostationary detector (Sutton, Lotze, Nolan, & Doyle, 2007) utilizes the cyclic correlation property of modulated signals. It performs well in low SNR regions. It consumes more time for spectrum sensing and it is computationally complex. In covariance based detector (Zeng & Liang, 2009), covariance matrix of the received signal is used to detect the signals. It utilizes the dispersive nature of channels. It is also affected by noise uncertainty.

Significance of Wideband Sensing

Wideband spectrum sensing techniques aim to sense a channel bandwidth that exceeds the coherence bandwidth of the channel. The excessive bandwidth increases the hardware complexity. Wideband sensing can detect more amount of unused spectrum of PU and provides more spectral opportunities to CR users. This not only increases the throughput of CR user but also allows them to switch between various spectrum holes. This provides seamless communication and thereby enhances the QoS of CR users.

Challenges and Requirements of Wideband Sensing

In additional to the challenges faced by traditional sensing techniques such as hardware requirements, hidden PU problem, sensing periodicity and noise uncertainty (discussed in Chapter 3) wideband spectrum sensing also has the following challenges:

1. **Wideband Signal Acquisition:** The fundamental challenge of wideband sensing is to devise mechanism to capture the entire wideband signal. Advanced reception techniques such as MIMO can be used to receive signals which make the RF front end hardware more complex (Tian, Leus, & Lottici, 2010). Depending on the hardware the RF circuitry processes the acquired signals as multiple RF chains or single RF chain.
2. **User Hierarchy:** When applying cognitive concept to heterogeneous network, the PUs distribution can be of different hierarchy. This kind of modulation schemes followed may be varied based on the spectrum used. Hence to protect the PU performance, it is essential that the CR user need to sense the PU with very low SNR.
3. **Wireless Fading:** The detection performance is limited by the received signal strength. The PU signal may be affected by deep fading, shadowing and local interference. This decreases the sensing accuracy and increases the possibility of missed detection. Cooperative spectrum sensing can be