Chapter 16
Boosting Secondary-User Performance: Challenges, Potential Solutions, and Expectations

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ABSTRACT

This chapter addresses a few challenges and issues in developing Cognitive Radio Networks (CRNs), and provides unique solutions to enhance security at physical layer and to boost CRN computing power in a distributed manner. In this age of vast connectivity, network security becomes more and more prominent. In addition to the security means added at the upper layers, security can be further enhanced at physical layer. In particular, location based wideband channel characteristic as a unique signature can be utilized for security enhancement. Such a scheme is proposed and examined in different configurations. Lack of computing power is another critical issue, as CRN is expected to have more and more features. Instead of increasing onboard computing power, off-board computing resources can be connected to boost overall computing power. With increased computing power, the CRNs would be able to undertake computationally heavy tasks such as executing machine-learning algorithms and performing radio intrusion detection.

16.1 INTRODUCTION

Cognitive Radio Networks (CRNs) have been a hot topic for more than a decade since Joseph Mitola III described the concept in 1998 (Mitola III & Maguire Jr, 1999), and it has been catalyzed after enriching the concept by researchers (Mitola III & Maguire Jr, 1999; Haykin, 2005; Akyildiz, Lee, Vuran, & Mohanty, 2006; Ghasemi & Sousa, 2008; Steenkiste, Sicker, Minden, & Raychaudhuri, March 2009). The term CRN or simply CR is not just a concept any more. Experiments and

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development work have been seen in the second half of the last decade (Pawelczak et al., 2011). In particular, the Federal Communications Commission (FCC) has adopted rules to allow unlicensed radio transmitters to operate in the broadcast television spectrum (TV white space) when that spectrum is not used by a licensed service, which sparks tremendous efforts in development of CRs in the TV white space (Nekovee, 2010). Despite explosive research and development as well as regulatory work throughout the world, commercial CR products have not appeared yet. Indeed, there is a long way to go before truly-cognitive radios are in front of average people. Advance in terms of performance, architecture and commercial development will continue. Seeing ten years of achievements, you may want to know what CR features people wish to see in the near future and what challenges are faced now by the researchers and developers.

This chapter focuses on just a few of many issues and concerns faced by the author in CRN related research and development. In next section some challenges and physical limitations are addressed, with emphasis on implementation aspect. Security concern and lack of computing power are among a list of critical issues. Following the next section, these two issues are addressed by proposing some approaches and showing evaluation results. Finally, the last section presents some expectations for certain features on future CRNs with enhanced computing power.

16.2 CHALLENGES AND PHYSICAL LIMITATIONS

Cognitive radios utilize and handle the spectrum in ways different from traditional radios do. Four basic functions, spectrum sensing, spectrum management, spectrum mobility and spectrum sharing, are required, which leads to many challenges in CRN research and development. In general, most of the challenges are related to frequency agility and computational power, and these two abilities are physically constrained.

Due to the nature of optimistic spectrum access, it is straightforward to consider multichannel option for the secondary users to maintain reliable connections. We have seen tremendous research effort regarding multichannel or multiband spectrum sensing and Media Access Control (MAC) protocols (Ganesan & Li, 2005; Zhang, Soong, & Xiao, 2007; Chong, Sung, & Sung, 2009). A frequency-agile physical layer is an essence to implement a multichannel version of dynamic spectrum access. It has to be pointed out that conventional transceiver design philosophy is no longer adequate in designing cognitive radio transceivers. Conventional radios are designed for fixed frequency band and known interferences, and typically preselect filters are used at the receiver input to notch unwanted frequency components. In contrast, without exactly knowing the signal frequency range, a cognitive radio receiver's Radio Frequency (RF) frontend has to have relatively wide bandwidth and be able to switch between frequency bands. The increased frequency bandwidth has to be coupled with increased linearity range in order to prevent the desired signal from being distorted. Programmable suppression of out-of-band interferences can be achieved at digital domain at the cost of additional resources for signal processing. At present processing bandwidth of 500 MHz to 1 GHz is very feasible, and the receiver can utilize large processing bandwidth in exchange for less frequency switching in analog circuits.

We are in the age of vast connectivity, and people especially enjoy freedom and mobility of wireless networks nowadays. Network security has become a prominent challenge. Compared to network security of wired networks, achieving wireless security is more difficult. This is because in radio communications signals are emitted in electromagnetic format, which is in favor of broadcasting fashion but harmful for security and privacy. In general confining a radio signal in a