Chapter L
Emerging Telecommunications Technologies:
Cognitive Radio

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ABSTRACT

The goal of this chapter is to introduce the novel concept of cognitive radio (CR) for wireless telecommunications. Cognitive radios are a new type of radio devices that include cognition and reconfigurability features. The raising number of studies in different areas of research shows their potential and the expectation created among the telecommunications community. In this chapter, the authors first introduce the reader to the new paradigm that cognitive radio networks have created; more specifically, they explain in detail the new next generation networks. Given that our intention is to introduce cognitive radio, the authors focus on the challenges in PHY layer and MAC sublayer and the most relevant studies in these fields. Finally, the integration of game theory and cognitive radio creates a new paradigm where the advantages of both technologies merge to solve complex problems.

INTRODUCTION

Wireless telecommunications are evolving towards very complex environments due to two main factors: the coexistence of different types of networks, such as WiFi and WiMAX, and the requirements of mobility and multimedia contents demanded by the users. Hence, a major concern is to be aware of and react to the variations in the wireless channel. Until now, the adaptation of wireless devices to the environment has been done through some type of adaptive transmission, but more intelligent functionalities than adaptive modulation are needed. Cognitive radio can deal efficiently with the aforementioned complex problem, endowing radios with the capability of thinking and, in the second stage, acting consequently.

The concept of cognitive radio is relatively new. Cognitive radio is a radio system capable to gather the features of the environment and to adapt their transmissions accordingly. To this end, it is essential to endow a cognitive radio with two primary functions: the capability of capturing information from the environment and reconfigurability.

This chapter is organized as follows: first, a descriptive overview of cognitive radio and some related concepts is presented to the reader. This overview presents relevant and recent works done for PHY and MAC layers for cognitive radio. We conclude this chapter with a discussion on the possible connection between cognitive radio and game theory.

COGNITIVE RADIO

As mentioned in the introduction, the term cognitive radio is credited to Mitola III and Maguire (1999). They introduced cognitive radio as a radio device with cognition functions. Before explaining in detail the concept of cognitive radio, it is useful to introduce the precedent technology, Software Defined Radio (SDR). SDR is defined as (FCC, 2005) "any radio that includes a transmitter in which the operating parameters of frequency range, modulation type or maximum output power can be altered by making a change in software without making any changes to hardware components that affect the radio frequency emissions". In other words, by using software the transmit power, adaptive modulation and transmission frequency, among other transmission parameters and features, may be changed.

Nevertheless, cognitive radio goes a step further than SDR, empowering the radio to change the transmission parameters based on interaction with the environment of operation. Among the wireless scientific community a widely accepted definition of cognitive radio is provided by Haykin (2005); he considers a cognitive radio as "an intelligent wireless communication system that is aware of its surrounding environment", with the ability of adapting its states to environmental changes. In other works, a cognitive radio can be described as a SDR endowed with a "brain" which not simply reacts to external changes but also "thinks" about the actions to take. Two key characteristics must then be associated to any cognitive radio: cognitive capability and reconfigurability.

However, what is exactly contained in the cognition part of these radios? Citing again (Haykin, 2005), three major tasks make up the cognitive capability:

1. Radio-scene analysis, in charge of the detection of spectrum holes and the estimation of interference.
2. Channel identification, which carries out the estimation of both channel state information (CSI) and channel capacity.
3. Power and spectrum management.

Figure 1 provides how these three tasks are connected. In practice, cognitive capability may reduce to signal processing or machine learning algorithms for implementation purposes.

Reconfigurability seems to be easier to characterize than cognition capability. This functionality is provided by a SDR platform, which carries out the suitable actions to change the radio parameters

Figure 1. Cognition tasks
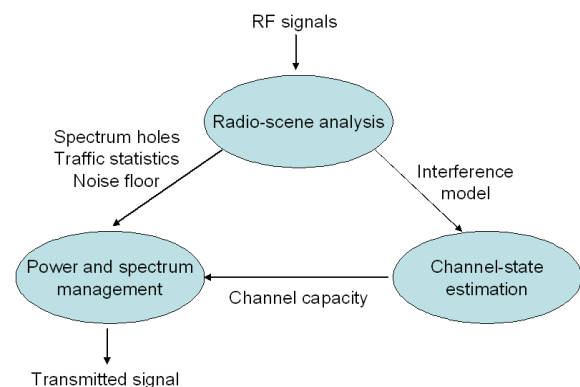
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