

# Chapter 8

## Dynamic Spectrum Access Techniques

### State of the Art

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#### ABSTRACT

*It is now widely recognized that wireless communications systems don't exploit the whole available frequency band. The idea has naturally emerged to develop tools to better use the spectrum. Cognitive Radio (CR) is the concept that meets this challenge. The CR is a form of wireless communication in which a transmitter/receiver can detect intelligently communication channels that are in use and those that are not, and can move to unused channels. This optimizes the use of available radio frequency spectrum while minimizing interference with other users. CRs must have the ability to learn and adapt their wireless transmission according to the ambient radio environment. The application of Artificial Intelligence (AI) approaches in the CR is very promising because they are essential for the implementation of CR networks architecture. They must be able to coexist to make CR systems practical, which may cause interference to other users. To solve the problem of congestion, CR networks use Dynamic Spectrum Access (DSA). In order to deal with this problem, the idea of cooperation between users to detect and share spectrum without causing interferences is introduced. The authors found a large number of suggested works relating to spectrum access, those using Auctions, a large number of approaches use the Game theory, but those using Markov chains are fewer. However, some research has been done in this area using Multi Agent Systems (MAS).*

#### INTRODUCTION

We currently attend the multiplication of telecommunication standards considering recent progress in this area. The increasing number of standards broadens the range of offers and available services

for each user; however, most available radio frequencies have already been allocated.

A study carried out by the Federal Communications Commission (FCC) has shown that some frequency bands are overloaded at the rush hours. However, the use of the frequency spectrum is not

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uniform: according to the hours of day and to the geographical position; a frequency band can be overloaded while another remains unused. The idea to develop tools to better use the spectrum has naturally emerged.

Cognitive Radio is the concept that meets this challenge; better use the spectrum.

The context of our work is an alliance between wireless networks and intelligent methods. The application of AI approaches in the CR is very promising; indeed it is used in the implementation of CR networks architecture. Users must be able to coexist to make CR systems practical, which may cause interferences to other users. In order to deal with this problem, the idea of cooperation between the users to detect and share spectrum without causing interference is introduced. However, since users generally have a limited knowledge about their environment, we claim that cooperative behavior can provide them with the necessary information to solve the global issues.

The main objective of our research is to intelligently manage radio resources in the context of a CR network. We think that the association of DSA techniques and the CR can provide a great future for the optimal management of frequencies. Thus, different machine learning techniques are considered, and negotiation and cooperation algorithms are also needed to ensure a better and efficient spectrum allocation.

In this chapter, we explain the different existing approaches for dynamic spectrum allocation. For simplicity, we give a short definition about CR and its functions; we speak about the use of AI techniques in the CR and finally, we speak about DSA and the different methods used for it such as Auction theory, Game theory, Markov models or Multi Agent Systems.

## COGNITIVE RADIO

The idea of CR was officially presented by Joseph Mitola in a seminar at KTH, the Royal Institute of

Technology in 1998, later published in an article by Mitola and Gerald Q. Maguire, Jr. in 1999 (Mitola J, 1999).

The term Cognitive Radio is used to describe a system with the ability to sense and recognize its context of use, in order to enable it to adjust its radio operating parameters dynamically and autonomously and learn the results of its actions and its environmental setting operation.

CR is a form of wireless communication in which a transmitter/receiver (transceiver) can detect intelligently communication channels which are in use and those that are not, and can move to unused channels. This optimizes the use of available spectrum radio frequency while minimizing interference with other users.

The principle of CR, included in the IEEE 802.22 and IEEE 802.16h (Grandblaise, 2006), requires an alternative spectrum management (i.e., a mobile called secondary may at any time access to frequency bands that are free, that is, not occupied by primary user (PU) of the licensed band). The secondary user (SU) will assign the service once completed, or once a PU has shown an inclination connection.

## Functions of Cognitive Radio

The main functions of CR are (Hossain, 2009):

1. **Spectrum Sensing:** This is the basic functionality; it consists on sensing unused spectrum and sharing it without interference with the other users. One of the goals of the spectrum sensing, especially for the interference sensing, is to obtain the spectrum status (free/busy), so that the spectrum can be accessed by a SU under stress of interference. The challenge is that of measuring the interference at the receiver caused by the primary transmissions of SUs.
2. **Spectrum Management:** Pick the best available frequencies to respond to the communication needs of users. CRs should

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