Chapter 6
Sensing Techniques for Next Generation Cognitive Radio Networks:
Spectrum Sensing in Cognitive Radio Networks

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ABSTRACT

Cognitive radio is the technology used to solve the problem of spectrum underutilization by performing spectrum sensing, spectrum management, spectrum sharing, and spectrum mobility. The primary goal of cognitive radio is open spectrum sharing. Spectrum is a scarce and valuable natural resource that has to be used very effectively. The static allocation of spectrum to the licensed users will lead to wastage of resources when the spectrum is unused by the licensed user. Spectrum sensing methodology helps in detecting the spectrum holes and enables the unlicensed users to access the unused bands in the licensed spectrum effectively without interfering the licensed users. Cognitive thinking takes wireless communication to the next level by sensing the electromagnetic environment and dynamically adjusts its operating parameters in order to achieve maximum throughput, mitigate interference, facilitate interoperability, etc. The chapter presents the basics of cognitive radio networks, its architecture, its application, and advantages of cognitive radio networks.

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INTRODUCTION

Cognitive Radio is:

an intelligent wireless communication system that is aware of its environment and makes use of the method of understanding just by building to learn from the environment and adapt to statistical variations in the input given.

The Cognitive environment is designed to meet –highly reliable communication whenever and wherever needed and efficient utilization of the radio spectrum. Dynamic Spectrum Management is the order of the day whereas Static Spectrum Management was followed since 1900s. Initially, cognitive radio concept was first proposed by *Joseph Mitola III* in the year 1998 and later was published in an article by Mitola and Gerald Q.Maguire in the year 1999. The first cognitive radio wireless regional area network standard was developed by IEEE 802 LAN/MAN standard committee in the year 2011.

Conventional radio assumes that it operates in an interference free spectrum band. So, there is no necessity to dynamically change the parameters. The view of unlicensed spectrum in the conventional radio band is as the "Wall of Interference" whereas the view of unlicensed spectrum in the cognitive radio band is as the "Windows of Opportunity". The "Opportunistic Use" of shared frequency as like unlicensed spectrum requires continuous sensing of the environment. The users who have been given legal rights to access the portion of the spectrum is called primary user. They have highest priority in accessing the spectrum. The users who can don't have legal rights but can access the portion of the spectrum allotted to the primary user without causing interference to the primary user is called as secondary user. The unused frequency bands in the spectrum are termed as "whitespaces" or "spectrum holes". The secondary user can access the licensed spectrum when the primary user is not using the band and when it senses the arrival of the primary user it either shifts to the next available spectrum hole or the secondary user reduces the percentage of the spectrum usage and avails it to the primary user giving them the first priority. The detection and usage of the spectrum hole by the cognitive user in shown in the Figure 1.

The cognitive radio not only makes use of the spectrum hole in the licensed spectrum but also the unlicensed spectrum when it gets an opportunity. This is shown in Figure 2. The abilities of a cognitive user are:

- **Spectrum Sensing:** Senses and detects for the unused spaces by the primary users in the spectrum band.
- **Spectrum Sharing:** Makes use of the unused white spaces of the primary users shares the spectrum hole information with the cognitive users.
- **Prediction:** Predicts the arrival of the primary user into the spectrum.
- **Fairness:** There may be more than one cognitive user on the spectrum. So, there should be fairness in the distribution of spectrum utilization opportunity among the cognitive users.
- **Routing:** The packets are transmitted to the destination effectively considering the parameters such as network life span, load on the network, shortest path, delay etc.
- **Reconfiguration Capability:** Make adjustments or reconfigure based on the environmental outcomes.
- **Environment Sensing:** Sense the environment for adaptable changes.
- **Trust and Security:** Build a trustworthy environment and a secure network.