Chapter 13
A Survey of Radio Resource Management in Cognitive Radio Networks

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ABSTRACT

The framework of "green communications" has been proposed as a promising approach to address the issue of improving resource-efficiency and the energy-efficiency during the utilization of the radio spectrum. Cognitive Radio (CR), which performs radio resource sensing and adaptation, is an emerging technology that is up to the requests of green communications. However, CR networks impose serious challenges due to the fluctuating nature of the available radio resources corresponding to the diverse quality-of-service requirements of various applications. This chapter provides an overview of radio resource management in CR networks from several aspects, namely dynamic spectrum access, adaptive power control, time slot, and code scheduling. More specifically, the discussion focuses on the deployment of CR networks that do not require modification to existing networks. A brief overview of the radio resources in CR networks is provided. Then, three challenges to radio resource management are discussed.

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INTRODUCTION

Some related researches, termed "multi-dimension resource allocation," are focused on the joint allocation of radio resources in CR networks. Whereas we will classify the resources and discuss the techniques used for each single resource in this chapter to exhibit the technical details. This can be termed "one-dimension resource allocation."

Diverse methods are generally adopted during resource management/allocation in CR networks to use these radio resources efficiently. These methods have been extensively studied in specified scenarios to achieve efficient and fair solutions for different network architectures (centralized/distributed) or user behaviors (cooperative/non-cooperative). This chapter presents an overview on the methods of dynamic resource management in CR networks. The three main resources are presented in this chapter: Dynamic Spectrum Access (DSA), Adaptive Power Control (APC), Time Slot and Code Scheduling (TSS).

BACKGROUND

The data rates in wired and wireless networks are driven by Moore's Law and are thus rising approximately tenfold, every five years (Zhang, 2011). Conversely, the requirements for multimedia high rate transmissions in Information and Communications Technology (ICT) drive the greatly increasing power consumption. According to a recent Ericsson research report (Ericsson Press Release, 2008), energy costs account for as much as half of a mobile operators operating expenses. The price paid for the enormous energy growth is a doubling of the power consumption in cellular networks infrastructure (base stations and core network) every 4–5 years. This was is about 60 TWh (billion kWh) in 2007. The radio access network accounts for 80% of this energy consumption (GreenComm, 2009). Most importantly, currently 3% of energy world-wide is consumed by ICT infrastructure. This causes about 2% of CO2 emissions world-wide, comparable to CO2 emissions by airplanes or one quarter of the world-wide CO2 emissions by cars (W-GREEN, 2008).

The steadily rising energy cost and the need to reduce global CO2 emission to protect our environment are economic and ecological drivers for the consideration of energy consumption in all fields of our manufacturing and daily lives. Therefore, radio networking solutions that improve energy efficiency, as well as resource efficiency (green communications), are of benefit to the global environment. It also makes commercial sense for telecommunication operators supporting sustainable and profitable businesses. Within the framework of "green communications," a number of paradigm-shifting technical approaches can be expected. These include, but are not limited to, energy-efficient network architecture and protocols, energy-efficient wireless transmission techniques (e.g., reduced transmission power and reduced radiation), cross-layer optimization methods, and opportunistic spectrum sharing without causing harmful interference pollution (i.e., green spectrum) (Zhang, 2011).

Cognitive radio (Mitola, 1999; Haykin, 2005) is one of the best candidates to achieve the targets of green communications. CR is a promising radio access method to increase resource utilization by exploiting unused or low utilization spectrum which has been already authorized to primary systems. Traditional wireless technologies allocate the wireless resources statically, whilst CR technology works in a sensing, learning, reasoning and acting manner, and hence allocates the resource dynamically. CR system is expected to dynamically allocate the power to the users who can use it most efficiently in dynamically changing environments. CR users adapt to the dynamic radio environments, then make decisions on their operational parameters, such as working spectrum, transmission power, time slot and even modulation and coding type. In CR frameworks, future wireless devices will not operate on stati-

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