Chapter 12
Spectrum Access and Sharing for Cognitive Radio

Raza Umar[1]
King Fahd University of Petroleum and Minerals, Saudi Arabia

Asrar U. H. Sheikh
King Fahd University of Petroleum and Minerals, Saudi Arabia

ABSTRACT

Cognitive radio (CR) has emerged as a smart solution to spectrum bottleneck faced by current wireless services, under which licensed spectrum is made available to intelligent and reconfigurable secondary users. CR technology enables these unlicensed secondary users to exploit any spectrum usage opportunity by adapting their transmission parameters on the run. In this chapter, the authors discuss the characteristic features and main functionality of CR oriented technology. Central to this chapter is Spectrum sensing (SS), which has been identified as a fundamental enabling technology for next generation wireless networks based on CR. The authors compare different SS techniques in terms of their sensing accuracy and implementation and computational complexities along with merits and demerits of these approaches. Various challenges facing SS have been investigated, and possible solutions are proposed.

INTRODUCTION

New wireless services and applications are being introduced day by day, resulting in insatiable demand for radio spectrum. Currently, the wireless networks are being regulated by government agencies that sell exclusive rights of radio frequencies over large geographical region to wireless system operators. This policy worked well in past as it provided an optimal solution that avoided interference between active wireless users. However, with steadily growing number of wireless subscribers and operators, fixed assignment of radio spectrum is proving to be a hurdle in the deployment of new wireless services or even enhancing existing services and applications to meet the requirements of wireless market. As a result Federal

DOI: 10.4018/978-1-4666-1797-1.ch012

Communications Commission (FCC) carried out a number of studies that investigated current spectrum scarcity with goal to optimally manage available radio resources. Recent measurements have revealed that a large portion of assigned spectrum is sporadically utilized. According to FCC (2003a) notice of proposed rulemaking and order, spectrum utilization varies from 15% to 85% with wide variance in time and space. This suggests that the root cause of current spectrum scarcity is not the physical shortage of spectrum rather it is inefficient fixed spectrum allocation. This fact questioned the effectiveness of traditional spectrum policies and opened doors to a new communication paradigm to exploit radio resources dynamically and opportunistically.

Dynamic and Opportunistic Spectrum Access (DOSA) is proposed to be the solution for inefficient spectrum utilization wherein unlicensed users are allowed to opportunistically access the un-used licensed spectrum without interfering with the existing users with legacy rights to that spectrum. In essence, these NeXt Generation (xG) wireless networks based on DOSA techniques will meet the requirements of wireless users over heterogeneous wireless architectures by making them intelligently interact with their radio environment. The key technology that enables xG network to use the spectrum dynamically and opportunistically is the *Cognitive radio* (CR) technology.

The key component of CR technology is the ability to measure, sense and ultimately adapt to the radio's operating environment. In CR terminology, the users with legacy rights on the usage of specific part of the spectrum are called *primary users* (PU) while the term *secondary users* (SU) is reserved for low-priority un-licensed users which are equipped with a cognitive capability to exploit this spectrum without being noticed by PU. Therefore, the fundamental task of SU (also termed as simply CR in literature) is to reliably sense the spectrum with an objective to identify a vacant band and to update its transmission parameters to exploit the unused part of the spectrum in such a way that it does not interfere with PU.

This chapter presents an introductory tutorial on Cognitive radio. It defines cognitive functionality, identifies its objectives and highlights characteristic features of CR to meet cognition requirements. Being the focus of this chapter, we identify *Spectrum sensing* (SS) as the key cognitive functionality. Spectrum sensing in essence is the task of obtaining awareness about the spectrum usage at a specific time in a given geographical region. Intuitively this awareness can be obtained by using beacons or geolocation and database. These approaches though appear simple but are practically infeasible because of prohibitively large infrastructure requirements and implementation complexity. Here, we focus on local spectrum sensing at CR based on primary transmitter detection. Various challenges associated with local spectrum sensing are discussed and sensing methodologies to meet these challenges are proposed. An in-depth performance comparison of these sensing methods is presented. The concept of local sensing is then extended to cooperative sensing and we highlight advantages, disadvantages and challenges faced in cooperative detection. This is followed by an Interference based detection approach which allows CR to use a frequency band as long as its transmissions keep the interference at primary receivers within a tolerance limit. Finally, we conclude the chapter with conclusions.

BACKGROUND

Cognitive radio is essentially an evolution of Software Defined Radio (SDR) whose communication functions are implemented in software so that when it interacts with its environment, it reacts upon its findings in order to dynamically exploit any available spectrum usage opportunities. The term CR has been coined by Mitola (2000) where the main focus was on how the