Chapter 23
Cognitive MIMO Radio:
Performance Analysis and Precoding Strategy

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ABSTRACT

The authors consider a cognitive radio network in which a set of cognitive users make opportunistic spectrum access to one primary channel by time-division multiplexing technologies. Multiple Input Multiple Output techniques (MIMO) are similarly considered to enhance the stable throughput for cognitive links while they should guarantee co-channel interference constraints to the primary link. Here, two different cases are considered: one is that cognitive radio network is distributed; the other is centrally-controlled that cognitive radio network has a cognitive base station. In the first case, how to choose one fixed cognitive user and power control for each transmission antenna at the cognitive base station are considered to maximize the cognitive link's stable throughput. In the second case, a scheme to choose a group of cognitive users and a Zero-Forcing method to pre-white co-channel interference to the primary user, are also proposed in order to maximize cognitive base station's sum-rate. The algorithm can be employed to realize opportunistic spectrum transmission over the wireless fading channels.

INTRODUCTION

Cognitive informatics (CI) has been developed fast recently, Wang (2003) describes it as a transdisciplinary expansion of information science that studies computing and information processing problems by using cognitive science and neuropsychology theories, and studies the cognitive information processing mechanisms of the brain by using computing and informatics theories. In his following studies, he not only does many contributions on cognition, cognitive computing, and artificial intelligence, but also depicts the perspectives on cognitive informatics and cognitive computing. The authors of this paper are inspired by his famous architecture of contemporary cybernetics and cognitive informatics (Wang, 2009) and try to do some researches on cognition and automation for transmitting antennas in the wireless communication network.

Federal Communications Commission (FCC) had reported that the ever fixed spectrum allocation leads to vast spatial variations in the usage of allocated spectrum. This motivates the concepts of opportunistic spectrum access which guarantees the coexistence of primary licensed users and cognitive non-legitimate users in the same spectral resource opportunistically. Cognitive radio technology (CR) based on software radio concept has been recently proposed as such a smart and agile technology (Mitola, 1999; Haykin, 2005). It is proposed for wireless transmission in which either a base station or a cognitive node changes its transmission or reception parameters to communicate efficiently avoiding interference with licensed users. This alteration of parameters is obtained by radio frequency spectrum, user behaviors and network state. Research fields about CR technology include spectrum sensing, spectrum management, spectrum mobility and spectrum sharing. With the conception of CI, it is a paradigm of cognitive informatics and computational intelligence. In a cognitive radio network, cognitive users (CU) are the second users who must detect the licensed frequency band to find free time slots for transmitting without too much interference to the primary users. The authors in this paper focus on how to two different cases about CR network with intelligent antennas: one is that cognitive radio network is distributed structure; the other is centrally-controlled that cognitive radio network has a cognitive base station. Analysis about the first case is based on priority queuing framework model, which is characterized by the facts that primary link is oblivious to the cognitive activity and that the cognitive link required not to interference the primary link too much. The model was studied by Tsybakov and Mikhailov (1979), and Szpankowski et al. (1988) several decades ago. Recently, Sadek, Liu, and Ephremides (2007) and Simeone, Gambini, Bar-Ness, and Spagnolini (2007) had made attempts at analyzing cognitive multiple access protocols with cooperation, but Sadek et al. and Devroye (2006) also expounded the stability and performance in implementing the proposed multiple-access strategy. Simeone, Bar-Ness, and Spagnolini (2007) and their upper contributions mainly illustrated detection error occurring when primary link using one antenna simply. However, these prior works lacked some easy solution to the problem that both the primary and cognitive links communicate using multiple transmission antennas.

Multiple Input Multiple Output techniques (MIMO) is one of several forms of smart antenna technology which uses multiple antennas at both the transmitter and receiver to offer significant increases in data throughput and link range without additional bandwidth or transmit power (Gesbert, Shafi, Shiu, Smith, & Naguib, 2003). Nowadays, MIMO technology has attracted much attention in wireless communications and is one important part of modern wireless communication standards such as IEEE 802.11n. With the aims at extending the coverage, increasing connectivity and capacity, we try to study MIMO technology in cognitive radio network. Such motivation is attractive for three reasons:

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