Chapter 10
On Fuzzy Logic-Based Channel Selection in Cognitive Radio Networks

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ABSTRACT
Cognitive radio networks are a new technology based on which unlicensed users are allowed access to licensed spectrum under the condition that the interference perceived by licensed users is minimal. That means unlicensed users need to learn from environmental changes and to make appropriate decisions regarding the access to the radio channel. This is a process that can be done by unlicensed users in a cooperative or non-cooperative way. Whereas the non-cooperative algorithms are risky with regard to performance, the cooperative algorithms have the capability to provide better performance. This chapter shows a new fuzzy logic-based decision-making algorithm for channel selection. The underlying decision criterion considers statistics of licensed user channel occupancy as well as information about the competition level of unlicensed users. The theoretical studies indicate that the unlicensed users can obtain an efficient sharing of the available channels. Simulation results are reported to demonstrate the performance and effectiveness of the suggested algorithm.

INTRODUCTION
Today, one of the most active areas of research in Cognitive Radio (CR) is on Dynamic Spectrum Access (DSA), which refers to the method used to detect, to select and to access spectrum holes. Related to this, an important challenge for the research and industrial communities is to bridge the gap between the existent research results and the large-scale deployment of Cognitive Radio Networks (CRNs) (Akyildiz, DOI: 10.4018/978-1-4666-6571-2.ch010
Lee, Vuran, & Mohanty, 2006). Sustained research efforts are needed to provide technological solutions able to take advantage of the great potential and commercial promises of CRNs. In a longer perspective, it is expected that DSA will go beyond the opportunistic spectrum access model and new technologies and policies will be developed for CRNs, to allow the access to a portfolio of different spectrum types like, e.g., licensed spectrum, unlicensed spectrum and leased spectrum. The radio devices are expected to be able to dynamically change the operating spectrum within the particular spectrum portfolio, and to do this on a “just-in-time” basis. Furthermore, the resources of the spectrum pool can be characterized in terms of context, location and technology. Parameters like price, QoS/QoE, energy saving and competition may be used in selecting the particular spectrum.

The focus of the paper is on the channel selection and access in CRNs for unlicensed users (also known as secondary users or SUs). We first provide an overview of the spectrum decision problem in CRNs. We also provide definition and description of the competition problem for SUs in CRNs. A new solution is advanced for channel access for SUs, which is based on their competition for the resources not used by licensed users (also known as primary users or PUs) as well as on the statistics of PUs behaviour. Simulation results are provided to demonstrate the performance and effectiveness of the suggested solution.

The rest of the paper is organized as follows. In Sections 2 and 3, we present the background, motivation and the adopted solution. In section 4, we describe the system model. Section 5 discusses the learning of idle time statistics. Section 6 describes the competition problem and the suggested method for alleviating the competition. Section 7 is about the hybrid decision making algorithm. The performance evaluation is presented in Section 8. Finally, we conclude the paper in Section 9.

BACKGROUND AND MOTIVATION

In CR networks, the licensed channels are either exclusively reserved for PUs or temporarily used by SUs. Extensive research has been done to develop the concept of CR, based on which the SUs are allowed to access the available channels (also known as spectrum holes) not being occupied by PUs. Moreover, when the PU occupies a channel, the SU in the same channel must leave. Otherwise, the PU transmission would be impaired.

Since PUs do not need to notify SUs of their activities, a time-slotted transmission scheme is suggested for SUs to communicate in CR networks. In this scheme, the SU’s transmission is divided into identical slots over time (Zhao, Tong, Swami, & Chen, 2007). During each slot, the SU first performs spectrum sensing to detect channel availability. The SU may then transmit data via an available channel (if it exists) within the remaining slot duration. Further, to alleviate the interruption from PUs, SUs need to learn from the statistical information about PUs’ activity and, based on that, to select the most available channels to use. An existing solution along with this line is given by using the idle-time-based statistics. For a single channel, being idle indicates the PU absence and the idle time indicates how long this absence is. Yang et al. (2007) consider in their work that the longer an available channel remains idle in the near future, the higher the channel availability becomes. Further, by predicting the idle time, the most available channel is attributed to the characteristic of having the longest remaining idle time.

The problem however is regarding the limitation of the reported results, which is basically due to limited theoretical models considered. Most of these models do not consider the problem of competition existing among SUs in accessing available channels. This problem is addressed by the fact that the idle
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