Chapter 13

A Complete Spectrum Sensing and Sharing Model for Cognitive Radio Ad Hoc Wireless Networks Using Markov Chain State Machine

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ABSTRACT

This paper presents the Cognitive Radio framework for wireless Ad Hoc networks. The proposed Cognitive Radio framework is a complete model for Cognitive Radio that describes the sensing and sharing procedures in wireless networks by introducing Queued Markov Chain method in spectrum sensing and Competitive Indexing Algorithm in spectrum sharing part. Queued Markov Chain method is capable of considering waiting time and is well generalized for an unlimited number of secondary users. It includes the sharing aspect of Cognitive Radio. Power-law distribution of node degree in scale-free networks is important for considering the traffic distribution and resource management thus we consider the effect of the topology on sensing and sharing performances. The authors demonstrate that CIF outperforms Uniform Indexing (UI) algorithm in Scale-Free networks while in Random networks UI performs as well as CIF.

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1. INTRODUCTION

In current communication networks, the average spectrum utilization is between 15% and 85%. Cognitive Radio (CR) is a solution to increase the spectrum utilization and ultimately the network capacity leading to generating new revenue streams with higher quality of service. With increasing demand for higher capacity in wireless networks due to the rapid growth of new applications such as multimedia, the network resources such as spectrum should be used more efficiently to fulfill the need for both quantity and quality of service. This implies an optimum resource management (Si, Sun, Yang, & Zhang, 2010; Toroujeni, Sadough, & Ghorashi, 2010). Spectrum is one of the most challenging network resources which need to be carefully consumed. Cognitive Radio Networks (CRN) are supposed to efficiently use idle portions of the spectrum (resource grid). There are many techniques to sense the idle spectrum channels and manage them to increase the networks efficiency. We introduce a spectrum sensing model based on air signal energy detection and study different probabilities for fault and correct detection in Section 3. The information obtained from sensing part will be used to optimally share the idle resources and fulfill the purpose of Cognitive Radio considering different aspects of primary and secondary users and of course network topology in Section 4.

The works done in spectrum sharing has faced some challenges and can be categorized as centralized spectrum sharing vs. distributed spectrum sharing, and cooperative spectrum sharing vs. non-cooperative spectrum sharing. Spectrum sharing can also be considered from inter or intra network perspective as either one or two operators share the resources. On the other hand, the network topology and the user distribution are determining factors that directly affect the network state of being either overloaded or underloaded. CRs can be employed in many applications. CR using dynamic spectrum access can alleviate the spectrum congestion through efficient allocation of bandwidth and flexible spectrum access. It provides additional bandwidth and versatility for rapidly growing data applications. Moreover, a CR network can also be implemented to enhance public safety and homeland security. A natural disaster or terrorist attack can destroy existing communication infrastructure, so an emergency network becomes indispensable to aid the search and rescue. CR can also improve the quality of service when frequency changes are needed due to conflict or interference, the CR frequency management software will change the operating frequency automatically even without human intervention. Additionally, the radio software can change the service bandwidth remotely to accommodate new applications. As communication networks tend to become more social-like networks, Ad hoc networks and in particular power-law distributed networks i.e., scale-free networks are proposed in this paper to be considered for developing spectrum sharing technique then a new method for sharing the spectrum is proposed and proved to have the optimum performance in increasing the network capacity. At the end the results are presented and compared.

2. NETWORK TOPOLOGY

The network topology is one of the main factors in considering the traffic flow and resource management in telecommunication networks. There are different ad hoc topologies like random and scale-free discussed in network theories each presenting certain characteristics.

A. Random Topology

There are classes of networks where the nodes are attached to the network in a random way meaning that the number of connections of nodes has a
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