Chapter 14

Application of Game Models for Cognitive Radio Networks

Yenumula B Reddy
Grambling State University, USA

ABSTRACT

Cognitive radio technology addresses the intelligent and adaptive models in wireless devices to obtain the unused spectrum (spectrum holes) without any inconvenience to the licensed users. Stochastic models were developed to detect and allocate the unused spectrum. Game theory models are the recent applications that support the latest future for efficient use of spectrum holes. The chapter discusses different game models and their applications to cognitive radio networks. The game theory models include potential games, cooperative games, and noncooperative games. The applications of game models require the mapping of cognitive components to game models. The application leads to efficient allocation of the unused spectrum to cognitive users. Further, the game models help to reduce the false alarms in detecting the primary user and communicate the cognitive users to track the available channels and obtain the appropriate channel.

INTRODUCTION

The difficulties in transferring files faster and getting a communication channel in busy times are some of the common problems in the current generation of advanced communication technology. The reason for this is that the number of users and amount of data transferred is increased in the exponential order. Manual solution is not enough to solve such problems. An automatic agent is required to take care of these problems and provide a comfortable solution. The agent that detects the idle spectrum and helps users to solve their problems is called a cognitive radio. Cognitive radio (CR) is an intelligent agent that detects the idle spectrum and improves the data transfer rate or helps to connect the communication channel. The proposed intelligent agent (IA) or CR helps to detect and utilize the unused spectrum and improves the functionality of the system. The agent works towards the needs of customers, user applications, and network. Further, game theory models were introduced to boost the spectrum detection and allocation.

Cognitive radios have reconfigurable capability to utilize available hardware and software through transmission parameters and protocols. It automatically detects the available channels in a wireless spectrum and adjusts the transmission and reception parameters. The CR with its built-in capabilities senses the presence of primary users.
and adopts its parameters to create minimum interference to primary users. Further, CR understands its limits and uses idle spectrum efficiently without losing primary user performance quality. Due to these capabilities, the CR monitors the performance continuously and determines the radio frequency environment, channel conditions and link performance. It uses these outputs and delivers the quality of service to cognitive users subject to an appropriate combination of user requirements, operational limitations, and regulatory constraints.

Cognitive radio networks (CRN) consist of licensed users (primary users) and unlicensed users (cognitive users). The cognitive users manage their activities in using the idle spectrum without disturbing primary users. The research activities in cognitive radio networks are new and require identifying the limits, available models, and understanding the design of these networks. CRN users are aware of the dynamic environment and adaptively adjust their operating parameters based on other cognitive users (CU) in the network and environment. The users in the environment will observe, learn, and act to pursue their goals. The cognitive users will cooperate if the cooperation benefits for them. The cognitive radio networks are adaptive in nature due to change of environment and unreliable nature of wireless networks. In the traditional spectrum sharing, even a small change in the radio environment, controller triggers for small change in the radio environment. The recent research shows that the CRN can be improved by incorporating game models (Wang et al., 2008a; Wang et al., 2010b; Neel et al., 2004; Srivastava et al., 2005; Devroye et al., 2008; Zhu, 2010; Eliasa et al., 2011; Li et al., 2010; Reddy, 2011a; Reddy & Smith, 2010b). The recent study shows that game models helps better than other models for efficient management of spectrum.

In CRN, the users are intelligent. They adjust to the environmental changes including traffic variations, user mobility and spectrum overheads. They observe, learn, deal with the situation and optimize their performance. They cooperate with other users if the cooperation benefits for them. Since the users in cognitive network compete for resources they behave selfishly. Therefore, they require intelligent behavior to achieve resources. Game models are suitable for cognitive networks, have been using the low power and short range communications. These include cordless phones, Bluetooth devices, near field communication (NFC) devices, and wireless computer networks. The cognitive radios are capable of delivering the services needed by these applications, since the fundamental concept is to sense the primary user, observe and learn the user needs and adjust the parameters as needed to deliver the services. The efficient delivery services of cognitive networks were built in its cognitive capabilities. Therefore, it is necessary to understand the theoretical limits and design the protocols and transmission schemes to exploit the cognitive capabilities.

The performance of the cognitive radio networks (CRN) depends upon the information availability on the environment it is currently active. The CRN infrastructure has feedback (observations) from environment, knowledgebase, learning mechanism, network support, and decision making system. The database is continuously updated with new information. The decision making part of the CRN system selects the appropriate information (spectrum detection and channel selection) and ignores the unnecessary part of the information collected. Game theory models are recent introduction for cognitive radio networks to detect and use the spectrum holes (Wang et al., 2008a; Wang et al., 2010b; Neel et al., 2004; Srivastava et al., 2005; Devroye et al., 2008; Zhu, 2010; Eliasa et al., 2011; Li et al., 2010; Reddy, 2011a; Reddy & Smith, 2010b). The recent study shows that game models helps better than other models for efficient management of spectrum.