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Novel Distributed Algorithm for Coalition Formation for Enhanced Spectrum Sensing in Cognitive Radio Networks

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Abstract

In this paper, we propose a novel algorithm for improving spectrum sensing in cognitive radio networks by forming coalitions among cognitive radio users in a fading channel environment. We use concepts from matching theory, specifically the stable marriage problem, to formulate the interactions among the cognitive radio users as a matching game for collaborative distributed spectrum sensing under target detection probability constraint. The utility function is defined as the average probability of false alarm per cognitive radio user. The advantage of stable marriage is that it always converges to a stable matching and is Pareto optimal when the preferences of cognitive radios are strict. In the proposed model, we extend the stable matching problem to propose a novel algorithm to form coalitions of varying sizes for improving the utility of cognitive radios (false alarm and throughput). The coalitions formed using the algorithm are stable and do not deviate from the final matching. We show using simulations that the proposed algorithm leads to stable coalitions and returns significant improvement in term of reduced probability of false alarm and improved throughput per cognitive radio user as compared to the non-cooperative scenario.

Keywords: Cognitive radio; Spectrum sensing; Distributed algorithms; stable matching; Gale-Shapley algorithm.

1. Introduction

As the wireless devices have become pervasive, the wireless traffic has increased exponentially. According to Cisco [1], the mobile data traffic has grown 4,000-fold over the past ten years. Due to this exponential growth in wireless traffic, both licensed and unlicensed spectrum band have become congested. There are not enough spectrum bands left to accommodate further this exponential growth of mobile traffic. This lack of spectrum is threatening the expansion of high speed ubiquitous wireless networks. However, a survey [2] made by a Spectrum Policy Task Force (STPF) within FCC indicates that the actual licensed spectrum is largely under-utilized in vast temporal and geographic dimensions. A remedy to solve the issue of spectrum scarcity and inefficient utilization is to allow unlicensed users to access licensed bands dynamically when licensed users are inactive on those bands. This novel idea of spectrum utilization is called dynamic spectrum access (DSA). One of the wireless devices, that promise efficient and flexible DSA, is cognitive radio (CR). CR is a novel technology which improves the spectrum utilization and spectrum scarcity by accessing the unused spectrum allocated to the licensed users also termed as primary users (PUs).

To access the licensed spectrum bands, the CRs need to sense the spectrum to identify the idle licensed band. For this purpose, CRs in cognitive radio network (CRN) can act cooperatively or non-cooperatively. However, it has been shown in the literature that cooperation results in improved performance. To design cooperative algorithms for CRN, the cooperative game theory that deals with the analysis of the interaction between groups of cooperating rational players to improve their over-

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