

Abstract

Cognitive Radio (CR) has emerged as a promising solution to overcome the spectrum scarcity problem for next generation radio communication. A Cognitive Radio Network (CRN) with CR enabled unlicensed nodes allow opportunistic communication by utilizing the unused spectrum also called spectrum holes in the licensed spectrum bands. To enable efficient spectrum aware CR communication for next generation radio, many challenging issues related to spectrum sensing, power and channel allocation and medium access control (MAC) layer sensing decision need to be addressed with utmost importance. The challenge in spectrum sensing is to achieve higher detection performance due to the secondary users inabilities to exploit the inherent spatial diversity. The cooperative spectrum sensing (CSS) has evolved as a probable solution to tackle this problem. In this direction, a number of cooperative spectrum sensing approaches have been attempted by researchers. Unfortunately, these approaches could not improve the detection performance beyond a certain limit. The majority of the approaches do not consider cooperation overhead due to reporting time and reporting energy. Also they do not consider using adaptive sensing threshold which is estimated based on secondary user's distance from the primary user. Utilization of detected spectrum holes to maximize the capacity rate needs an efficient and optimal power allocation scheme, designing such a scheme is challenging. A number of water-filling based power allocation approaches have been proposed by the researches, which face challenges in terms of ensuring strict primary protection and the computational overhead to find the water level for optimal solution. Furthermore, the power allocation approaches proposed to maximize the capacity rate for multiuser underlay network suffer from the problem of convergence. To enable MAC level decision about the availability of channel in proactive sensing, the estimation of channel usage pattern of primary user is very essential. In this direction, researchers have proposed techniques to predict the channel availability using Hidden Markov Model (HMM) for interweave mode of access. Developing a model to predict channel availability for underlay mode of access is challenging and not addressed so far.

We begin by developing a coalitional game theoretic framework for cooperative

spectrum sensing for ad-hoc CRNs. It addresses the problem of minimizing the cooperation overhead in terms of reporting time and reporting energy to enhance the detection performance. Furthermore, to improve the detection performance by exploiting the spectral diversity of the SUs, the game theoretic framework is extended for distributed threshold adaptive cooperative spectrum sensing (TACSS). It also addresses the problem of minimizing cooperation overhead due to reporting error and reporting energy.

With the enhanced detection performance of the CSS schemes, next we investigate the technique to make the efficient use of the detected opportunities for maximizing the capacity rate for SUs. A water-filling (WF) based optimal power allocation technique for a single pair of SUs is developed to maximize the capacity rate using OFDMA mode of channel access using underlay communication. The technique finds the optimal water-level while maintaining the average interference power (AIP) tolerance limit of the primary users. A distributed power allocation (DPA) scheme to maximize the capacity rate while ensuring primary protection for multiuser scenario is developed which incorporates an additional constraint of self-interference among SUs. The DPA scheme is modeled using the potential game theoretic formulation for multiuser underlay communication scenario, which allows the basic non-cooperative power allocation game to reach the Nash Equilibrium (NE) for ad-hoc CRNs. The iterative water-filling (IWF) based scheme is adopted to devise the optimal power allocation scheme.

Finally, the estimation and modeling of primary users channel usage pattern to predict channel availability at MAC level for underlay mode of channel access is developed using a Hidden Markov Model (HMM) based technique. A distributed data dissemination protocol is developed to utilize the proposed channel usage model and discover the opportunities in the licensed channel, while tolerating the interference power constraint (IPC).

Keywords: Cognitive Radio, Cognitive Radio Network, Capacity rate, Primary user, Secondary user, Game theory, Reporting error, Reporting energy, Nash Equilibrium, Spectrum sensing, Underlay communication, Spectral diversity