Avis de soutenance de thèse

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Sujet de thèse :

Game theory and learning algorithms for controlling self-organizing networks

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Résumé de la thèse :

The recent advances in technology, fueled by the ever increasing mobile data traffic, have triggered new network paradigms and various technical challenges. Therefore, the next generation of wireless communication systems is expected to incorporate smart capabilities and several optimization techniques in order to rise above the current challenges. In this respect, my thesis work combines game theory and distributed learning algorithms in order to model, analyze, and provide clear insights on current networks paradigms. Indeed, game theory is adapted to the multi-agent nature of the wireless communication environment. It provides the necessary tools to model interactions between conflicting agents. It also allows to design strategic solutions and mechanisms through fully distributed learning algorithms. In this thesis, we are interested in three network paradigms, namely: cognitive radio networks, heterogeneous networks, and Internet of things networks. In the first part, our focus is on cooperative spectrum sensing for cognitive radio networks. We adopt a volunteer dilemma and an evolutionary game approach to model interactions between secondary users. We study users' behaviors under both a static environment, with fixed number of secondary users, and under a dynamic environment with a random number of users. We show two counter-intuitive properties. First, when the number of secondary users increases, opportunistic users are more likely not to sense the primary channel. Second, when secondary users know about the presence of potential cooperators, they are more likely to free-ride the sensing task. Finally, in order to attain the proposed game-theoretic solution concepts, we propose fully distributed learning schemes and show their performance through simulation. In the second part, we are interested in heterogeneous networks. Our focus is on power resource allocation among small base stations and wireless sensor nodes. In particular, we identify the power allocation problem in heterogeneous networks with a potential game. This class of games is characterized by a potential function, and has a specific property: a pure Nash equilibrium solution always exists and it is, moreover, either a local or a global optimum of the potential function. Using the discrete property of the set of transmit powers, we prove that, in our case, all Nash equilibria are global optima. In order to reach such an equilibrium, we propose a fully distributed algorithm, of low complexity, adapted to both small-cells and wireless sensor networks. Besides, since coordination among nodes is very stringent in a heterogeneous networks context, we propose a practical algorithm implementation that limits the wireless signaling overhead. Finally, we illustrate the performance of the proposed algorithm through various simulation scenarios. In the third part, we are rather interested in reducing energy consumption through a power control scheme. We present a novel approach while dealing with energy efficiency in Internet of things networks. Indeed, instead of achieving the best network performance by maximizing the quality of service (QoS), we propose that devices can target satisfactory QoS levels only, in order to achieve a better energy efficiency. We consider satisfaction equilibria, mainly the efficient satisfaction equilibrium, to ensure a target QoS, and save energy. We identify conditions of existence and uniqueness of efficient satisfaction equilibrium under a stationary channel assumption. Under a fast fading channel assumption, we propose an alternative solution namely the long term satisfaction equilibrium, and describe how to reach this solution efficiently. Finally, in order to find a satisfactory solution per all connected devices, we propose fully distributed strategic learning schemes, and show through simulations their qualitative properties.