Dynamic Resource Allocation in Heterogeneous Wireless Networks

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1 Introduction

As the wireless technology and standards continue to evolve, wireless communication systems and standards continue to promise to support an even higher number of mobile users, new applications, higher data rates, better coverage and more stringent quality of service (QoS) standards. Users need to be provided with high data rates and reliable service irrespective of their mobility or location. Heterogeneous Networks (HetNets) is one possible network architecture that can help in meet these challenging demands.

In HetNets, the mobile network is constructed with layers of small and large cells. One common example is the coexistence between macrocells and femtocells in cellular networks. This architecture is faced with the task of resource allocation (power, channel, time) for small cells in order to ensure reliable and high quality service to both primary (macrocell) users as well as secondary (femtocell) users. Furthermore, since the small cells are usually user-deployed, the locations and number of small cells in a HetNet is not fixed. This calls for dynamic and intelligent resource allocation algorithms for these networks. Various methods have been utilized for control of femtocell resources: open vs closed access and centralized control vs distributed coordination.

2 Project Description

In this project, I am planning to perform a comparative study of the different techniques used for spectrum allocation in HetNets through simulations. The techniques will be compared for their computational point of view (timing performance and convergence) as well as the results which they achieve in terms of QoS for secondary users, fairness of resource allocation, overall network capacity and the extent of possible degradation of QoS for primary users. For the purpose of this project, I will be considering macrocell - femtocell HetNet. Each macrocell has several primary users, femtocells and each of the femtocells has one or more femtocell users. It is assumed that the macrocells and femtocells coexist in the same frequency spectrum are the resources are allocated through a distributed control. Only frequency and power will be considered for resource allocation. The objective is to increase the sum of capacities for all femtocells while still maintaining above threshold QoS for primary users.

One method of performing resource allocation is Q-learning [1] [2]. Q-learning is a type of reinforcement learning, where the agent learns an optimal control policy through delayed rewards acquired through interaction with the environment through a Markov Decision Process (MDP). Q-learning involves the use of a reward function and a policy information table. The reward function returns a higher reward for actions (resource allocations) that are more favourable, as defined by the optimization objective. In this approach, femtocells are treated as independent agents, which are all trying to optimize a common reward function. The second method is the use of Evolutionary Game Theory (EGT) approach for dynamic resource allocation in a distributed control setting. EGT is a suitable tool to address the self organized small cell resource allocation problem since it allows the players with bounded rationality to make individual decisions and learn from the environment for attaining the equilibrium with the minimum information exchange [3]. A third possible approach is described in [4], where the dynamic power and channel allocation problem is formulated as an integer programming problem.

References

