DYNAMIC CHANNEL ASSIGNMENT AND POWER ALLOCATION STRATEGIES IN MULTI-CHANNEL WIRELESS NETWORKS

By

Xiang Luo

An Abstract of a Thesis Submitted to the Graduate

Faculty of Rensselaer Polytechnic Institute

in Partial Fulfillment of the

Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject: ELECTRICAL ENGINEERING

The original of the complete thesis is on file
in the Rensselaer Polytechnic Institute Library

Examining Committee:

Koushik Kar, Thesis Adviser

Alhussein A. Abouzeid, Member

Biplab Sikdar, Member

Christopher D. Carothers, Member

Rensselaer Polytechnic Institute
Troy, New York

September 2009

(For Graduation December 2009)

ABSTRACT

In this dissertation, we focus on dynamic channel assignment and power allocation strategies in multi-channel wireless networks. We first consider the problem of uplink scheduling in a point-to-multipoint network where channel states differ across channels as well as users, vary with time, and can be measured only infrequently. We demonstrate that, unlike infrequent measurement of queue lengths, infrequent measurement of channel states reduces the maximum attainable throughput. We further prove that in the multi-channel point-to-multipoint network, a dynamic scheduling policy that depends on both the channel rates (averaged over the measurement interval) and the queue lengths, attains the maximum possible throughput.

We next address the continuous-backlog version of the joint channel assignment and power allocation problem for maximum throughput in the multi-channel point-to-multipoint network. In this setup, a set of orthogonal channels must be assigned to a set of users, where each user splits its power optimally across the channels allocated to it. While the optimal power allocation solution has a "water-filling" type structure, the optimal channel assignment problem is very challenging due to the non-linear dependence of user throughput on the set of channels assigned to it. We analyze the system in the two extremal SINR regimes (very high and very low SINR) and show how the optimal solutions can be obtained in these regimes in a computationally efficient manner. We next consider the same question but in the presence of per-user fairness constraints. Our goal is to maximize the overall effective data rate in the network, taking into account variations in channel rates across channels as well as users, while satisfying minimum rate constraints for each user. Although this problem is in general a complex non-linear mixed-integer optimization question, we show that the optimal schedule and power allocation can be computed in polynomial time under a high SINR approximation.

Finally, we address the stochastic version of the joint channel assignment and power allocation question in the multi-channel point-to-multipoint network, taking into account randomness in the packet generation process by users. Our goal is

to obtain channel assignment and power allocation solutions that can dynamically adapt to changing channel conditions, and would maximize system throughput under per-user bandwidth (QoS) constraints, in a long-term sense. Building upon stochastic optimization techniques, we obtain an optimal scheduling policy that operates without knowledge of arrival rates and channel statistics (depending only on the instantaneous channel states and the queue lengths), and attains the overall system throughput that is arbitrarily close to the maximum achievable value with all per-user bandwidth constraints satisfied. Since obtaining the jointly optimal channel assignment and power allocation policy is computationally difficult, we also evaluate the performance of a solution that is computationally simpler but approaches the optimal solution in the high-SINR regime.