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Coping with Interference in Wireless Networks

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To my parents

Preface

In this book we study the effect of interference and methods of coping with it in a wireless network. We approach the problem from three different perspectives. The first which involves physical layer is a method to cancel out interference in a multi-access channel. We consider J transmitter units each equipped with N transmit antennas over wireless Rayleigh fading channels. Previously, it was proved that when each transmitter unit has N transmit antennas, using $(J-1)N+r$ receive antennas for any $r \geq 1$, the receiver can completely separate the signals of J users. The provided diversity to each user was shown to be Nr if the units employ space-time trellis codes even if the units transmit asynchronously. Here, we consider the case when all units are synchronized and employ Quasi-Orthogonal Space-Time Block Codes ($N > 2$). It is proved that in this case a receiver with $J+r-1$ antennas, with $r \geq 1$, can separate the transmitted signals of all units and provide each unit with a diversity order of Nr.

Based on our interference cancellation technique, we then offer an array processing scheme which provides trade-off between diversity and spatial multiplexing. It is shown via simulations that this array processing scheme performs better than well-known modulation schemes, e.g. space-time block codes and BLAST, for a moderate number of receive antennas. We then derive the diversity order of these multiple antenna multi-user cancellation and detection schemes.

In our second approach we assume the physical layer did not remove interference fully. We then try to optimize our medium-access control (MAC) layer. We consider the problem of joint routing, scheduling and power control in multi-hop wireless networks. We use a linear relation between link capacity and signal to interference noise ratio in our formulation. In a previous work, using a duality approach, the optimal link scheduling and power control that minimizes the total average transmission power is found. We formulate this problem as a linear programming problem with exponential number of constraints. To cope with the exponential number of constraints, we propose an iterative algorithm based on the cutting plane method. The separation Oracle for the cutting plane algorithm turns out to be an element-wise concave optimization problem that can be effectively solved using branch and bound algorithm.

We extend the same method to find the optimal ***routing*** scheduling and power control. Simulation results show that this methodology is more efficient and scalable compared to the previously proposed algorithm.

As a third approach we investigate the connectivity of fading wireless ad-hoc networks. We first define interference, and based on that propose a few metrics of connectivity. We then study the effect of interference on connectivity based on each of those metrics.

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