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Coping with Interference in Wireless Networks

 Springer

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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.

Seyed Javad Kazemitabar

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Contents

1	Introduction	1
1	Coping with Interference in Physical Layer	1
2	Coping with Interference in Medium-Access Control (MAC) Layer	3
3	Effect of Interference on Connectivity	6
2	Multi-User Communication and Interference Cancellation	9
1	The Channel Model	9
2	Interference Cancellation Using Space-Time Block Coding	9
3	Interference Cancellation Using Quasi-Orthogonal Space-Time Block Coding	15
4	Interference Cancellation Using Minimum Decoding Complexity Quasi-Orthogonal Space-Time Block Codes (MDC-QOSTBC)	23
5	Application of the New Interference Cancellation Scheme in Array Processing	25
6	Simulation Results	26
3	Diversity Analysis of Multiple-Antenna Multi-User Systems	31
1	Diversity Order in a Communication Scheme	31
2	Multi-User Detection Using Alamouti	32
3	Multi-User Detection for More than Two Transmit Antennas	42
4	Joint Array Processing and Space-Time Coding	49
5	Discussion	49
	Appendix A	49
	Appendix B	56
4	Global Optimal Routing, Scheduling and Power Control for Multi-Hop Wireless Networks with Interference	59
1	Modeling and Problem Formulation	59
2	Power Control, Scheduling and Routing Algorithm	63
3	Nonlinear vs. Linear	70
4	Simulation Results and Discussion	71

- 5 Connectivity in Wireless Networks 79**
 - 1 The Capacity Metric 79
 - 2 The *SER* Metric 84
 - 3 Capturing Temporal Correlation of Ergodic Channels 89
 - 4 Experimental Verification of Analysis 89

- References 97**

- Index 101**

List of Figures

Fig. 2.1 Simulation results after interference cancellation when there are 2 users each transmitting QOSTBC with QPSK modulation 24

Fig. 2.2 Bit error probability vs. SNR for the new array processing scheme, and OSTBC at 2 bits/s/Hz; 8 transmit and 2 receive antennas 25

Fig. 2.3 Bit error probability vs. SNR for the new array processing scheme, and QOSTBC at 6 bits/s/Hz; 8 transmit and 2 receive antennas 26

Fig. 2.4 Bit error probability vs. SNR for the new array processing scheme, and BLAST-ML at 8 bits/s/Hz; 8 transmit and 2 receive antennas 27

Fig. 2.5 Bit error probability vs. SNR for the new array processing scheme, and BLAST-ZF at 8 bits/s/Hz; 8 transmit and 8 receive antennas 28

Fig. 2.6 Bit error probability vs. SNR for the new array processing scheme, and BLAST-ZF at 12 bits/s/Hz; 12 transmit and 12 receive antennas 29

Fig. 3.1 Comparison of the two MUD systems with two Alamouti equipped users 50

Fig. 4.1 Flowchart of the power control-scheduling algorithm 65

Fig. 4.2 Flowchart of the routing algorithm 69

Fig. 4.3 One of the simulated networks with 50 nodes 72

Fig. 4.4 Comparison of the final constraint counts in the optimization LP 73

Fig. 4.5 Comparison of the time it takes for each algorithm to converge 74

Fig. 4.6 Comparison of the total consumed power 75

Fig. 4.7 Comparison of the number of active links 75

Fig. 4.8 Generated routes for 2 networks with 51 two-way links (102 single-way links) 76

Fig. 4.9 Comparison of the linear approximation with the actual nonlinear model 76

Fig. 5.1 Normalized BPSK plots of $1 - CDF(SER)$ versus S_{out} for a wireless link utilizing different antenna configurations with $SINR = 3$ dB 91

Fig. 5.2 BPSK plots of \bar{C} versus \overline{SINR} for an isolated wireless link utilizing different antenna configurations 92

Fig. 5.3 Connectivity graphs of a random topology network in a square domain of 1000 square meters. The *columns from left to right* correspond to single antenna, hybrid, and double antenna mobile nodes. (a) The *illustrations of the first row* show the results of utilizing probabilistic connectivity metric of (5.11) with $C_{\text{out}} = 2$ bps/Hz and $\Delta_C = 0.01$. (b) The *illustrations of the second row* show the results of utilizing ergodic connectivity metric of (5.19) with $C_{\text{out}} = 4$ bps/Hz. (c) The *illustrations of the third row* show the results of utilizing probabilistic connectivity metric of (5.30) with $S_{\text{out}} = 0.02$ and $\Delta_S = 0.01$. (d) The *illustrations of the fourth row* show the results of utilizing ergodic connectivity metric of (5.37) with $S_{\text{out}} = 0.0001$ 93

List of Tables

Table 5.1	A comparison of the relative sizes of the largest connected cluster utilizing outage capacity connectivity metric	94
Table 5.2	A comparison of the relative sizes of the largest connected cluster utilizing ergodic capacity connectivity metric	94
Table 5.3	A comparison of the relative sizes of the largest connected cluster utilizing probabilistic <i>SER</i> connectivity metric	94
Table 5.4	A comparison of the relative sizes of the largest connected cluster utilizing ergodic <i>SER</i> connectivity metric	94