

MULTIPLE ACCESS CHANNELS

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Multiple Access Channels

Theory and Practice

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Preface

While multiple-access communication dates back to systems invented in the 1870's to transmit simultaneous data through a single wire, the foundation of the discipline now known as "multiuser information theory" was laid in 1961, when Claude E. Shannon published his paper [1] on two-way channels. Since then, multiuser information theory has been an extremely active research area, and has seen a large number of fundamental contributions, covering, besides the two-way channel studied in [1], multiple access, interference, broadcast, and wiretap channels (see [2] for a brief historical account of the development of this theory up to 1998). However, several key canonical problems have defied many efforts [3].

The NATO Advanced Study Institute on Coding and Analysis of Multiple Access Channels was organized in the Europa Congress Center, Budapest from August 26 to September 5, 2006, in the form of an advanced course on multiple access channels, during which leading experts working in the fields of information theory, coding theory, multiple user communications, discrete mathematics, etc., surveyed recent and general results on multiple-access channels (rate regions, rate splitting, etc.), and gave an overview of the problems of current CDMA solutions (fading channels, multi-user detection, multiple-antenna systems, iterative joint decoding, OFDMA, etc.). The lecturers investigated the information-theoretic bounds of the most important deterministic channels, too (OR channel, adder channel, collision channel, slow frequency hopping, random access, Euclidean channel), together with some efficient code constructions for both synchronous and asynchronous access. The slides of the lectures are available at: <http://www.szit.bme.hu/natoasi/program.html>.

This volume includes 16 contributions that were prepared in the occasion of the Institute, organized in three parts.

The first part includes chapters devoted to the information-theoretical aspects of multiple-access communication. The first chapter, coauthored by Imre Csiszár and András György, focuses on the basic coding theorems for multiple-access channels, with special focus on a system with two senders and one receiver. The next contribution, by Bixio Rimoldi, is devoted to rate-splitting multiple access. This theory shows how the problem of coding/decoding for multiple-access channels can be reduced to that of coding/decoding for point-to-point channels. The two following chapters, coauthored by Danyo Danev, Zoltan Füredi, Bálint Laczay, and Miklós Ruzinkó, discuss the signature coding problem of multiple-access adder and Euclidean channels. In one further chapter, Edward C. van der Meulen, surveys the most representative results on the relay channel obtained in the period 1968–2006, and discusses the recent topic of relay-without-delay channels. The chapter of Jack K. Wolf reviews noiseless coding with side information, as well as some recent results on noisy source coding. This part is concluded by a chapter on coding for channels with constrained and unconstrained side information, authored by Yossef Steinberg.

The second part, devoted to multiple-access techniques, is opened by the chapter by Ezio Biglieri, which examines, through a simple—but by no means trivial—case, a

wireless channel endowed with multiple transmit and receive antennas. The chapter focuses on capacity limits, receiver design, and code choices. Martin Bossert's contribution focuses on orthogonal frequency-division modulation in wireless environment, and in particular on coding schemes suitable for that technique. Braided code-division multiple access (CDMA) is covered in the subsequent chapter by Kamil Sh. Zigangirov and Marcos B. S. Tavares, where a novel CDMA technique, based on *braided codes*, is described. Next chapter, by László Györfi, Sándor Györi, and James L. Massey, covers the stability and instability of random-access systems with feedback, based on the fact that such systems are generally well-modelled by homogeneous Markov chains. This part is concluded by a chapter on random-access channels with the feedback of collision's multiplicity, authored by Bálint Laczay and Miklós Ruzinkó.

The third part of this volume covers coding techniques. A. J. Han Vinck describes the construction of codes that approach or achieve the capacity by focusing on two specific models, the 2-adder and the switching channel, respectively, with and without feedback. In his chapter, Anthony Ephremides introduces what is now known as "network information theory," focusing on the study of the multi-access channel from the perspective of a network, with special emphasis on stability issues and network coding. László Györfi and Sándor Györi describe some bounds and code constructions for multiple-access collision channels without feedback and for slow frequency hopping with asynchronous access. Finally, Ernst Gabidulin reviews the metrics that can be chosen as cost functions for the optimization of codes for general channels.

For help with local arrangements during the NATO ASI we want to thank Sándor Györi, Gusztáv Hencsey and Mariann Kindl. We are very grateful to all people who helped making this NATO Advanced Study Institute on Coding and Analysis of Multiple Access Channels a great success. We hope that this event may further lead to setting new milestones in this fascinating area.

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