Signal and Information Processing Laboratory

Prof. Dr. A. Lapidoth,   Prof. Dr. H.-A. Loeliger

ANNUAL REPORT

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Research Period   2004

Teaching Period   2003/2004

Foreword

2004 was a very exciting year for our Institute. Not only did we host the Fourth Technion-ETH Workshop on Coding and Information Theory (February 16-17, 2004) but we also hosted, together with the Communication Technology Laboratory, the 18th International Zurich Seminar on Communication (February 18-20, 2004). We take this opportunity to thank all of you who have helped make these events so successful.

2004 was also a year of change for our Institute. It saw Ms. Renate Agotai retire after years of faithful service to our Institute. We shall miss her expertise and her noble presence. We wish her the very best for her retirement. On the other end of the spectrum we had two very exciting young additions to our Institute: Matthias Ti-Ya Moser (born January 11, 2004) and Miriam Lapidoth (born November 17, 2004). We wish them and their parents good health and lots of joy.

Replacing Ms. Agotai is Ms. Marion Braendle, whom we warmly welcome to our community along with our new Ph.D. students Junli Hu, Tobias Koch, and Michèle Wigger.

We have also had the pleasure of hosting a number of visitors to our Institute. Among them are Mehdi Mokaraie and Prof. Ping Li. We are particularly indebted to Dr. Gerhard Kramer who visited our Institute and offered (together with me) an advanced course on Multi-user Information Theory.

We thank our support staff for the first rate conditions at our Institute and hope that these conditions may lead to excellence in teaching and research.

April 2005   Amos Lapidoth

Contents

1. Personnel

Professor for Information Theory:

Prof. Dr. Amos Lapidoth

Professor for Signal Processing:

Prof. Dr. Hans-Andrea Loeliger

Adjunct Lecturer: **Dr. Kurt Heutschi**

Secretaries: **Mrs. Bernadette Röösli**
Mrs. Renate Agotai   left on 30.11.2004
Mrs. Marion Brändle   since 1.11.2004

Technical Supervisor: **Dr. Max Dünki**

Research Assistants:

Justin Dauwels	Dipl.Phys.Eng.
Matthias Frey	Dipl.El.Eng.
Markus Hofbauer	Dipl.El.Eng.
Daniel Hösli	Dipl.El.Eng.
Junli Hu	Dipl.El.Eng. since 1.4.2004
Tobias Koch	Dipl.El.Eng. since 11.10.2004
Volker Koch	Dipl.Eng.
Sascha Korl	Dipl.Eng.
Patrick Merkli	Dipl.Eng. Microtechn.EPF
Natalia Miliou	Dipl.El.Eng.
Stefan Moser	Dipl.El.Eng.
Maja Ostojic	Dipl.El.Eng.
Stephan Tinguely	Dipl.El.Eng.
Wigger Michèle	Dipl.El.Eng. since 1.7.2004

Technical Staff: **Francesco Amatore**
Thomas Schärer
Patrik Strebel   El.Eng.HTL

Scholarship Recipient:

Jelena Stamenkovic	University of Nis, Nis Rep. of Serbia	01.01. – 15.07.04

Academic Guests: (see 6.1 for report of activities)

Dr. Gerhard Krämer	Lucent Technologies, New Jersey, USA	08.05. – 30.05.04
Mehdi Molkaraie	EPF Lausanne, Switzerland	05.09. – 15.10.04
Prof. Ping Li	City University of Hong Kong Kowloon, Hong Kong	01.06. – 31.08.04
Prof. A. Singer	University of Illinois at Urbana- Champaign, Urbana, IL, USA	21.11. – 22.11.04

2. Teaching

2.1 Lectures

Sem.	Instructors	Title	ETH-No.
5th	Prof. H.-A. Loeliger	Stochastic Models and Signal Processing	227-0101
8th	Prof. H.-A. Loeliger	Algebra, Codes, and Signal Processing	227-0416
5th/7th	Prof. A. Lapidoth	Applied Digital Information Theory I	227-0417
6th	Prof. A. Lapidoth	Information Transfer	227-0104
6th	Prof. A. Lapidoth Dr. G. Krämer	Topics in Multi-Terminal Information Theory	227-0419
7th	M. Hofbauer und Dr. R. Kretzschmar	Adaptive Filters and Neuronal Networks	227-0467
8th	Dr. H.P. Schmid	Analog Signal Processing and Filterung	227-0468
7th	Dr. K. Heutschi	Acoustics I	227-0950
8th	Dr. Heutschi	Acoustics II	227-0478

2.2 Practica

Sem.	Instructors	Title	ETH-No.
5th/6th	Practica	Laboratory for "Fundamentals in Electrical Engineering"	227-0095
1st/2nd	D. Hösli, S. Korl	Cellular Automata	PPS
3rd/4th	V. Koch, M. Ostojic	Practical Signal Processing using a DSP	PPS
2nd/3rd	Th. Schaerer	EMG Biofeedback Device	PPS
3rd/4th	P. Merkli, M. Frey P. Strebel	Probability Gates and Analog Decoding	PPS
3rd/4th	S. Moser	Introduction to LaTeX	PPS

2.2 Semester Projects and Diploma Theses

During the winter semester 2003/04 and summer semester 2004, 12 Semester Projects (15 candidates) and 3 Diploma Theses (4 candidates) were carried out.

Candidates	Title	Supervisor
Semester Projects WS 2003/04		
Martin Arnold	Adaptive Schätzung von AWGN-Kanalparametern	Frey Merkli
Beat Kessler	Redundancy in Analog VLSI Soft-Decoders	Merkli Frey
Andreas Ess Tobias Gysi	Real-Time Signal Processing Tasks for RHWOS (Turbo Decoder on a Xilinx Virtex FPGA)	Walder/TIK Frey
Rolf Grüninger	Optimization of an Iterative EMG signal decomposition algorithm	Koch
Roland Abt Marco Diefenbacher	Whisker-based obstacle avoidance in the AMouse project	Fend, Korl Koch
Adrienne Heinrich	Switch in Hearing Instrument	Hofbauer
Semester Projects SS 2004		
Simon Dellenbach	Akustische Verkehrsklassierung	Lippuner Kälin/Siemens
Christian Rijke	Simulation of EMG Signals to Test Decomposition Algorithms	Koch
Conradin Merk	Seismosomnography: Heartbeat Detection using the Cardioballistic Effect	Merkli Koch Brink/IHA
Simon Schneiter	Störgeräuschbefreiung für Sprachsignale	Korl Koch
Peter Kaufmann	Pseudo-Noise Sequence Synchronization for GSP Signals	Ostojic Dauwels
Martin Byröd	Segmentation and Decomposition of EMG Signals	Koch
Diploma Theses WS 2003/4		
Benjamin Amsler Samuel Bruhin	Zerlegung von EMG Signalen mittels graphischen Modellen und iterativen Algorithmen	Koch Korl

| Tobias Koch | On the Prelog of MISO Fading Channels | Moser
Hösli
Miliou |

Diploma Theses SS 2004

| Markus Leuthold | Ear canal transfer function estimation | Heutschi
Stirnemann/
Phonak |

3. Research

3.1 Research Areas

The Signal and Information Processing Lab focusses on research and teaching in the following areas:

Information Theory and Coding

Information theory, error correcting codes, and their application to communication systems. Current topics:

- Bounds on the capacity of fading channels
- On multi-access channels (MAC) at high SNR
- On MIMO Ricean fading channels
- Multi-access channels with feedback
- Numerical computation of information rates and channel capacity
- Robust communication for multi-access channels
- Non-coherent networks
- High SNR capacity asymptotics for non-regular fading channels
- Combined source-channel coding
- Feedback in wireless communications
- The Fading Number for MIMO systems

Digital Signal Processing

Current topics:

- Fundamentals of graphical models ("factor graphs")
- Speech enhancement in hearing aids
- Decomposition of electromyographic signals
- Clock noise and synchronization in communications receivers

Analog Signal Processing

Current topics:

- Decoding in analog VLSI
- Synchronization of pseudo random signals
- A/D converters

3.2 Current Research Projects

Information Theory and Coding

On the asymptotic capacity of stationary Gaussian fading channels

We study the high SNR asymptotic capacity of stationary Gaussian SISO fading channels with memory. Previously we showed that when the fading is REGULAR capacity increases double logarithmically in the SNR. Here we study the NON-REGULAR case. Inter alia, we derive the capacity pre-log.

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Professor: Dr. Amos Lapidoth

On non-coherent fading networks

We study the capacity of a non-coherent fading network. The network topology enters the channel model via the location of the deterministic zeros in the otherwise random fading matrix. It is shown that asymptotic capacity can be computed combinatorially from the location of the zeros.

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Professor: Dr. Amos Lapidoth

On the feedback capacity of discrete-time multi-access channels

An achievable region for the two-user discrete memoryless multiple-access channel with noiseless feedback is derived. The proposed region includes the Cover-Leung region, with the inclusion being for some channels strict.

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On the capacity of Multi-Input Multi-Output Ricean fading channels with perfect side-information

We consider a discrete-time memoryless Multiple-Input Multiple-Output (MIMO) fading channel where the fading matrix can be written as the sum of a deterministic (line-of-sight) matrix D and a random matrix H whose entries are IID zero-mean unit-variance complex circularly-symmetric Gaussian random variables. It is demonstrated that if the realization of the fading matrix is known at the receiver but not at the transmitter, then the capacity of this channel under an average power constraint is monotonically non-decreasing in the singular values of D. This complements a recent result of Kim and Lapidoth demonstrating the monotonicity of the mutual information corresponding to isotropically distributed Gaussian input vectors. We also show that the eigenvectors of the optimal

covariance matrix of the Gaussian input vector coincide with the right singular vectors of D.

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Professor: Dr. Amos Lapidoth

How good is an isotropic Gaussian input on a MIMO Ricean channel?

For a MIMO Ricean fading channel with perfect side information at the receiver we derive an analytic upper bound on the difference between capacity and the mutual information that is induced by an isotropic Gaussian input. We show that if the number of receiver antennas is at least equal to the number of transmitter antennas, then, as the signal-to-noise ratio tends to infinity, such an input is asymptotically optimal. But otherwise such an isotropic input might be suboptimal. We also propose an iterative algorithm to calculate the optimal power allocation.

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On the capacity region of the coherent Ricean multi-access channel

We study the capacity region of Ricean fading multiple-access channel where the receiver, but not transmitters, is cognizant of the fading realization. We seek conditions under which the capacity region corresponding to a given set of mean matrices is larger than the one corresponding to another.

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On the asymptotic capacity of multiple-input single-output fading channels with memory

The capacity of Gaussian fading channels with memory is studied where neither the transmitter nor the receiver has access to the realization of the fading process, though both are fully cognizant of the fading laws. The emphasis is on the high signal-to-noise ratio (SNR) regime.

For regular fading processes an upper bound on the fading number of multiple-input single-output (MISO) Gaussian fading channels is derived. It is shown that this bound is tight (i.e., it coincides with a lower bound) if the fading process is spatially independent and if it is additionally either zero-mean or its spectral density matrix contains identical entries.

For non-regular fading processes, an upper bound on the capacity pre-log of multiple-input multiple output (MIMO) Gaussian fading channels is derived when the fading is spatially independent. It is shown that this bound is tight in the MISO case. Additionally, an upper bound on the capacity pre-log of MISO Gaussian fading channels when the fading is not spatially independent as well as

an expression for the capacity pre-loglog when capacity only grows double-logarithmically in the SNR is given.

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Duality bounds on the cut-off rate with applications to Ricean fading

We propose a technique to derive upper bounds on Gallager's cost-constrained random coding exponent function. Applying this technique to the non-coherent peak-power or average-power limited discrete time memoryless Ricean fading channel, we obtain the high signal-to-noise ratio (SNR) expansion of this channel's cut-off rate. At high SNR the gap between channel capacity and the cut-off rate approaches a finite limit. This limit is approximately 0.26 nats per channel-use for zero specular component (Rayleigh) fading and approaches 0.39 nats per channel-use for very large specular components.

We also compute the asymptotic cut-off rate of a Rayleigh fading channel when the receiver has access to some partial side information concerning the fading. It is demonstrated that the cut-off rate does not utilize the side information as efficiently as capacity, and that the high SNR gap between the two increases to infinity as the imperfect side information becomes more and more precise

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The fading number with feedback

We study the effect of feedback on the high-SNR asymptotic capacity of non-coherent MIMO fading channels with memory. For single-input single-output systems we have already established that feedback increases neither the fading number nor the pre-log. The general case is now under study.

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Bounds on the capacity of fading channels

The goal of this project is to obtain accurate estimates of the capacity of fading channels, which are typically encountered in mobile wireless communication. The capacity of such channels serves as the ultimate upper bound on the rates at which reliable communication is possible. Moreover, with the advent of Turbo-codes, one can often approach these rates with practical coding schemes. Since the exact calculation of capacity is intractable, one must resort to upper and lower bounds. To this end we have developed a new technique to derive upper bounds on the capacity of general channels, and we have applied this technique to fading channels. Together with some lower bounds that we have found for such channels, we are now in a position to understand the behavior of the channel capacity for the large family of multi-antenna fading channels with or without memory and with or without side information related to the fading realization. We

have further developed the concept of "capacity achieving input distributions that escape to infinity" and showed how his concept can be used to derive asymptotic estimates of channel capacity. Using this paradigm we were able to derive a high-SNR asymptotic expansion for the capacity of a number of fading models. In particular we have solved the single-input single-output (SISO) case (with memory) as well as the multi-input single-output (MISO) case.

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The fading number of SIMO fading channels with memory

We derive the fading number of a general (not necessarily Gaussian) single-input multiple-output (SIMO) fading channel with memory, where the transmitter and receiver-while fully cognizant of the probability law governing the fading process-have no access to the fading realization. It is demonstrated that the fading number is achieved by IID circularly-symmetric inputs of log squared-magnitude that is uniformly distributed over a signal-to-noise (SNR) dependent interval. The upper limit of the interval is the logarithm of the allowed transmit power, and the lower limit tends to infinity sub-logarithmically in the SNR. Among the new ingredients in the proof is a new theorem regarding input distributions that escape to infinity. Upper and lower bounds on the fading number for SIMO Gaussian fading are also presented. Those are computed explicitly for stationary m-th order auto-regressive AR(m) Gaussian fading processes.

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Numerical Computation of Information Rates

The information rate and the channel capacity (in the sense of Shannon) are key properties of any communications channel. However, for many important channels with memory, it is not known how to compute these quantities with sufficient accuracy.

Since 2001, we have made significant progress with such numerical methods. In particular, the information rate of any finite-state source/channel model (with up to a few thousand states) can now be computed accurately. Upper and lower bounds on the information rate of very general (non finite-state) channels can be computed either by finite-state approximations or by reduced-state trellis computations. We are now extending this work to make use of "particle filter" methods.

In collaboration with A. Kavcic, we have also been studying an extension of the Blahut-Arimoto algorithm to optimize the information rate over finite-state Markov sources with a fixed number of states.

This work was motivated mainly by applications in magnetic recording, but the results have a much wider scope.

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Digital Signal Processing

Clock Noise and Synchronization

This project is concerned with the following two related topics:

 - Phase synchronization in communication receivers.

 - Effects of nonideal clocks in communication receivers.

These topics are of central, and growing, importance to digital communications, but not well understood. We are studing these topics from several sides: physics and circuit theory, information theory, and signal processing. We heavily rely on modeling by factor graphs and signal processing by the summary-product algorithm.

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Decomposition of EMG Signals

All muscular activity is triggered by electrical pulses in the nerve cells that control individual groups ("motor units") of muscle fibres. The measurement and the analysis of such electrical signals is of significant interest to physicians.

 Our laboratory has a long tradition in the processing of such electromyographic (EMG) signals. The signals as measured by various types of electrodes consist of the linear superposition of (the signals corresponding to) many motor units. The main signal processing task is to identify the "signatures" of the individual motor units and to decompose the measured signal into the corresponding components.

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Speech Enhancement in Hearing Aids

In noisy environments, the perceived quality of speech signals in hearing aids is often unsatisfactory. We are studying the enhancement of such speech signals in two separate approaches.

1. Use of two microphones. Here we focus on the "blind" identification of linear filters for noise reduction. A first goal is to understand the achievable speech quality by "optimal" linear filtering under a variety of conditions.

2. Model-based nonlinear filtering. We use factor graphs to specify a variety of generalized hidden Markov models and we explore many versions of the summary-product algorithm to clean up the signals.

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Basics of Graphical Models

Most of our research is somehow related to graphical models (factor graphs) and to message passing algorithms on such graphs. We are interested in a wide variety of conceptual and algorithmical issues. Examples include

- applied signal processing by summary propagation

- adaptation and learning

- local formulation of Kalman filtering, expectation maximization, particle methods, etc.

- improved message passing with structured summaries

- electrical networks and other physical systems as factor graphs

- Fourier and Lagrange duality.

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Decoding and Equalization

Equalization is a fundamental topic in communications. We are interested in advanced iterative equalization techniques.

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Analog Signal Processing

Decoding and More in Analog VLSI

Error correcting codes may be represented by "factor graphs", and iterative "probability propagation" decoding operates by "message passing" along the edges of the graph. Back in 1998, we discovered that the factor graph of many error correcting codes (including trellis codes, turbo codes, and low-density parity check codes) can be translated directly into analog transistor circuits that operate in continuous time and in parallel. Such analog decoders are composed of "probability gates", where currents represent probabilities and voltages represent logarithms of probabilities (or of probability ratios). Such analog decoders might allow the use of error correcting codes in applications where digital decoders would be too slow or would consume too much power.

We have built simple decoder chips as well as a collection of "probability gates" as individual integrated circuits; the latter allowes us to put together and to study

several simple decoders on the breadboard level.

More recently, we have extended analog probability-propagation to synchronization. We have demonstrated that a clockless continuous-time circuit can synchronize to a properly designed periodic waveform, even in the presence of substantial noise. This work also sheds some light on the connection between statistical state estimation and the subject of "entrainment" of dynamical systems.

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3.3 Completed Research Projects

Moser Stefan

Duality-Based Bounds on Channel Capacity

ETH Diss.Nr. 15769 (Referee: Prof. Dr. A. Lapidoth)

In his famous 1948 paper "A Mathematical Theory of Communication", Claude E. Shannon derives the ultimate limit of reliable communication - the *channel capacity* - and gives a general expression of this limit as a function of the conditional probability distribution describing the channel. Unfortunately, this expression involves an optimization that is very difficult - if not infeasible - to evaluate analytically or numerically for most channels of interest. Therefore a great interest in good upper and lower bounds to channel capacity exists.

In this thesis a technique is proposed for the derivation of upper bounds on channel capacity. It is based on a dual expression for channel capacity where the maximization (of mutual information) over distributions on the channel input alphabet is replaced with a minimization (of average relative entropy) over distributions on the channel output alphabet. Every choice of an output distribution leads to an upper bound on mutual information. The chosen output distribution need not correspond to any distribution on the channel input. With a judicious choice of output distributions one can often derive tight upper bounds on channel capacity.

Further, a technique is proposed for the analysis of the asymptotic capacity of cost-constrained channels. The technique is based on the observation that - under fairly mild conditions on the channel – any input distribution that achieves a mutual information with the same growth-rate in the cost constraint as the channel capacity must *escape to infinity*; *i.e.*, under such a distribution for any finite cost, the probability of the set of input symbols of lesser cost tends to zero as the cost constraint tends to infinity.

The above techniques are applied to various channels. Firstly, the channel capacity of three channels that model optical communication is investigated: the free-space optical intensity channel, an optical intensity channel with input-dependent noise, and the Poisson channel. In all three cases both a peak- and an average-power constraint are imposed where the average-to-peak-power ratio is to be kept constant. For the free-space optical intensity channel new firm (*i.e.*, not asymptotic) upper and lower bounds are derived that coincide asymptotically for the power constraints tending to infinity where their ratio is held fixed. In the other two cases new firm lower bounds and asymptotic upper bounds are given. In the same asymptotic limit the bounds coincide so that for all three models the capacity is asymptotically precisely known.

Secondly, the above techniques are applied to multiple-antenna flat fading channels with memory where the fading process is assumed to be *regular* (*i.e.*, of finite entropy rate) and where the realization of the fading process is unknown at the transmitter and unknown (or only partially known) at the receiver. It is demonstrated that, for high signal-to-noise ratios (SNR), the capacity of such

channels grows only double-logarithmically in the SNR. To better understand this phenomenon and the rates at which it occurs, the *fading number* is introduced as the second term in the high-SNR asymptotic expansion of capacity, and its value or an estimate on it is derived for various fading channels. It is observed that at rates that are significantly higher than the fading number, communication becomes extremely power inefficient, thus posing a limit on practically achievable rates.

For various fading channels upper and lower bounds on the fading number are presented: for single-input multiple-output (SIMO) fading channels with memory the bounds coincide, thus yielding a complete characterization of the fading number for general stationary and ergodic fading processes with one transmit and one or more receive antennae. It is also demonstrated that for memoryless multiple-input single-output (MISO) fading channels, the fading number is achievable using beam-forming, and an expression for the optimal beam direction is derived. This direction depends on the fading law and is, in general, not the direction that maximizes the SNR on the induced single-input single-output (SISO) channel. Based on a new closed-form expression for the expectation of the logarithm of a non-central chi-square distributed random variable, some closed-form expressions for the fading number of various channels with Gaussian fading are provided, including SISO fading channels with stationary, ergodic, circularly symmetric, Gaussian fading. The fading number of the latter is determined by the fading mean, the fading variance, and the mean squared error in predicting the present fading from its past; it is not directly related to the Doppler spread.

Finally, in the case of regular multiple-input multiple-output (MIMO) fading channels with memory, it is shown that all corresponding bounds that have been derived in this thesis also hold true when there is an additional noiseless feedback link from the receiver to the transmitter. Further, in the asymptotic case, it is shown that the fading number of general SISO fading channels is *not changed* by feedback in spite of possible memory in the fading process. Moreover, for regular SISO fading channels with memory and partial receiver side-information it is shown that noiseless feedback and the disclosure of the partial side-information at the transmitter does not increase the fading number.

In the case of non-regular (*i.e.*, of entropy rate being negative infinity) SISO Gaussian fading with memory, noiseless feedback is shown to have no impact on the *capacity pre-log* (*i.e.*, the ratio of channel capacity to the logarithm of the SNR at high SNR).

3.4 Completed Dissertations

MOSER Stefan   Duality-Based Bounds on Channel Capacity

ETH Diss. Nr. 15769
Referee: Prof. Dr. A. Lapidoth
Co-referee: Prof. Dr. E. Telatar

4. Congresses, Meetings and Committees

4.1 Congress Organization

Prof. Lapidoth

Member of the Technical Programm Committee for the 2004 International Zurich Seminar.

Organizer of the 2004 4th ETH-Technion Workshop on Information and Communication Theory.

Prof. Loeliger

Chairman, 2004 International Zurich Seminar on Communications.

4.2 Participation in Congresses and Meetings

Dauwels Justin	Machine Learning Summer School 2004, Pascal Network, Berder Island, France, 12.- 5.9.2004.
Dauwels Justin	Quantum Systems for Information Technology Workshop, Flums, Switzerland, 5.–7.3.2004.
Dauwels Justin	Research Stay with Digital Communications Research Group, Ghent University, Belgium, 6.–30.1.2004.
Dauwels Justin	Research Stay with Mitsubishi Electric Research Lab, Cambridge, MA, USA, 26.3.-10.6.2004.
Dauwels Justin	Conference on Fundamental Aspects of Complexity, Abdus Salam International Center for Theoretical Physics, Trieste, Italy, 6.–9.9.2004.
Dauwels Justin	Workshop on Statistical Aspects of Electronic Systems, Lavin, Switzerland, 28.–30.10.2004.
Frey Matthias Merkli Patrick	3rd Analog Decoding Workshop, Banff, Canada, 8.–9.6.2004.
Hofbauer Markus	ICA 2004, Granada, Spain, 22.–24.9.2004.
Daniel Hösli	5th International ITG Conference on Source and Channel Coding (SCC), Erlangen, Germany, 14.-16.1.2004.
Daniel Hösli	International Symposium on Information Theory (ISIT) 2004, Chicago, Illinois, USA, 27.6.-2.7.2004.
Koch Volker	26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (IEEE EMBC 2004), San Francisco, CA, USA, 1.–9.2004.
Koch Volker	5th International Scientific Conference on Prevention of Work related Musculoskeletal Discords (Premus 2004), Zurich, Switzerland, 11.-15.7.2004.
Koch Volker	XVth Congress of the International Society of Electrophysiology & Kinesiology (ISEK 2004), Boston, MA, USA, 18.-21.6.2004.
Korl Sascha	ICASSP, International Conference on Acoustics, Speech, and Signal Processing, Montreal, Canada, 17.–21.5.2004.
Lapidoth Amos	International Zurich Seminar on Communications, ETH Zurich, Switzerland, 18.-20.1.2004.

Lapidoth Amos	5th International ITG Conference on Source and Channel Coding (SCC), Erlangen, Germany 14.-16.1.2004.
Lapidoth Amos	IEEE Communication Theory Workshop - Capri, Italy, 5.-8.5.2004.
Lapidoth Amos	IEEE International Symposium on Information Theory (ISIT 2004), Chicago, Illinois, USA, 27.6.-2.7.2004.
Lapidoth Amos	IEEE Workshop on Signal Processing Advances Wireless Communications (SPAWC) 2004, Lissabon, Portugal, 12.-14.7. 2004.
Lapidoth Amos	3rd Joint Workshop on Communications and Coding (JWCC'04), Donnini-Firenze, Italy, 14.10.2004.
Loeliger Hans-Andrea	International Zurich Seminar on Communications, ETH Zurich, Switzerland, 18.-20.1.2004.
Loeliger Hans-Andrea	4th ETH – Technion Information Theory Workshop, Zurich, Switzerland, 16.–17.2.2004.
Loeliger Hans-Andrea	Newcom Scientific Meeting, Torino, Italy, 18.-19.3.2004.
Loeliger Hans-Andrea	ISCCSP 2004, Hammamet, Tunesia, 20.-27.3.2004.
Loeliger Hans-Andrea	ISIT 2004, Chicago, USA, 27.6.-2.7.2004.
Loeliger Hans-Andrea Ostojic Maja	42nd Allerton Conference on Communications and Computing, Allerton House, Monticello, Illinois, USA, 29.9.-1.10.04.
Loeliger Hans-Andrea	Scuola Normale Superiore Workshop, Pisa, Italy, 29.–30.11.2004.
Miliou Natalia	4th ETH - Technion Information Theory Workshop, ETH Zurich, Switzerland, 16.-17.2.2004.
Miliou Natalia	International Zurich Seminar on Communications, ETH Zurich, Switzerland, 18.-20.2.2004.
Miliou Natalia	International Symposium on Information Theory, Chicago, Illinois, USA, 27.6.-2.7.2004.
Moser Stefan	4th ETH-Technion Workshop, ETH, Zurich, Switzerland, 16.-17.2.2004.
Moser Stefan	2004 International Zurich Seminar on Communications, ETH, Zurich, Switzerland, 18.2.-20.2.2004.
Moser Stefan	23rd Convention of Electrical & Electronics Engineers (IEEEI 2004), Herzlia, Israel, 6.9.-7.9.2004.

Moser Stefan   2004 International Symposium on Information
                                  Theory and its Applications (ISITA'04), Parma,
                                  Italy, 10.10.-13.10.2004.

4.3 Service Activities and Society Memberships

Prof. Lapidoth

Fellow of the IEEE

Member of the IMS Institute of Mathematical Statistics,
Bethesda, USA

Associate Editor for Shannon Theory, IEEE New York

Research Affiliate in the Research Laboratory of Electronics (RLE) at
the Massachusetts Institute of Technology (MIT)

Member of the Center for Communication and Information
Technologies (CCIT), Technion, Haifa, Israel

Prof. Loeliger

Fellow of the IEEE

Chairman of the IEEE Switzerland Chapter on Digital
Communication Systems

Member of the Proposal Preparation Committee of NEWCOM

Dr. Heutschi

Member of the Acoustical Society of America

Member of the Audio Engineering Society

Member of the Swiss Acoustical Society (SGA)

Member of the German Acoustical Socyety (DEGA)

Associate Editor for Acta Acustica united with Acustica

4.4 Presentations by Institute Members

Dauwels Justin	"An analog circuit that locks onto a pseudo-noise signal", Kanazawa Institute of Technology, Japan, 16.12.2004.
Dauwels Justin	"Message passing factor graphs and analog circuits, school and conference on fundamental aspects of complexity", Abdus Salam International Center for Theoretical Physics, Trieste, Italy, 6.-9.9.2004.
Dauwels Justin	"An analog circuit that locks onto a pseudo-noise signal", Workshop on Statistical Aspects of Electronic Systems, Lavin, Switzerland, 28.-30.10.2004.
Frey Matthias Merkli Patrick	"An analog circuit that locks onto a pseudo-noise signal", 3rd Analog Decoding Workshop, Banff, Canada, 8.-9.6.2004.
Frey Matthias Merkli Patrick	"A brief introduction to analog decoding", Presentation for visitors from Israel, ETH Zurich, Switzerland, 22.6.2004.
Hofbauer Markus	"Optimale Lineare Separation und Entfaltung von ueberlagerten akustischen Quellen", Swisscom Innovations, Berne, Switzerland, 14.12.2004.
Hösli Daniel Lapidoth Amos	"The capacity of a MIMO ricean channel is monotonic in the singular values of the mean", 5th International ITG conference on Source and Channel Coding (SCC), Erlangen, 16.1.2004
Hösli Daniel	"How good is an isotropic gaussian input on a MIMO ricean channel?", IEEE International Symposium on Information Theory (ISIT 2004), Chicago, Illinois, USA, 27.6.-2.7.2004.
Hösli Daniel	"Dialog- und gestaltungsorientierte Analyse der Situation des Mittelbaus am Departement fuer Informationstechnologie und Elektrotechnik der ETH Zürich zur Identifikation von Handlungsfeldern" Abschlussvortrag mit Volker Koch im Rahmen der Nachdiplomarbeit in Betriebswissenschaften am D-MTEC, ETH Zurich, Switzerland, 3.11.2004.
Koch Tobias	"On the capacity of noncoherent fading channels", Bell Laboratories, Lucent Technologies, Murray Hill, NJ, USA, 8.10.2004.
Koch Volker M.	"Decomposition of electromyographic signals by iterative message passing in a graphical model", 26th Annual International Conference IEEE.

	Engineering in Medicine and Biology Society (EMBC 2004), San Francisco, CA, USA, 1.-5.9.2004.
Koch Volker M.	"A novel EMG signal decomposition approach using a graphical model and an iterative algorithm", Fifth International Scientific Conference on Prevention of Work related Musculoskeletal Disorder (Premus 2004), Zurich, Switzerland, 11.-15.7.2004.
Koch Volker M.	"A new EMG signal decomposition approach using factor graphs", XVth Congress of the International Society of Electrophysiology & Kinesiology (ISEK 2004), Boston, USA, 18.-21.6.2004.
Lapidoth Amos	"On the capacity of fading channels at high SNR: facts and artifacts", Technion, Haifa, Israel, 1.1.2004.
Lapidoth Amos	"The truth about capacity calculations for fading channels", Royal Institute of Technology (KTH), Signal Processing, Stockholm, Sweden, 1.9.2004.
Lapidoth Amos	"On the capacity of non-coherent fading networks", Third Joint Workshop on Communications and Coding (JWCC '04), Donnini – Firenze, Italy,14.-17.10.2004.
Lapidoth Amos	"On the high-SNR capacity of non-coherent networks", Department Colloquium of the Bar-Ilan School of Engineering, Bar-Ilan University, Ramat-Gan, Israel, 9.12.2004.
Loeliger Hans-Andrea	"Signal processing with factor graphs", 4th ETH – Technion Information Theory Workshop, Zurich, Switzerland, 16.-17.2.2004.
Loeliger Hans-Andrea	"Signal processing with factor graphs: examples", ISCCSP 2004, Hammamet, Tunesia, 20.-27.3.2004.
Loeliger Hans-Andrea	"On Markov structured summary propagation and LFSR synchronization", 42nd Allerton Conference on Communication, Control, and Computing, Allerton House, Monticello, USA, 29.9.-1.10.2004.
Loeliger Hans-Andrea	"On factor graphs and message passing algorithms" Workshop Scuola Normale Superiore, Pisa, Italy, 29.-30.11.2004.
Miliou Natalia	"Duality bounds on the cut-off rate with applications to ricean fading", IEEE International Symposium on Information Theory (ISIT 2004), Chicago, Illinois, USA, 2.7.2004.
Moser Stefan	"Feedback increases neither the fading number nor the pre-log", 23rd Convention of Electrical & Electronics Engineers (IEEE 2004), Herzlia, Israel, 7.9.2004.
Moser Stefan	"Duality-based bounds on channel capacity", EPFL, Lausanne, Switzerland, 15.9.2004.

Moser Stefan   "The fading number of SIMO fading channels with
                                memory", International Symposium on Information
                                Theory and its Applications (ISITA'04), Parma, Italy,
                                11.10.2004.

4.5 Organization of Lectures, Seminars, and Colloquia

Colloquium Speakers for the Colloquium "Electronics and Communications" were:

Invited by Prof. Lapidoth:

17.05.2004   **Prof. Gregory Wornell**, Department of Electrical Engineering and Computer Science. Massachusetts Institute of Technology, "Provably Good Multimedia Content Authentication Systems".

29.04.2004   **Ofer Zeitouni,** University of Minnesota and Technion, Israel, "Concentration, Cental Limit Theorems, and Large Deviations for Large Random Matrices".

02.08.2004   **Prof. Shlomo Shamai**, Technion, Haifa, Israel, "Pragmatic Cooperative Transmission on the Downlink to Collocated Terminals".

23.09.2004   **Dr. Gerhard Kramer**, Bell Laboratories, Murray Hill, NJ, USA, "Models and Theory for Relay Channels with Receive Constraints".

Invited by Prof. Loeliger:

15.06.2004   **Prof. Li Ping,** City University of Hong Kong, "Interleave-Division Multiple-Access".

04.08.04   **Dr. Martin Hänggi,** University of Notre Dame, Notre Dame, USA, "The Geometry of Wireless Ad Hoc and Sensor Networks with Fading".

16.09.2004   **Mehdi Molkaraie,** EPF Lausanne, Switzerland, "On Belief Propagation and Statistical Physics".

06.10.2004   **Mehdi Molkaraie,** EPF Lausanne, Switzerland, "Energy minimization, graph theory and iterative algorithms".

22.11.2004   **Prof. A. Singer,** University of Illinois at Urbana-Champaign, USA, "Topics in Universal Prediction and Filtering".

Invited by Dr. Heutschi

21.01.04   **Georg Thomann, Dipl. Umwelting,** ETH, Akustik, EMPA Dübendorf, Switzerland,

"Physikalische Grundlagen und die Zuverlässigkeit von Fluglärmsituationen am Beispiel von FLULA".

28.01.04 **Dr. phil. Mark R. Brink,** Hygiene und Arbeitsphysiologie, ETH Zurich, Switzerland,
"Schlafqualität und Fluglärm in den Nachtrandstunden: Methodik und erste Ergebnisse einer laufenden Feldstudie im Umkreis des Zürcher Flughafens".

04.02.04 **Katja Wirth, lic.phil.I,** Hygiene und Arbeitsphysiologie, ETH Zurich, Switzerland,
"Wie lärmbelastigt sind Flughafenanwohner? Fakten und Hintergründe".

12.05.04 **Heinrich A. Metzen, Dipl.-Ing.,** DataKustik GmbH, Greifenberg, Germany,
"Bauakustische Auralisation – Praktisches Hilfsmittel oder Spielerei?"

23.06.04 **Karl-Wilhelm Hirsch, Dr.-Ing.,** Institut für Lärmschutz, Dusseldorf, Germany,
"Physikalische und lärmakustische Aspekte des Schiesslärms".

10.11.04 **Dr. H-E de Bree**, R&D Microflown Technologies, AH Zevenaar, The Netherlands,
"The Microflown, a dedicated acoustical particle velocity sensor enabling new applications in the world of sound & vibrations".

5. Publications

Dauwels J.,
Loeliger H.-A.,
Merkli P.,
Ostojic M.

"On Markov-structured summary propagation and LFSR synchronization", Proc. 42nd Allerton Conf. on Communication, Control, and Computing, Monticello, Illinois, Sept. 29 - Oct. 1, 2004.

Dauwels, J.,
Loeliger H.-A.

"Phase estimation by message passing", Proc. 2004 IEEE Int. Conf. on Communications, pp. 523-527, Paris, June 20-24, 2004.

Dauwels J.,
Loeliger H.-A.

"Computation of information rates by particle methods", Proc. 2004 IEEE International Symposium on Information Theory, p. 178, Chicago, USA, June 27 - July 2, 2004.

Dauwels J.,
Wymeersch H.,
Loeliger H.-A.,
Moeneclaey M.

"Phase estimation and phase ambiguity resolution by message passing", Proc. 11th International Conference on Telecommunications and Networking, pp. 150-155, Fortaleza, Brazil, August 1-6, 2004.

Hoesli Daniel,
Lapidoth Amos

"The capacity of a MIMO ricean channel is monotonic in the singular values of the mean", Proceedings of the 5th International ITG Conference on Source and Channel Coding (SCC), Erlangen, Nuremberg, January 14-16, 2004.

Hoesli Daniel,
Lapidoth Amos

"How good is an isotropic gaussian input on a MIMO ricean channel?", Proceedings 2004 IEEE International Symposium on Information Theory (ISIT'04), p. 291, June 27 - July 2, 2004, 2004.

Hoesli Daniel,
Lapidoth Amos

"Monotonicity results for coherent MIMO ricean channels", arXiv:cs.IT/0412060, Dec, 13, 2004.

Hofbauer Markus

"On the FIR Inversion of an acoustical convolutive mixing system: properties and limitations", ICA 2004, Independent Component Analysis and Blind Signal Separation, G. Puntonet, September, ICA, Springer, 2004.

Koch V. M.,
Loeliger H.-A.

"A new EMG signal decomposition approach using factor graphs", Proc. of the XVth Congress of the International Society of Electrophysiology & Kinesiology (ISEK 2004), p. 65, Boston, USA, June 18-21, 2004.

Koch V. M.,
Loeliger H.-A.

"A novel EMG signal decomposition approach using a graphical model and an iterative algorithm", Proc. of the Fifth international scientific conference on prevention of work related musculoskeletal disorders (Premus 2004), pp. 243-244, Zurich, Switzerland, July

	11-15, 2004.
Koch V. M., Loeliger H.-A.	"Decomposition of electromyographic signals by iterative message passing in a graphical model", Proc. of the 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (IEEE EMBC 2004), pp. 65-68, San Francisco, USA, September 1-5, 2004.
Korl S., Loeliger H.-A., Lindgren A.G.	"AR model parameter estimation: from factor graphs to algorithms", Proc. ICASSP'04, vol. V, pp. 509-512, Montreal, Canada, May 17-21, 2004.
Lapidoth Amos	"On the capacity of non-coherent fading networks", Proceedings Third Joint Workshop on Communications and Coding (JWCC'04), Donnini-Firenze, Italy, Oct. 14-17, 2004.
Lapidoth Amos	"On the high-SNR capacity of non-coherent networks", arXiv:cs.IT/0411098, Nov 29, 2004.
Lapidoth Amos, Miliou Natalia	"Duality bounds on the cut-off rate with applications to ricean fading", Proceedings 2004 IEEE International Symposium on Information Theory (ISIT '04), p. 544, 2004.
Lapidoth Amos, Moser Stefan M.	"Feedback increases neither the fading number nor the pre-log", Proceedings 23rd IEEE Convention of Electrical & Electronics Engineers in Israel (IEEEI'04), Herzlia, Israel, Sept. 6 - 7, 2004.
Lapidoth Amos, Moser Stefan M.	"The fading number of SIMO fading channels with memory", Proceedings International Symposium on Information Theory and its Applicatons (ISITA'04), pp. 287-292, Parma, Italy, Oct. 10-13, 2004.
Lapidoth Amos, Moser Stefan M.	"The fading number of single-input multiple-output fading channels with memory", submitted to IEEE Transactions on Information Theory, 2004.
Loeliger H.-A.	"An introduction to factor graphs", IEEE Signal Processing Mag., pp. 28-41, Jan., 2004.
Loeliger H.-A., Dauwels J., Koch V.M., Korl S.	"Signal processing with factor graphs: examples", Proc. First Int. Symp. on Control, Communications and Signal Processing, pp. 571-574, Hammamet, Tunisia, March 21-24, 2004.

6. Guests, Visitors

6.1 Activities of Academic Guests at the Institute

Guests of Prof. Lapidoth:

Ofer Zeitouni,
Universtiy of Minnesota and Technion,
Minicourse "Concentration, central limit
theorems, and large deviations for large
random matrices".   29.04.2004

Guests of Prof. Loeliger:

Dr. Gerhard Krämer,
Lucent Technologies, New Jersey, USA,
Lectures on "Topics in Multi-Terminal Information
Theory".   08.05.-30.05.04

Prof. Ping Li,
City University of Hong Kong, Kowloon, Hong Kong,
collaboration with Prof. Loeliger and presented a talk on
 "Interleave-Division Multiple-Access".   01.06.-15.10.04

Mehdi Molkaraie,
EPF Lausanne, Switzerland,
collaboration with Prof. Loeliger and J. Dauwels,
presented two talks on: "On Belief Propagation and
Statistical Physics" and "Energy minimization, graph theory
and iterative algorithms".   05.09-15.10.04

Prof. A. Singer,
University of Illinois at Urbana-Champaign, Urbana, IL, USA,
presented a talk on "Topics in Universal Prediction and
Filtering".   21.11.-22.11.04