EURANDOM

Annual Report 2005

EURANDOM is a European research institute for Statistics, Probability, Stochastic Operations Research and their Applications, founded June 30, 1997.

Mission statement

The mission of EURANDOM is to foster research in the stochastic sciences and their applications. It achieves this mission:

- by recruiting and training talented young researchers and helping them to find their way to tenured positions in academia and industry;
- by carrying out and facilitating research through postdoctoral and graduate appointments, visitor exchange and workshops;
- and by taking initiatives for collaborative research at the European level.

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1. PREFACE

Introduction
EURANDOM is a European institute for the study of random phenomena. It performs research in statistics, probability, stochastic operations research and its applications.

Evaluation
One of the most important events in 2005 for the institute was the evaluation of the institute by an international committee chaired by Peter Glynn (Stanford), which visited us in August. The evaluation was requested and organised by the Netherlands Organisation for Scientific Research (Nederlandse Organisatie voor Wetenschappelijk Onderzoek - NWO). We are very proud that the review was extremely positive, EURANDOM receiving excellent scores. In its report the panel states that, "In the seven years of its existence, EURANDOM has become a pre-eminent center for the study of stochastics, playing a key role in the development of the discipline both locally within The Netherlands and globally within Europe and beyond." The panel made several valuable suggestions. As a follow-up, EURANDOM has made some adaptations to the structure of the SIM (statistics) programme, and is enlarging the relations with several departments of TU/e.

People
On December 31, 2005, EURANDOM had a scientific staff of 17 postdocs and 6 PhD students. 11 junior researchers left the institute; most of them obtained a tenured position in academia. One third of our junior staff are women. Chapter 4 contains a sample of the research of one of the junior reseachers, Johan van Leeuwaarden, who defended his PhD thesis at TU/e in June 2005 (cum laude).

EURANDOM decided to formalise the regular visits and contributions of some of its former postdocs, by "appointing" them as Research fellow: Luis Artiles Martinez, Adriana Gabor (until October 2005), Peter Grünwald, Madalin Guta, Patrick Lindsey and Nelli Litvak.

Sara van de Geer stepped down as scientific advisor as she moved from the University of Leiden to ETH Zürich.
William Rey stepped down as advisor, as the BMM project was ended.

Scientific activities
EURANDOM hosted 10 workshops in 2005, and 45 visitors for a total period of a few days up to 2 months. Professor Francois Baccelli was EURANDOM professor 2004/2005. He visited the institute monthly between October 2004 and May 2005, and gave a Mini-course on "Stochastic Geometry and Wireless Modeling".

In May 2005 EURANDOM welcomed as EURANDOM professor Sid Resnick, professor and director of the School of Operations Research and Industrial Engineering at Cornell University, USA. His research activities focus on applied probability and sometimes cross the boundary into statistics. He gave a public lecture and a Mini-course on "Heavy Tailed Analysis".

During the months August and September, Professor Offer Kella (Hebrew University of Jerusalem, Israel) stayed at EURANDOM as Stieltjes Professor. He gave a public lecture at CWI during the annual Stieltjes afternoon, and a Mini-course at the Vrije Universiteit. We are grateful to the Thomas Stieltjes Institute (a research school through which several Dutch mathematics departments collaborate) for making this visit possible.

Board
Professor Rutger van Santen stepped down as rector of TU/e and therefore as member of the board of EURANDOM. He was succeeded by the new rector of TU/e, Professor Hans van Duijn.

Professor Cor Baayen stepped down as member of the board (member on behalf of NWO) and was succeeded by Jan Karel Lenstra (director CWI). We thank both departing board members for their creative guidance and strong support.

Scientific Council
The Scientific Council met on September 23 and 24. Key points on the agenda were the results of the evaluation, and the future development of EURANDOM.

Professor Claudia Klüppelberg left the Scientific Council. The management of EURANDOM is grateful for her valuable contributions. Professor Volker Schmidt (Universität Ulm) has been appointed as new member.

On Saturday morning, the members of the council attended lectures by EURANDOM alumni Peter Grünwald, Madalin Guta and Silke Rolles, in the framework of a meeting of the alumni network. EURANDOM values this network highly. Based on an exchange of information (personal and professional), we try to keep track of former EURANDOM researchers.

Change of Directorship

The meetings of the Scientific Council and of the alumni were linked with a "stochastic afternoon" http://ww.eurandom.tue.nl/workshops/2005/ISS/stochasticsafternoon_23sept.htm) that marked the change in directorship of EURANDOM.
Frank den Hollander left EURANDOM as scientific director, accepting the chair of Probability Theory in the University of Leiden, and Henry Wynn left as scientific co-director. I have taken over as scientific director.

EURANDOM is much indebted to both Frank den Hollander and Henry Wynn for their major contributions towards making EURANDOM the wonderful place it presently is: an institute with many talented young researchers, bustling with workshops, seminars and other activities, and hosting large groups of visitors.

Frank den Hollander, who was appointed as member of the Royal Dutch Academy of Sciences (KNAW) in the course of the year, has served EURANDOM from the beginning as scientific advisor, and for the past five years as scientific director. A workshop (http://www.eurandom.tue.nl/workshops/2005/ISS/ISS_main.htm) was organised in his honour.

I am very happy that EURANDOM will continue to benefit from his wisdom and scientific excellence, a.o. via his continuing role as scientific advisor of the RSS programme.

Onno Boxma
Scientific Director
May 2006

2. THE INSTITUTE

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2.1. Management

EURANDOM is a foundation with the mission to enhance scientific research in statistics, probability and stochastic operations research and its applications in Europe. To realise this goal the foundation has established a research institute with the same name.

The **Board** of the foundation consists of:
- Dr.ir. J.M.M. Ritzen (chair);
- Professor dr. J.K. Lenstra (member) since January 1, 2005;
- Professor dr. R.A. van Santen (member), until March 1, 2005;
- Professor dr.ir. C.J. van Duijn (member), since April 1, 2005.

Directors
- Professor W.Th.F. den Hollander, scientific director (TU/e, Universiteit Leiden & EURANDOM), until October 1, 2005;
- Professor O.J. Boxma (TU/e & EURANDOM), since October 1, 2005;
- Professor H.P. Wynn, scientific co-director (London School of Economics, United Kingdom & EURANDOM), until October 1, 2005;
- Ir. W.J.M. Senden, managing director.

2.2. Scientific Council

EURANDOM has a Scientific Council, which advises the Board and the directors on the scientific programme and on strategic research issues. The following scientists serve as member of the Scientific Council:

- Professor S. Asmussen, Department of Mathematical Statistics, Lund University, Sweden
- Professor F. Baccelli, École Normale Supérieure, Paris, France
- Professor E. Bolthausen, Universität Zürich, Switzerland
- Professor S. Borst, Centrum voor Wiskunde en Informatica, Amsterdam, The Netherlands
- Professor D. Dawson (chair), Carleton University, Ottawa & McGill University, Montreal, Canada
- Professor F. Delbaen, Eidgenössische Technische Hochschule Zürich, Department of Mathematics, Zürich, Switzerland
- Professor A. Frigessi, University of Oslo, Norway
- Professor P. Green, University of Bristol, United Kingdom
- Professor A. Greven, Mathematisches Institut, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany
- Professor P. Hall, Centre for Mathematics and its Applications, Australian National University, Canberra, Australia
- Professor C. Klüppelberg, Technische Universität München, Germany
- Professor P. Massart, Université Paris Sud XI, Orsay, France
- Professor N. Veraverbeke, Hasselt University, Diepenbeek, Belgium.

New member as of July 1, 2005:
- Professor V. Schmidt, Universität Ulm, Germany

Member who stepped down in 2005:
- Professor C. Klüppelberg, Technische Universität München, Germany

The Scientific Council of EURANDOM met on September 24, 2005 directly after the workshop *Interacting Stochastic Systems* (September 20-23, 2005) and the *Stochastics Afternoon* (September 23, 2005). Main items on the agenda were the outcome of the self-evaluation, possibilities for cooperation and the future development of EURANDOM.

2.3. Scientific Advisors and Steering Committees

The research of EURANDOM consists of three programmes. Each programme is led by senior scientists who supervise the programme and provide guidance to the research of the postdoctoral fellows (PDs) and graduate students (PhDs). The activities in each programme are overseen by an international steering committee.

Queueing and Performance Analysis (QPA)

Scientific advisors
- Dr. I. Adan (TU/e)
- Professor R. Boucherie (Universiteit Twente)
- Professor O.J. Boxma (TU/e)
- Professor M. Mandjes (CWI & Universiteit van Amsterdam)

Steering committee
- Professor F. Baccelli (École Normale Supérieure, Paris, France)
- Professor S.G. Foss (Heriot Watt University, Edinburgh, United Kingdom)
- Professor O. Kella (The Hebrew University of Jerusalem, Israel)
- Professor F.P. Kelly (Cambridge University, United Kingdom)
- Professor G. Koole (Vrije Universiteit Amsterdam)
- Professor J. Wessels (TU/e, The Netherlands)

Random Spatial Structures (RSS)

Scientific advisors
- Professor R. van der Hofstad (TU/e)
- Professor W.Th.F. den Hollander (Universiteit Leiden)

Steering committee
- Professor E. Bolthausen (Universität Zürich, Switzerland)
- Professor A. Bovier (Weierstrass Institut & Technische Universität Berlin, Germany)
- Professor A.C.D. van Enter (Universiteit Groningen, The Netherlands)
- Professor G.R. Grimmett (University of Cambridge, United Kingdom)
- Professor C. Maes (Katholieke Universiteit Leuven, Belgium)
- Professor R. Meester (Vrije Universiteit Amsterdam, The Netherlands)
- Professor E. Olivieri (Università degli Studi di Roma 'Tor Vergata', Italy)
- Professor V. Sidoravicius (Instituto de Matématica Pura e Aplicada, Rio de Janeiro, Brasil)
- Professor J. Steif (Chalmers Tekniska Högskola, Gothenborg, Sweden)

Statistical Information and Modelling (SIM)

Scientific advisors
- Dr. A. Di Bucchianico (TU/e)
- Professor S. van de Geer (Universiteit Leiden), *until October 2005*
- Professor R. Gill (Universiteit Utrecht)
- Dr. M. de Gunst (Vrije Universiteit Amsterdam)
- Professor C.A.J. Klaassen (Universiteit van Amsterdam)
- Professor H. Wynn (London School of Economics, United Kingdom), *until September 2005*

Steering committee
- Professor P. Donelly (University of Oxford, United Kingdom)
- Professor U. Gather (Universität-Dortmund, Germany)
- Professor P. Green (University of Bristol, United Kingdom)
- Professor M. Newby (City University, London, United Kingdom)
- Professor S. Tavaré (University of South Carolina, United States of America)
- Professor A. Tsybakov (Université Paris VI, France)

In addition to these programmes, two projects were still running in 2005 but also ended in 2005:

Battery Modelling and Management (BMM)

Scientific advisor
- Dr. W. Rey (Philips Research Laboratories, The Netherlands)

At the end of 2005 a follow-up of this project, i-BAT, has been approved by SenterNovem (Innovatiesubsidie Samenwerkingsprojecten of the Dutch Ministry of Economic Affairs).

Reinsurance (RI)

Scientific advisor
- Professor J. Teugels (Katholieke Universiteit Leuven, Belgium)

As a sequel of this project a workshop will be organised on *Risk Measures and Risk Management for High-Frequency Data* within the MATHFSS project.
Another result is the idea to establish a new subtheme - Multivariate Risk Modelling - within the Queueing and Performance Analysis programme.

2.4. Scientific staff

The junior scientific staff of EURANDOM consists of:
- PDs with appointments from 6 months up to 2-3 years;
- PhDs with appointments of 3-4 years;
- Research fellows with part-time 1–year appointments.

During the year 19 junior researchers were (co-)financed by external funds, from which:

In natura (6):
- 1 PhD via an appointment at the Vrije Universiteit Amsterdam, NWO-VIDI grant;
- 1 PD since November 2004 and 1 PD since January 2005, both via an appointment at the Universiteit Leiden, NWO Open Competition grant;
- 1 PD since April 2004 and 1 other PD since September 2005, both via an appointment at the Mathematics Department of the TU/e, NWO-VIDI grant
- 1 PhD (since July 2005) via TU/e, Department of Mathematics, NWO Open Competition

Industry (7):
- 1 PhD (until June 2005), 1 PhD (since December 2005) and 1 PD (until November 2005) working on a contract with Philips;
- 1 PhD (until September 2005) working on an EET contract with Philips;
- 1 PD (until April 2005) and 1 PhD (until April 2005), both working on an EET contract with Flextronics, the TU/e Department of Technology Management, and EURANDOM;
- 1 PD position on a Vodafone contract (since December 2004)

Other: NWO Open Competition, Marie Curie Individual Fellowships, BRICKS (6):
- 1 PD with a NWO Open Competition grant (since February 2004) and 1 PD with a NWO Open Competition grant (since November 2005);
- 1 PD with a NWO Open Competition grant (until October 2005);
- 1 PD with a Marie Curie Individual Fellowship (until September 2005);
- 1 PD with BRICKS funding via the TU/e Department of Mathematics and Computer Science (since October 2004);
- 1 PD (since September 2005) in a joint employment with the Department of Mathematics and Computer Science, TU/e.

On December 31, 2005, **23** researchers (PDs and PhDs) were working at EURANDOM and 1 junior researcher was closely linked to the research at the institute, via the Scientific advisor R. van der Hofstad.

Queueing and Performance Analysis

Postdocs:
- Dr. D. Denisov (since October 2004) - partly on BRICKS funding
- Dr. H.P. Tan (since December 2004) - Vodafone contract
- Dr. E. Tzenova (since September 2004)
- Dr. A. Gabor (since September 2005) - partly financed by NWO VICI grant of Prof. G. Woeginger, TU/e
- Dr. Bernardo D'Auria (since February 2005)
- Dr. J. van Leeuwaarden (since September 2005)

PhDs:
- J. van Leeuwaarden (until June 2005) - industry contract with Philips
- M. Vlasiou (since September 2002)
- P. Beekhuizen (since December 2005)

Research Fellows:
- Dr. N. Litvak (Universiteit Twente)
- Dr. A. Bumb (Universiteit Twente) *until September 2005*

Random Spatial Structures

Postdocs:

- Dr. F. Camia (April 2003 - September 2005) - Marie Curie Individual Fellowship since February 2004
- Dr. G. Maillard (since February 2004) - NWO Open Competition grant, Prof.dr. W.Th.F. den Hollander
- Dr. R.-J. Messikh (until September 2005)
- Dr. A. Sakai (since March 2004) - NWO-VIDI grant, Prof.dr. R. van der Hofstad
- Dr. R. Sun (since October 2004)
- Dr. D. Znamenski (October 2003 - October 2005) - NWO Open Competition grant, Prof.dr. R. van der Hofstad
- Dr. C. Giardina (since January 2005) - NWO Open Competition, Dr. F. Redig (Universiteit Leiden)
- Dr. N. Pétrélis (since November 2005) - NWO Open Competition grant, Prof.dr. W.Th.F. den Hollander
- Dr. M. Holmes (since September 2005) - NWO VIDI grant, Prof.dr. R. van der Hofstad
- Dr. M. van Wieren (since September 2005)

PhDs:

- A. Fey-den Boer (since March 2004), NWO-VICI grant, Dr. F. Redig and Prof.dr. R. Meester (Vrije Universiteit Amsterdam)

Statistical Information and Modelling

Postdocs:

- Dr. W. Bergsma (September 2003 - August 2005), partly on industry contract
- Dr. F. Enikeeva (May 2003 - June 2005)
- Dr. A. Koloydenko (October 2002 - September 2005), partly industry contract with Philips Medical Systems
- Dr. N. Lalam (since February 2004)
- Dr. L. Mohammadi (since November 2004) - NWO Open Competiton grant, Prof.dr. S. van der Geer (Universiteit Leiden)
- Dr. F. Rigat (since September 2004)
- Dr. V. Kulikov (until February 2005)

PhDs:

- T. Figarella (since June 2003), partly industry contract
- P. van de Ven (since February 2003)
- I. Corro Ramos (since July 2005) - NWO Open Competition grant, Dr. S. Di Bucchianico (TU/e)

Research Fellows:

- Dr. P. Lindsey (Universiteit Maastricht)
- Dr. P. Grünwald (CWI Amsterdam)
- Dr. L. Artiles Martinez (freelance consultant)
- Dr. M. Guta (Radboud Universiteit Nijmegen).

Stochastics of Extremes and Risk Analysis / Reinsurance

Postdocs:

- Dr. M. Sarma (May 2003 - June 2005)
- Dr. S. Ladoucette (March 2003 - March 2005)

Battery Modelling and Management

Postdoc:

- Dr. D. Danilov (October 2002 - October 2005)

PhD:

- I. Snihir (September 2003), partly industry contract

For details on the work of the researchers, see Chapter 3, section 3.4.1. For more information about their publications, see Chapter 5, section 5.1 and 5.2.

2.5. Administrative support

- Mrs. M.E.J.G.H. Brangers-Lempens - management assistant (April 2001) 0,9 fte
- Drs. C.M.M. Cantrijn - policy officer (October 1997) 0,8 fte
- Mrs. L. Coolen-van Will - workshop officer (June 1998) 0,7 fte
- Ms. F. Drouvin - temporary secretary (April - October)
- Ms. A. Goth, workshop assistant (April 2005) - 0,1 fte
- Drs. J.J. Kamperman - personnel officer (October 1998) 0,8 fte (maternity leave April - October)
- Mrs. P.M. Koorn-van Hulten - administrative officer (January 2003) 0,5 fte

The scientific and administrative staff is appointed by the TU/e and seconded to EURANDOM.

From TU/e assistance was received in the following areas:

- Legal, social and financial administration of personnel - Department of Personnel Affairs;
- Financial administration of the organisational unit and of the foundation - Department of Economics and Financial Affairs;
- Housing (including heating, building services, etc.) - Department of Housing;
- Arranging for accommodation in the University Guest House - Student Service Centre;
- Support and advice on visa matters - Back-Office Personnel Department;
- Library services, especially from the Department of Mathematics and Computer Science;
- Installation and management of the EURANDOM computing facilities - Department ICT Services;
- Assistance with the organisation of workshops and conferences and printing services - Department of Internal Affairs.

A total of 31 persons were employed by TU/e - EURANDOM on December 31, 2005, including the managing director and the support staff (consisting of 7 persons). In addition, 11 senior scientists were associated with EURANDOM as scientific advisor and 6 scientists were associated as research fellow.

In 2005 8 people started to work at EURANDOM, 11 people left EURANDOM.

3. RESEARCH PROGRAMMES

The research description below is listed under the name of the principal investigator, but collaboration is the normal way of work at EURANDOM.

For details concerning the scientific results obtained, we refer to the publications of the researchers and to the EURANDOM Report series. *See Chapter 5, section 5.1. and 5.2.*

3.1. Queueing and Performance Analysis (QPA)

Scientific advisors for this programme are Ivo Adan (TU/e), Richard Boucherie (Universiteit Twente), Onno Boxma (TU/e and CWI) and Michel Mandjes (CWI and Universiteit van Amsterdam).

Queueing phenomena occur in several real-life situations when resources (machines at a factory, elevators, telephone lines, traffic lights) cannot immediately render the amount or the kind of service required by their users. Similar congestion phenomena also arise at the byte level, in modern data-handling technologies (communication systems, computer networks); they are typically less visible but their effects at user level are usually not less serious. Such congestion phenomena are often very effectively studied by mathematical methods from queueing theory. Adopting the abstract terminology from queueing theory, the object of study is formulated as a network of service units with customers requiring services at those units. The nature of the arrival and service processes is usually such that they have to be represented by stochastic processes. Accordingly, queueing theory is an area of applied probability theory and of stochastic operations research.

Queueing theory is an extremely active area of research. One of the key reasons for its strong viability is that, time and again, interesting new questions from, mainly, computer-communications and manufacturing give rise to new and challenging queueing problems. Much research is being triggered by the need to understand and control the behaviour of modern computer-, communication- and manufacturing systems, and thus to improve their design and performance.

Information and communication technology is a vital sector in today's world economy. The future development of this field strongly depends on contributions from mathematics. In the early stages of this development in the design of computer-communication systems, the emphasis was on functionality. In recent years quality of service has become the most important criterion, which is expressed in terms of performance and reliability of the systems in relation to telematics applications. Queueing networks also provide the models for the description of manufacturing systems and for the analysis of their performance and reliability aspects. These economically vital applications of queueing networks make this project of prime interest.

The goal of this programme is to give a strong impetus to the analysis of queueing systems and their applicability to the performance analysis of computer-, communication- and production networks. The programme consists of three themes:

- Queueing Theory
- Performance Analysis of Production Systems
- Performance Analysis of Communication Systems

The programme keeps close ties with the Stochastic Operations Research group (SOR) at the TU/e Department of Mathematics and Computer Science. Several members of the latter group are involved in the activities of the project, including Dr. I. Adan, Professor S. Borst, Professor O. Boxma, Dr. R. Núñez-Queija, Dr. J. Resing, Professor J. van der Wal and Dr. A.P. Zwart, as well as a number of PhDs. There are also several interactions with researchers from the group of Professor M. Mandjes at CWI, Professor R. Boucherie's group at the Universiteit Twente, and other institutes.

3.1.1. Summary of the research by members of the QPA group

Ivo Adan worked on various stochastic models. Together with E. Tzenova, M. Mandjes (UvA) and W. Scheinhardt (UT) he worked on the asymptotics for networks of two fluid queues.
He also continued to work with M. Vlasiou on the analysis of a Lindley-type equation, arising from a carousel application.
Further, he worked with G.-J. van Houtum (TU/e) on a mixed lost-sales backordering inventory problem with two customer classes. Together with J. Vissers (Erasmus MC, Prismant) and N. Dellaert (TU/e), he studied admission planning concepts in hospitals.

Bernardo D'Auria has studied a general decomposition formula that is valid for M/G/ω queues in random environments. In addition I have developed a geometric-probabilistic approach to study the case of M/M/ω in an environment given by an ON-OFF process.
Together with S. Resnick (Cornell University) he has investigated an M/G/ω model for teletraffic data that assumes the transmission rates and the file sizes are independent random variables. For this model has been investigated the limit behaviour for small scales.

Onno Boxma. Various studies with EURANDOM researchers B. D'Auria, D. Denisov, A. Gabor, J. van Leeuwaarden, H.P. Tan and M. Vlasiou; see their text. With R. Núñez-Queija and former EURANDOM postdoc N. Hegde: analysis of sojourn times in queues with discriminatory processor sharing. With M. Mandjes and visitor (Stieltjes chair) O. Kella: two studies on Lévy processes and queues. With visitor H. Albrecher: analysis of certain risk models, which are related to queueing models.
In addition, several studies on queueing models were completed. With R. Bekker (queues with adaptable service speed, with applications to the TCP protocol and to production systems). With R. Egorova and B. Zwart (on processor sharing). With I. Adan and D. Perry (on the G/M/1 queue) and with D. Perry, W. Stadje and S. Zacks (on so-called growth-collapse models).

Richard Boucherie. Research of R. Boucherie concentrated on mathematical models for spare part inventory systems, and on mathematical models and algorithms for joint capacity and rate allocation in UMTS networks. Research on UMTS networks is carried out in cooperation with A.F. Gabor, and embedded in the Vodafone project.

Denis Denisov's research is mainly concerned with random walks and Levy processes with heavy-tailed increments. Together with Seva Shneer he has finished the study of the local asymptotics for the cycle maximum of the random walk. S. Shneer and he have also found tail asymptotics for the first passage times of Levy processes. As an application of the latter result, they obtained tail asymptotics for the busy period of the single server queue. The paper is to be finished soon. With B. Zwart he extended a theorem of Breiman (1965) and applied his results to analyze a class of random difference equations. With O. Boxma and S. Resnick he has been studying the service disciplines of the single-server queue which are in some sense intermediate between the Processor Sharing (PS) and First Come First Served (FCFS) disciplines. They study service disciplines whose stationary sojourn time has a tail lighter than the tail of stationary sojourn time in the FCFS queue but heavier than in the PS queue.

Adriana Gabor. Together with R. Boucherie and I. Endrayanto (University of Twente), A. Gabor has been investigating the sojourn time distribution of requests in a two cell CDMA network. Different scenarios, as equal rates, equal powers, optimization of the throughput have been analyzed.
Furthermore, she has been cooperating with J.K. van Ommeren (University of Twente), on the analysis of an acceptance policy for a stochastic knapsack problem, characterized by Poisson arrivals of the objects and random sizes.
Together with O. Boxma, S. Núñez-Queija, H.P. Tan, A. Gabor has done research on modelling and approximating an integrated-services system in a single UMTS cell. Using time-scale decomposition, they developed approximations based on a fluid modeling approach to evaluate the performance of an admission control strategy for integrated (elastic and streaming) services in a single UMTS radio cell.

Johan van Leeuwaarden focusses on several topics in applied probability, queueing theory in particular. In June 2005 he defended his thesis. Recent and current research deals with transient behavior of queues (with O. Boxma and B. D'Auria), relaxation time for queues in heavy traffic, rate of convergence of certain types of scaling (with B. Zwart and A.J.E.M. Janssen), maximimum of the Gaussian random walk (with A.J.E.M. Janssen), queues with delay (with D. Denteneer), asymptotics through functional equations and lattice path counting for QBD processes (with E. Winands and M. Squillante).

Hwee Pink Tan. Together with O. Boxma, S. Núñez Queija and A. Gabor he evaluated the performance of an admission control strategy for streaming and elastic users that enforces a minimum rate guarantee by means of capacity reservation. They propose approximations to estimate the performance of this strategy. They apply time-scale decomposition for limiting regimes, and for non-limiting regimes they propose a novel weighted approximation. Simulation results suggest that the performance is almost insensitive to traffic parameter distributions and is well estimated by the proposed approximations.

Together with D. Miorandi and M. Zorzi he investigated the limiting properties, in terms of capacity and delay, of an ad hoc network employing a topology-transparent scheduling scheme. In particular, they focus on Time-Spread Multiple Access (TSMA) protocols, which are able to offer a deterministic upper bound on the access delay. The analysis is based on some asymptotic properties of geometric random graphs. The analytical framework is applied for both static and mobile networks. The obtained results are compared with results present in the literature for the case of an optimum (centralized) scheduling scheme.

Elena Tzenova has been working with I. Adan and M. Mandjes on the tail asymptotics of the buffer content processes in steady state for a multi-class fluid model. So far they had results on a simple two-class model with a single on-off source. Furthermore, together with I. Adan and E. Lefeber she has been investigating another problem on a reentrant two machine Markovian system with four buffers where the first machine works under the LBFS discipline. Obtaining the steady-state probabilities in a product form by directly solving the balance equations of the system turns out not to be possible. Therefore, they were later on considering other possible approaches.

Maria Vlasiou has been working on a monotone non-increasing Lindley-type stochastic recursion that appears in applications in warehousing and queuing theory. Together with I. Adan she has derived the steady-state waiting time distribution for this recursion, in the case where the preparation times are on a bounded support. Together with B. Zwart, she has derived for generally distributed service times and phase-type preparation times the time-dependent waiting time distribution, the covariance function between two waiting times, the distribution of the cycle length, and general properties of the covariance function, independent of any assumptions on the distributions of the service and preparation times. With O. Boxma, M. Vlasiou has been working on a stochastic recursion that is a natural extension of the above described model. This extension includes both Lindley's recursion, and the Lindley-*type* recursion mentioned above, as special cases. For this extension they have derived the steady-state distribution of the waiting time for generally distributed service times and phase-type preparation times.

3.1.2. Research activities

Workshops and conferences

- February 2-5, 2005 (QPA/EURO-NGI)
Rare events in communication networks

See Chapter 6, section 6.1 for more detailed information.

Lectures and Seminars

15. In addition EURANDOM Professor F. Baccelli, gave a Mini-course, consisting of a series of 5 lectures.

See Chapter 6, section 6.2 for more detailed information.

EURANDOM visitors

QPA hosted 10 visitors, including the Stieltjes Chair (a long term visitor for 2 months); altogether 16 weeks.

See Chapter 6, section 6.3 for more detailed information.

General remarks

Johan van Leeuwaarden defended his thesis *Queueing Models for Cable Access Networks* in June 2005 and left afterwards for a research position at the ING bank. He returned to EURANDOM as a postdoc in September 2005; Elena Tzenova left at the end of December 2005.

Bernardo D'Auria joined QPA in February 2005. Adriana Gabor was already familiar with the institute through regular visits from the Universiteit Twente, where she had a postdoc position. She started working at EURANDOM in September 2005, partly on a VICI grant of Professor G. Woeginger (TU/e). Paul Beekhuizen started in December 2005 on an industry contract with Philips.

3.1.3. External contacts / cooperation

There are close ties with the TU/e Department of Mathematics and Computer Science, as well as with CWI. Onno Boxma and Michel Mandjes are part of a EC Network of Excellence (EURO-NGI), which brought lots of activities to EURANDOM in 2005.
One PhD of the QPA group was working on a contract with Philips on *Cable access networks*.
In December a new project on *Networks on a chip* with Philips was started with a new PhD.
Some of the postdocs partly spent their time on research related to a Vodafone assignment.
Participation in BRICKS brought closer cooperation with CWI and Universiteit Twente. Moreover, one PD position was (partly) financed by this programme.

See Chapter 3, section 3.1.1, for more detailed information about the researchers and Chapter 5, section 5.1 and 5.2 for more information about their publications.

3.2. Random Spatial Structures (RSS)

Scientific advisors for this programme are Remco van der Hofstad (TU/e) and Frank den Hollander (TU/e & Universiteit Leiden).

The RSS-programme moves at the interface between probability theory and statistical physics. It focusses on the study of systems consisting of a large number of interacting random components. These components interact with each other and with their environment. Even when the interaction is local, such systems typically exhibit a complex global behaviour, with a long-range dependence resulting in anomalous fluctuations and phase transitions.

To mathematically understand these systems requires the use of powerful probabilistic ideas and techniques. The challenge is to introduce simple models, which serve as paradigms, and to unravel the complex "random spatial structures" arising in these models. Statistical physics provides the conceptual ideas, while probability theory provides the mathematical language and framework. The important challenge is to give a precise mathematical treatment of the physics that arises from the underlying complexity.

Mathematical statistical physics is currently going through a phase of rapid and exciting development. Some of the key items associated with interacting random systems are finally being understood at the mathematical level, such as critical exponents, surface fluctuations, non-Gibbsianess, and spin glass behaviour. Interacting random systems are recognised world-wide as being of primary scientific importance. Mathematical statistical mechanics is widely known to foster interdisciplinary approaches and to provide expertise and training in analysing and modelling complex random processes.

The RSS-programme focuses on three themes:

- Critical phenomena
- Disordered media
- Combinatorial probability

In addition, the programme aims to extend towards applications in biology.

Interacting random systems occur in a multitude of theoretical and applied settings. Examples are:

- Ising spins: magnetism
- Lattice gas dynamics: metastability
- Percolation: porous media
- Interacting diffusions: population dynamics
- Random graphs: communication networks
- Self-avoiding walk: polymers
- Sandpiles: self-organised criticality

Key techniques are:

- Gibbs theory, renormalization, conformal invariance, entropy production, hydrodynamic scaling
- Multi-scale analysis, large deviations, spectral theory
- Combinatorial inequalities, lace expansion, random graph theory.

There is a close interaction and collaboration with the probability and statistics group at the TU/e Department of Mathematics and Computer Science. Most of the group members are active at EURANDOM. In addition, there is close contact with the group in stochastic operations research at EURANDOM and the department.

3.2.1. Summary of the research by members of the RSS-group

Federico Camia research activities in 2005 focused mainly on ongoing work with C.M. Newman on the continuum scaling limit of two-dimensional critical percolation. We have completed one paper, which has now been accepted for publication in Communications in Mathematical Physics, and made progress in the writing of a second paper which will be submitted soon.
Related to the above line of research is the work in collaboration with L.R. Fontes and C.M. Newman on the continuum scaling limit of two-dimensional near-critical percolation and related models, such as the minimal spanning tree, invasion percolation and dynamical percolation. This collaboration started in the summer of 2004, but significant progress was made in the summer of 2005. A first paper has been accepted for publication in the Journal of Statistical Physics and a second one is in preparation.
Another ongoing project concerns the mathematical analysis of the interesting phenomenon called universality in the physics literature (the term is now currently used also in the mathematics literature). I have

been working on this in the context of two-dimensional percolation and the Ising model.
F. Camia also worked on completing an article on the so-called Edwards' hypothesis for a class of spin models extensively investigated by both physicists and mathematicians. The article has been published by the European Physical Journal B.

Anne Fey-den Boer. Together with F. Redig (TU Eindhoven) and under supervision of R. Meester (VU Amsterdam), A. Fey has been studying various aspects of the sandpile model. We have compared the abelian sandpile model to a related parameter-driven model, to investigate if the stationary sandpile indeed corresponds to a phase transition. We have published interesting results, but a lot of open questions still remain.
Furthermore, together with C. Quant (VU Amsterdam) we are studying Zhang's sandpile model, a non-abelian variant that has hardly been studied analytically before. Zhang conjectured that in the limit of infinite volume, the stationary state tends to that of the abelian sandpile model. We managed to prove this in one dimension.

Cristian Giardinà has studied (in collaboration with F. Redig and J.R. Chazottes) the relation between waiting times and relative entropy in the context of the continuous time random process. This gives the generalization of the Ornestein-Weiss theorem to the continuous-time setting. Furthermore, he has been working on disordered systems, where he obtained (together with P. Contucci) a general proof of Ghirlanda-Guerra identities for Gaussian spin-glasses. This has been used also as a tool for numerical investigation of models in finite dimension (Edward-Anderson model). Finally he worked on non equilibrium systems, where he introduced a Hamiltonian (stochastic) model to verify Fourier law. This last work is in collaboration with J. Kurchan.

Remco van der Hofstad worked with D. Znamenski and G. Hoog-hiemstra (TU Delft) on graph models for complex networks. We have shown that the distances in random graph models depend sensitively on the degree structure in the graph. This project is funded by an NWO Networking grant.
With M. Heydenreich, we have shown that percolation on high dimensional tori exhibit random graph asymptotics at the critical point. With A. Sakai, he has worked on the contact process in sufficiently high-dimensions.
Further research activities were the following. With G. Slade (UBC Vancouver) and F. den Hollander (Leiden), we have identified the survival probability for critical spread-out oriented percolation above 4 spatial dimensions. With W. Koenig (Leipzig) and D. Brydges (UBC Vancouver), we have investigated the local times of continuous-time random walks. With W. Koenig (Leipzig) and P. Moerters (University of Bath), we have given a full universality characterization of the Parabolic Anderson model with i.i.d. fields. With J. Spencer (New York University), we have analysed the number of connected graphs with given number of edges and vertices. Finally, with T. Schenk, E. Fledderus and P. Smulders (TU/e, Electrical Engineering), we have identified the intercarrier interference in Phase Noise impaired OFDM systems.

Frank den Hollander worked with J. Gärtner (Berlin) and G. Maillard on "intermittency for catalytic particle systems", with A. Bovier (Berlin) and R.-J. Messikh (Lausanne) on "Wulff shape of large critical droplets under stochastic dynamics", and with D. Dawson (Ottawa), A. Greven (Erlangen), J. Swart (Prague) and R. Sun on "renormalization of two-type branching populations". The first of these projects is funded by NWO, the second and third by DFG and NWO, as part of the Dutch-German Bilateral Research Group. In November, a new project was started with S. Whittington (Toronto) and N. Pétrélis on "heteropolymers near random interfaces", which is also funded by NWO.
Further research activities were: "survival probability in critical oriented percolation" with R. van der Hofstad (TU Eindhoven) and G. Slade (Vancouver), "random walk in random scenery" with J. Steif (Gothenburg), "intersection of Wiener sausages" with M. van den Berg (Bristol) and E. Bolthausen (Zürich), "localization transitions of heteropolymers in emulsions" with S. Whittington (Toronto), "phase transitions for interacting diffusions" with A. Greven (Erlangen), and "a stochastic model for T-cells recognizing foreign antigens" with E. Baake and N. Zint (Bielefeld). The latter two are also part of BRG.

Mark Holmes. Together with E. Perkins we have proved a sufficient set of conditions for convergence of finite dimensional distributions of certain measure-valued processes to those of another such process.
Together with A. Sakai we have proved exact results for senile random walks (with application to senile walks with linear reinforcement) and for memory 2 once-reinforced and persistent random walks.

Gregory Maillard. Together with J. Gärtner (Technische Universität Berlin, Germany) and F. den Hollander (Universiteit Leiden), G. Maillard has worked on intermittency in a catalytic random medium. In particular, they have finished a paper concerning the behavior of Lyapunov exponents when the catalyst is simple exclusion with a symmetric random walk transition kernel. They also started to investigate a similar study for the case when the catalyst is voter model with a symmetric random walk transition kernel. Furthermore, he is working on the problem of phase transition for continuous and positive chains with complete connections with R. Fernández (Université de Rouen, France).

Reda-Jurg Messikh is on leave at EPF Lausanne since September 2005. His research at present time concerns metastability, phase coexistence and percolation. Under the direction of F. den Hollander and A. Bovier, he has been investigating the metastable behavior of a lattice gas at finite temperature under the Kawasaki dynamics. Besides this project, he is continuing the line of research started in his PhD concerning the link between the Wulff shape and the critical phenomena. He plans to continue working on the metastability project with A. Bovier and F. den Hollander.

Nicolas Pétrélis started to work at Eurandom in November 2005 under the direction of F. den Hollander. He studied new stochastic models of random copolymers in a random emulsion. Thus, November and December have been dedicated to start this collaboration. N. Pétrélis studied in particular the article, which has been written by F. den Hollander and S. Whittington about this topic. He also finished his first article, called "Polymer pinning at an interface". This article has been accepted for publication in Stochastic Processes and their Applications.

Frank Redig. Time evolution of Gibbs measures under local stochastic dynamics. Collaboration with A. van Enter (Groningen), C. Külske (Groningen). Further collaborations on this subject are planned with S. Roelly (Potsdam) and with J. Steiff (Gotheborg).
Sandpiles and self-organized criticality: thermodynamic limits of abelian sandpiles and other non-local processes. Collaboration with C. Maes (Leuven), E. Saada (Parijs), R. Meester (VU Amsterdam), A. Fey-Den Boer and A. Jarai (Ottawa).
Large deviations for KMS-states of quantum spin systems. Collaboration with K. Netocny (Praag), A. van Enter (Groningen) and possibly in the future C. Maes (Leuven) and R. Fernandez (Rouen).
Concentration inequalities for dependent random fields. Collaboration with C. Külske (Groningen), P. Collet (Polytechnique, Parijs) and J.R. Chazottes (Polytechnique, Parijs).
Matching and approximate matching of Gibbsina sequences and random fields with applications in mathematical biology (BLAST-algorithm). Collaboration with C. Giardinà and E. Verbitsky (Philips Research, Eindhoven).
Hitting and return times of rare patterns in random fields, collaboration with E. Verbitsky (Philips Research, Eindhoven), J.R. Chazottes (Paris) and C. Giardinà.

Akira Sakai mainly devoted himself this year to the work on the Ising model, which proves the ferromagnetic mean-field behavior above four dimensions without requiring the so-called reflection positivity of the spin-spin coupling. This is a strong evidence to support universality for Ising ferromagnets.
Applications of the lace expansion: scaling limits of various lattice models and random walks and self interacting random walks (e.g. RRW).

Rongfeng Sun has been working with F. den Hollander on a project joint with D. Dawson, A. Greven and J.M. Swart on the renormalization analysis of hierarchically interacting two-type branching models. They have so far classified the fixed points and fixed shapes under certain regularity assumptions. He also worked with S. Belhaouari, T. Mountford and G. Valle. They established the convergence of one-dimensional voter model interface to Brownian motion under optimal moment conditions and obtained sharp estimates for the equilibrium interface size. He has also been working with A. Gre-

ven and A. Winter in Erlangen on the scaling limit of genealogy forests of one-dimensional spatial Moran models, and with J.M. Swart from Prague on the Brownian net.

Maarten van Wieren has been developing a discrete model for a simple protocellular artificial organism, where the main focus has been on modeling the membrane. In accordance with the literature on continuous membranes (lipid bilayers), a Hamiltonian has been proposed that restricts the surface area and volume for the membrane, leaving the curvature of the surface as the main influence of the shape. A new definition for curvature had to be introduced for such discrete objects, such that in the scaling limit the regular curvature (for continuous curves) is recovered. Additionally a dynamics has been proposed for the transitions of the membrane.

Dmitri Znamenski. Together with R. van der Hofstad (TU/e) and G. Hooghiemstra (TU Delft) D. Znamenski has been working on the project: Statistical Analysis of Internet Data. Two articles devoted to topological properties in the random graph models have been submitted. Another two are in progress. The first is devoted to multilevel modelling of Internet topology, the second - to the diameter of a power law random graph. During spring 2005 Dmitri Znamenski gave two lectures on random graph models at International workshops on random graph models at International workshops in Berkeley and Research Triangle Park, USA.

3.2.2. Research activities

Workshops and conferences

- January 3-7, 2005

Dynamical Systems, Probability Theory and Statistical Mechanics

- March 14-18, 2005

Workshop on self-similar random structures Hausdorff dimension and branching

- September 20-23, 2005

Workshop *Interacting Stochastic Systems*

- October 13-14, 2005

BRG-meeting

- December 16, 2005

One-day Workshop *Physics in Ecology*

See Chapter 6, section 6.1, for more detailed information.

Lectures and seminars

26.

See Chapter 6, section 6.2 for more detailed information.

EURANDOM visitors

RSS hosted 24 visitors; altogether for 32 weeks.

See Chapter 6, section 6.3 for more detailed information.

General remarks

Federico Camia left EURANDOM in September 2005 for a VENI position at the Vrije Universiteit Amsterdam. Reda-Jürg Messikh interrupted his appointment at EURANDOM in September 2005 for a one-year position at the EPFL Lausanne. Dmitri Znamenski left EURANDOM in October 2005 for a position at Philips Research Laboratories.

Christian Giardinà started at EURANDOM in January 2005. He holds an Open Competition position at Leiden University, doing research mainly at EURANDOM. Mark Holmes also started in September 2005 on a position financed by the NWO-VIDI grant of Remco van der Hofstad, TU/e. Maarten van Wieren also started in September 2005. Nicolas Pétrélis also holds a position out of the NWO Open Competition; he arrived in November 2005.

3.2.3. External contacts / cooperation

The RSS-group continued to have intensive contacts with scientists in Germany, amongst others in the framework of the Dutch-German Bilateral Research Group (BRG) on "Mathematics of Random Spatial Models from Physics and Biology". On December 14, 2005 (Bonn) the activities of the group received a positive mid-term review. The group is now awaiting for a decision from DFG and NWO. BRG runs from April 2003 until March 2009.

Together with German research groups, in 2005 again a YEP (Young European Probabilist) workshop was organised.

Frank den Hollander chairs the ESF Scientific Programme "Random Dynamic Systems in Spatially Extended Systems" (RDSES), which involves 13 European countries. RDSES runs from April 2002 until Summer 2007.

Together with A. Bovier (WIAS, Berlin), F. Dunlop (Université de Cergy-Pontoise) and A. van Enter (member Steering Committee RSS), Frank den Hollander organised the Les Houches Summer School on Mathematical Statistical Physics that took place July 4-28. Several postdocs of the RSS group attended the Summer School. Funding for the Summer school came from the European Science Foundation, the CNRS (France), the NSF (USA) and the University of Grenoble.

See Chapter 3, section 3.3.1, for more detailed information about the researchers and Chapter 5, section 5.1 and 5.2 for more information about their publications.

3.3. Statistical Information and Modelling (SIM)

Scientific advisors for this programme are Alessandro Di Bucchianico (TU/e), Sara van de Geer (Universiteit Leiden) *until October 2005*, Richard Gill (Universiteit Utrecht), Mathisca de Gunst (Vrije Universiteit, Amsterdam), Chris Klaassen (Universiteit van Amsterdam) and Henry Wynn (London School of Economics, United Kingdom) *until October 2005*.

Mathematical statistics is an indispensable tool in all fields of modern science. At EURANDOM we focus on themes from four areas presently undergoing vigorous development, and supplying major challenges to statistics and data-analysis: biology, computational learning, industry, quantum information. Each area presents its own unique types of problem, but the same fundamental ideas from theoretical statistics can be applied in all, giving insight and creating underlying links. The availability of huge amounts of data, having a complex stochastic structure depending on very many unknown parameters, calls for statistical modelling and analysis techniques having a different flavour from classical methodology. Despite modern computational power, the problems require a closer than ever intertwining of algorithms and theory: scientific ambition and the size and complexity of data grow faster than our ability to mechanically process those same data. Statistical optimality and computational feasibility cannot both be achieved at the same time; compromises need to be made and the guiding principles of classical statistical theory do not necessarily lead to useful solutions. Still, we need to capitalize more than ever on what we have learnt from classical statistical theory, and in particular from asymptotic (large sample) optimality theory.

The programme has three themes:
- Statistical Learning
- Statistics in Biology
- Industrial Statistics

Research focuses on the areas:
- Molecular Biology and Genetics
- Computational Learning (statistical learning, adaptive methods, prediction)
- Industrial Statistics (algebraic methods, reliability)
- Quantum Information (optimal quantum measurement)

Underlying and unifying mathematical statistical themes are:

- high-dimensional statistical modelling
- Bayesian methodology (sometimes studied from frequentist perspectives)
- empirical process theory
- asymptotic optimality
- missing data problems and hidden Markov models
- experimental design
- algebraic and geometric methods
- statistical information
- networks

The SIM programme runs in close collaboration with mathematical statisticians of the stochastics groups at Vrije Universiteit van Amsterdam, Universiteit Amsterdam, Universiteit Leiden, Universiteit Utrecht, and TU/e.

Former post-docs L. Artiles Martinez, P. Grünwald, M. Guta and P. Lindsey were associated to the SIM programme as Research Fellow.

3.3.1. Summary of the research by members of the SIM group

Wicher Bergsma worked in an EET project: In 2005 W. Bergsma together with V. Kulikov achieved a major success by demonstrating the possibility of online monitoring of machine performance using dynamic calibration of aggregated profiles, in particular, vibration measurements. He has been building on this success by trying to extend the methodology to other types of profiles, in particular, the time profile of a lift motor for a papertray, and has achieved very promising results in this respect. The internal parameters to be decoded from the profile were in this case the load on the paper tray and the motor voltage used. Inverse regression techniques, using linear models, turned out to make calibration possible, with a potential limitation, however, namely that the internal parameters should be known to lie within a limited range.

In the field of general statistics, W. Bergsma has also developed a new correlation coefficient, which overcomes the drawback of the ordinary correlation that its being zero does not imply independence. He proved some important theorems and has developed an

orthogonal decomposition of the new coefficient. These results should prove useful in a wide variety of applications where the dependence between random variables is of interest, and may provide a good alternative to regression methods for assessing dependence if the researcher does not wish to rely on too many assumptions.

Isaac Corro Ramos. In July 2005 I. Corro Ramos started his PhD research. Together with L. Hakobyan (TU/e, LaQuSo) and under the supervision of K.M. van Hee and A. Di Bucchianico he is learning about Software Testing and Reliability, Petri Nets and Information Systems Architecture. Related to these subjects he followed a course in reliability and a course in information systems.
Together with L. Hakobyan, he has been working with the tool Stresser, doing some testing on it, and performing some experiments for further analysis. They also wrote a first draft of what will be the user manual for Stresser.
In 2005 they have also been writing a report in which they detail some results obtained on State Machine Workflow Nets.

Alessandro Di Bucchianico worked on several topics in 2005. With P. van de Ven and H. Wynn he worked on estimation procedures for location-dispersion regression models. He also worked on algebraic methods for confounding in mixture experiments. As result of organizing a joint EURANDOM-EIDMA minicourse in March 2005 on symmetry and statistics by M. Viana (Chicago) and A. Cohen (TU/e), he started to work with Peter van de Ven on linking the group theoretic approach to experimental design with the Gröbner basis approach of Wynn and Pistone.
With M. Hušková he continued working on developing GLRT-based control charts that detect specific alternative hypotheses. A paper on control charts for persistent changes of the mean is in preparation.
An overview paper with T. Figarella, M. Jansen (TU/e) and H. Wynn describing wavelet-based procedures for signature analysis arising from the Flextronics project was finished and accepted as one of the key note papers for the MMR 2004 proceedings.
With K. van Hee and J.-F. Groote (both TU/e, Computer Science Department) A. di Bucchianico worked on black-box models for statistical certification of software. The results were written down in a technical report and submitted.
In the NWO funded STRESS project, A. Di Bucchianico worked with K. van Hee and the PhD students I. Corro Ramos and L. Hakobyan (TU/e and LaQuSo) on statistical certification procedures based on Petri net models of software. As a first step, a report was written on generating random SMWf nets, a subclass of Petri nets.
With G. Mooiweer (TU/e and Sara Lee company), A. Di Buchianico finished a paper on control charts for high yield processes. In this paper a new expression for the variance of the run length of a CCC chart was found. The results are being implemented at Sara Lee to monitor leaks in vacuum coffee packs.
Finally, A. Di Bucchianico worked with S. Kuhnt (Dortmund) on extending the data feature approach of Davies to conditional Gaussian models. Preliminary results were obtained on constructing suitable metrics on probability spaces.

Farida Enikeeva. Together with E. Belitser (Utrecht University) F. Enikeeva has been studying an empirical Bayes approach to problems of testing and adaptive estimation in the Gaussian white noise model. The main goal of the research was to infer about the smoothness of an unknown parameter. Under the assumption that the parameter belongs to a Sobolev subspace with unknown smoothness a test statistic was obtained for the corresponding goodness-of-fit problem. Under certain assumptions this test is asymptotically unbiased and consistent. The considered problem is closely related to adaptive estimation and to theconstruction of confidence intervals. The test statistic and the corresponding adaptive estimator can be easily computed in practice.
F. Enikeeva has started investigating applications of the empirical Bayes approach to adaptive filtering of the random signal in the white noise model.

Talía Figarella. The research of T. Figarella concentrated on finishing the analyses of the two life tests performed on the BDT module of a copy machine with different operating conditions such as load and voltage. We were concerned with the singularity detection of a motor current signal. These singularities are related to the condition of the brushes of the motor, which are rather sensitive to wear out. As the me-

chanical contact between brushes and commutation segments increases, the rising parts of the current commutation waves become wider and this is a signal of brush wear. We successfully implement an algorithm to localize the singular points of the commutation waves based on the wavelet maxima lines. The width of the rising part of the commutation waves is then calculated from these maxima lines. We observed that the rising width of commutation waves increases linearly with time, and therefore can be used as an indicator of the brushes wear.

Sara van de Geer. In 2005 S. van de Geer has been co-organizer of the PASCAL workshop "Modelling in Classification and Statistical Learning". She is also site manager of the Network "Pattern Analysis, Statistical Modelling and Computational Learning", Associate Editor of the Annals of Statistics, Associate Editor of Bernoulli, Associate Editor of Statistica Sinica, member of the Conseil Scientifique CIRM and member of the European Regional Committee of the Bernoulli Society, and of the Conference Committee.
She has been invited to give lectures in Helsinki (National Visitors Program, Merkrijärvi Research Station, March 2005), in Brussels (Francqui workshop, May 2005), Santander FoCM Learning Theory Workshop (July 2005), Oberwolfach ("Statistische und Probabilistische Methoden der Modellwahl" (October 2005) and Zürich ("Swiss Statistical Seminar", November 2005).

Richard Gill. The research of R. Gill was mainly on several aspects of quantum statistics: design of experiments for testing quantum non-locality, and optimal estimation of quantum states. The remarkable result was obtained in: Acin, A., Gill, R.D., and Gisin, N.: Optimal Bell tests do not require maximally entangled states, *Phys. Rev. Letters* **95** that the best Bell-type test does not use a maximally entangled state in higher dimensions (this work was joint with theoretical physicists in Geneva and Barcelona, respectively, and speedily published in Phys. Review Letters).
R. Gill also worked with former post-doc Peter Grunwald on the notion of "coarsening at random" in the theory of statistical inference in the presence of missing data. We discovered a simple algorithmic characterization of the important coarsening at random property, which we connected to a generalization of the notion of a partition which we call uniform multicovers. A geometrical interpretation was also found. A publication has been submitted.

Mathisca de Gunst worked on several projects concerning stochastic modelling and statistical analysis of biological data.
One project, with Bert van Duijn (TNO-voeding, Leiden), and Olga Shcherbakova (Department of Mathematics, Vrije Universiteit Amsterdam), deals with ion channel kinetics, and during the past year concentrated on several mathematical issues concerning the behaviour of Bayesian posteriors for hidden Markov models.
Furthermore, with Nicola Armstrong, Geert Geeven (Department of Mathematics, Vrije Universiteit Amsterdam), Guus Smit (Molecular and Cellular Neurobiology, Vrije Universiteit Amsterdam) and Joost Verhaagen (Netherlands Institute for Brain Research, Amsterdam) focusses on modelling the gene network underlying neuronal outgrowth.
Here a start was made with the statistical analysis of different types of genetic data using Bayesian networks.
Finally, with Fabio Rigat (EURANDOM), Rick Jansen (Department of Mathematics, Vrije Universiteit Amsterdam), Jaap van Pelt (Netherlands Institute for Brain Research, Amsterdam), Arjen Brussaard and Arjen van Ooyen (Department of Experimental Neurophysiology, Vrije Universiteit Amsterdam), research was performed on the analysis of spatio-temporal patterns in neuronal networks. In particular, a dynamic Bayesian network model was developed for the connectivity structure of neuronal cells in vitro and statistical methods were designed to analyse multi-electrode array data with this model.

Chris Klaassen. The research project with Nadia Lalam in collaboration with the bioinformatics group of Jaap Kaandorp (UvA) resulted in proofs of the consistency of the pseudo maximum likelihood estimator of the parameters of a system of ordinary differential equations. Such a system is used in modelling the gene regulatory network for the segmentation phase of the embryo of the Drosophila Melanogaster.
Some support was given to Leila Mohammadi in her research on the asymptotics of classification problems in machine learning.
Research in statistical process control with former Eurandom PostDoc Roxana Ion resulted in a publication in the Journal of Nonparametrics.

Alexey Koloydenko. Working with a team of advanced developers at the Medical Information Technology Lab of Philips Medical Systems (Best, The Netherlands), A. Koloydenko has been developing statistical methods to discriminate between the colon polyps and polyp-like formations mistakenly detected by the existing algorithm. Using a combination of statistical tools ranging from parametric models for distributions of subsets of relevant measurements to kernel-based geometric learning approaches, he can significantly reduce the number of detected confusions, which verifies on independent testing data. A. Koloydenko has also been instrumental in developing and evaluating certain other ideas and methods related to the Computer Aided Diagnostic in general and polyp recognition in particular.

Vladimir Kulikov was only half a month at EURANDOM in 2005. He continued working with H. Lopuhaa (TU Delft) on different aspects of monotone density estimation. Together with W. Bergsma he also worked on dynamic calibration in application to online monitoring of photocopying machines using vibration data.

Nadia Lalam is investigating the problem of efficient estimation of parameters arising in a model of genetic regulatory networks that play a fundamental role in many biological processes. The aim is to quantify the interactions between genes occurring in a regulatory network when considering gene expression data obtained by confocal laser scanning microscopy. As a case study, the segmentation of the Drosophila embryo is considered. Pseudo maximum likelihood estimators have been studied relying on statistical modelling of the available gene expression data. These estimators should entail a better summary of the information contained in the gene expression data than the currently used least squares estimators. Moreover, she considered some statistical aspects related to the Polymerase Chain Reaction for which an unknown quantity of DNA molecules is amplified through the succession of PCR cycles. She proposed to infer via MCMC methods the initial number of DNA molecules number together with the probability of replication of a molecule when modelling PCR with branching processes.

Leila Mohammadi has been working with F. Merkl on optimal lower bounds. They proved a general theorem and applied it to classification problems. Using their results, Mohammadi showed that the rate of convergence in the threshold estimation problem "Asymptotics in empirical risk minimization" (Mohammadi and van de Geer, 2005) is optimal if a bound on the number of thresholds is known. If no bounds on the number of thresholds are known, the rate of convergence is optimal up to log factors.

Fabio Rigat has progressed in the area of statistical modelling of neuronal nets in collaboration with M. de Gunst and J. van Pelt. He is working on Markov chain Monte Carlo methods primarily by himself, with some feedback from A. Mira and M. West.

Peter van de Ven. In 2005 P. van de Ven has been studying several methods for identifying location and dispersion effects using unreplicated fractional factorial designs. Several methods proposed for a linear dispersion model that appeared quite different at a first look, were shown to be equivalent. Together with A. Di Bucchianico he started investigating the relationship between Fourier analysis on groups and statistical inference in factorial designs.

3.3.2. Research activities

Workshops and conferences

- March 14-18, 2005 SIM/EIDMA
Mini-course *Symmetry studies*

- June 24, 2005
Regional Meeting on *Design of Experiments (DOE) and Statistical Process Control (SPC)*

- October 3-5, 2005
Workshop *PASCAL II*

See Chapter 6, section 6.1 for more detailed information.

Lectures and seminars
13.

See Chapter 6, section 6.2 for more detailed information

EURANDOM visitors
SIM hosted 10 visitors, altogether 17 weeks. One of them was a long-term visitor; he worked at EURANDOM during 2 months.

See Chapter 6, section 6.3 for more detailed information.

General Remarks
Vladimir Kulikov left in February for a position at the ING bank, Amsterdam. Farida Enikeeva left in June for a position at the Institute for Information Transmission Problems (ITTP), Bioinformatics group, Moscow, Russia. Wicher Bergsma left in August for a position at the London School of Economics, United Kingdom. Alexei Koloydenko left in September for a position at the University of Nottingham, United Kingdom.

In July 2005 Isaac Corro Ramos started working on an NWO Open Competition funded project submitted by Dr. S. Di Bucchianico and Professor K. van Hee, TU/e. This is a joint project with LaQuSo (Laboratory for Quality Software). Research at LaQuSo focuses on the domain of verification and validation of software systems and covers both models and software code.

3.3.3. External contacts / cooperation

EURANDOM did put a lot of effort in the EU FP6. Since December 1, 2003 EURANDOM participates in the Network of Excellence PASCAL. Apart from this EU Network and the Dutch research groups with an interest in quantum information, the group has contacts with industrial partners, among others via the Signal Analysis project (with Flextronics and the TU/e). The researchers of the SIM programme also have several contacts with groups in life science in The Netherlands.

See Chapter 3, section 3.3.1, for more detailed information about the researchers and Chapter 5, section 5.1 and 5.2 for more information about their publications.

3.4. Battery Modelling and Management (BMM)

Scientific advisor for this programme was William Rey (Philips Research Laboratory). The project leader was Peter Notten (TU/e & Philips), who is known for his fundamental and experimental work on Electrochemical Energy Storage.

The project BMM aimed at a better understanding of the battery processes (modelling) with the goal of improving the way batteries are being used (management). EURANDOM contribution was the mathematical modelling in close collaboration with other specialists.

This multidisciplinary project involved three main partners: the electrochemical expertise from TU/e Department of Chemistry, industrial know-how provided by Philips Research Laboratories (Physics Laboratory), while EURANDOM investigated the mathematical facets.

The BMM project was successful at different levels. For both NiMH and Li-ion batteries sophisticated battery models have been set up, accurately describing and simulating the complex behaviour of these systems under a wide variety of operating systems.

3.4.1. Summary of the research by members of the BMM project

Dmitry Danilov. Together with P. Notten (TU/e, Department of Chemical Technologies), D. Danilov has been working on two major topics. One is mathematical modeling of the ageing of the Lithium-ion batteries. A full scale model describing functioning of the Lithium ion battery including degradation processes has been worked out.

Main results of the model were helpful in designing the BOOST-charge algorithms. Second topic is the simulation of the hydrogen storage in hydride-forming materials with emphasis on description of the hydrogen kinetics (A. Ledovskikh is another co-author). Results of the research are important for construction of hydrogen-containing energy devices such as fuel-cells and NiMH batteries. In particular, the equilibrium kinetic characterisation of the pressure-composition hydrogen isotherms has been obtained.

Iryna Snihir. During the period under review, activities were focused on giving an idea on how the statistical shape analysis can be used for State-of-Charge (SoC) estimation of the battery. In our context, we described a shape based on the information that remains when location of the voltage curves due to the current transitions, rotational effects and measurements error were filtered out from the curves. The final result gave an obvious classification scheme and, as a by-product, a SoC estimate.

Some work has been also done in the direction of distinguishing between a signal and a noise (data = signal + white noise) based on the number of local extremes while monotonically estimating the data by the method of taut string proposed by L. Davies; the "recipe" to accurately separate a signal from white noise still needs investigations.

See Chapter 3, section 3.4.1, for more detailed information about the researchers and Chapter 5, section 5.1 and 5.2 for more information about their publications.

3.5 Stochastics of Extremes and Risk Analysis (SERA) / Reinsurance (RI)

Scientific advisor for this programme is Jef Teugels (Katholieke Universiteit Leuven, Belgium).

The former EURANDOM programma Stochatics of Extremes and Risk Analysis (SERA) programme ended in the summer of 2004 as part of the research realignment. A promising line of research was Reinsurance, lying at the interface of economics, finance and particularly insurance. Part of SERA continued as the research project RI. One of the most popular forms of risk sharing is *reinsurance*. In an attempt to cope with excessively large claims (catastrophes, terrorism) or/and an unexpectedly high number of them (earthquakes, floods), a reinsurer sells part of his portfolio to a reinsurer, splitting the income but also the risk over the partners. Major projects are to develop optimality criteria and appropriate risk measures to decide what type of reinsurance should be taken and for what premium. Theoretical research in this area is still in its infancy. In the framework of a dynamical financial analysis, there is a strong need to investigate financial and economical issues that are relevant with respect to reinsurance.

3.5.1. Summary of the research by members of the SERA/RI project

Sophie Ladoucette has studied the asymptotic behavior of a ratio defined as a random sum of squares to the square of a random sum. She obtained results on the limiting behavior of arbitrary moments of this quantity under a heavy-tailed assumption for the underlying distribution. Together with J. Teugels, she also derived asymptotic results on the weak laws of the ratio. This has been applied to get the limiting behavior of risk measures such as the sample coefficient of variation and the sample dispersion, two well-known measures of dispersion. Finally, S. Ladoucette and J. Teugels investigated the asymptotic behavior of the reinsured amount in new reinsurance treaty that they proposed, namely the quote-share drop down excess-of-loss reinsurance treaty. They established weak laws and asymptotics for arbitrary moments.

Mandira Sarma. Together with J. Danielsson, B. Jorgensen and C. de Vries, M. Sarma has worked on comparing several risk measures under the rules of first and second order stochastic dominance and for heavy tailed asset returns distributions. They have established some interesting results on the consistency of preference ordering of assets with respect to different measures. They have also examined the issue of VaR sub-additivity and established analytically and with a simulation exercise that for heavy tailed asset returns VaR is sub-additive in the tail region. M. Sarma has also worked on empirical characterisation of the tail behaviour of financial returns from India's financial markets. Further, together with D. Guégan she worked on empirically characterising the dependence structure of interest rates of various maturies from India's inter bank money market.

3.5.2. Research activities

Workshops and conferences

- May 9-10-11, 2005

Workshop *Risk Measures & Risk Management General Aspects*

- December 12 & 13, 2005

Workshop *The Economics & Finance of Extremes*

See Chapter 6, section 6.1 for more detailed information.

Lectures and seminars

EURANDOM visitors

SERA/RI hosted 2 visitors for 1 week.

See Chapter 6, section 6.3 for more detailed information.

General Remarks

Sophie Ladoucette left for a PhD position at the Katholieke Universiteit Leuven, Belgium and Mandira Sarma left for a position at the Indian Statistical Institute, New Delhi, India.

3.5.3. External contacts / cooperation

Through the advisor, there is a close cooperation with the Mathematics Department in Leuven (Belgium).
The NEST activities brought European cooperation with the other ERCOM members, especially IHES (France), CRM (Barcelona) and Bar Ilan University, Israel; activities starting in 2006.

4. EXAMPLE OF RESEARCH: Queueing models for cable access networks
Dr. Johan van Leeuwaarden

As announced in the introduction, we present here more in detail an example of the research in the QPA-group.

Cable networks were originally designed to broadcast analogue television signals from the service provider to its users. With the help of hybrid fiber coaxial technology, most cable networks have been upgraded to provide bidirectional data transfer. The upgraded networks, referred to as cable access networks, thus allow for users to transmit signals to the service provider, which opens up a new world of interactive multimedia services with Internet browsing as most prominent application. The upgrade of cable networks asks for ways to deal with the new situation of bidirectional data transfer. There has been a broad research effort on the description and investigation of protocols for regulating cable access networks. Our work is part of this effort.

We first introduce the basic characteristics of cable access networks. In particular, we describe how these characteristics give rise to challenging research issues. In particular, we discuss how the division of network capacity among its users leads to a two-stage process, which can be described in terms of several queueing models. Most of these queueing models are solved analytically. From these solutions, we derive performance measures that can be used to assess the performance of cable access networks, expressed in terms of capacity and delay characteristics.

The queueing models presented are interesting in their own right. Apart from their application in cable access networks, the models may find application in other fields. They incorporate characteristics of multi-access communication and resource sharing, issues that are the topic of ongoing research in fields like computer networks, radio frequency tagging, networks on chips, satellite systems, mobile telephony, and many more.

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1. Cable access networks

The central point of the cable access network, which is connected to all users, is referred to as the head-end (HE). A service provider can transmit signals from the HE to the users over the *downstream channel*, and users can transmit signals from their location to the HE over the *upstream channel* (see Fig. 1). The downstream channel is used exclusively by the HE, while the upstream channel is shared by the users. Typically, the number of users connected to the same cable network ranges between 100 and 1000.

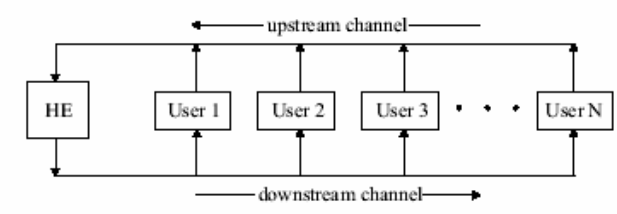

Fig. 1: Schematic view of a cable access network with N users

2. Multi-access communication and request-grant mechanism

The shared upstream channel is an example of multi-access communication, in which multiple users have access to the same communication channel. The range of applications of multi-access communication goes far beyond cable access networks and has attracted much attention from many researchers.

A typical problem in multi-access communication is that whenever users transmit signals simultaneously, a collision causing signal loss occurs. This is also the case for the shared upstream channel in cable access networks. A concomitant problem for cable access networks is that users are incapable of monitoring each other's behavior and therefore cannot coordinate their transmissions themselves.

A common way to deal with this situation is to use a *random access protocol*, in which users transmit their message immediately without any form of coordination. Collisions might occur, so users must be informed when their message has been lost due to a

collision. In case of collision, the HE sends a message to the user, and upon receipt the user will give it another try and retransmit the message. A random access protocol might work well, in particular when the load on the communication channel is low. When the load is high, collisions are more likely to occur and cause a substantial loss of capacity, which calls for a more sophisticated protocol.

To construct such a protocol, a scheduler can be installed at the HE that allocates the upstream capacity among the users. Then, each user must inform the HE about its capacity needs, after which the HE constructs a schedule and informs each user of the capacity it will receive. This information exchange between users and HE is often based on a *request-grant mechanism*, which can be described as follows. Before a user can transmit its actual message, it sends a request message to the HE. This request message only contains the specifications of the actual message that a user wants to transmit. The request messages are handled by a random access protocol and could collide. However, the collided capacity remains limited, since the request messages are small. Still, the request messages require upstream capacity, but in return the HE gets the information based on which a collision-free schedule can be constructed. The HE informs the users when they can transmit their actual messages during reserved and thus collision-free time intervals.

3. Queueing theory and performance analysis

Queueing theory deals with analyzing congestion problems. Congestion may occur when users share a service system with limited capacity. Whenever the total demand to a system is more than its service capacity, the users should form some queue or waiting line. Users often decide individually when they need a certain service. Due to this uncontrolled arrival process to the system and the often varying service requirements of the users, queues may build up and dissolve over time, which leads to the formulation of stochastic models.

In the context of the cable access network, the upstream channel is the service system and the amount of data that users want to transmit is the service demand. The capacity of the upstream channel is limited, so queues will be formed. The available capacity and the way in which the users are served fully describe the service system. How the queues evolve, though, depends on both the service system and the behavior of the users.

Queues cause delay, which for some services could be problematic. That is, delay causes longer transmission times of data and therefore affects the quality of service provided to the user. Consequently, delay characteristics provide measures for the quality of the service system.

The upstream channel of cable access networks regulated by a request-grant mechanism might be viewed as a two-stage tandem queue. When a user wants to transmit data, it first joins the *request queue* where it waits until its request gets granted. Once granted, the user moves to the *data queue* and waits until its data gets transmitted. The data queue is virtual in the sense that packets are not actually lined up in a queue. Instead, the users hold their packets until they are allowed to actually transmit these. The total service capacity for both queues is equal to the capacity of the upstream channel. How the upstream capacity is scheduled, i.e., divided among the two queues, will determine the delay experienced by the users at each of the two stages.

4. Scheduling the upstream capacity

Starting from the abstraction of the two-stage tandem queue we now address the issue of scheduling the upstream capacity.

A first way to schedule the upstream capacity is to give priority to one of the queues. If priority is given to the request queue, all incoming requests are handled until no requests are left. Then, the data of granted requests is transmitted only until a first new request arrives, and users might experience a substantial delay at the data queue. If priority is given to the data queue, a user is taken into service at the data queue right after getting its request granted at the request queue. In this case, the user has no delay at the data queue but could experience substantial delay at the request queue.

Giving priority to the data queue seems reasonable. That is, when both queues are nonempty, the users in both queues benefit from serving the data queue, since all users require service there eventually. On the contrary, the users at the data queue do not benefit from serving the request queue.

What makes cable access networks different from the above standard tandem queue settings is *transmission delay.* Due to the transmission delay, it takes a while before the scheduling instructions sent by the HE reach the users. So, from the moment a user gets served at the request queue it takes a while before the user is informed by the scheduler. Therefore, the upstream capacity cannot be used immediately for transmitting the data of this user. In Fig. 2 this is illustrated schematically.

The transmission delay could influence the behavior of the system considerably. Sala et al. [18] investigated the strategy that gives priority to the data queue by simulating a cable access network regulated by a request-grant mechanism with transmission delay. The capacity not needed for serving the data queue is used for the request queue. They observe that this type of scheduling

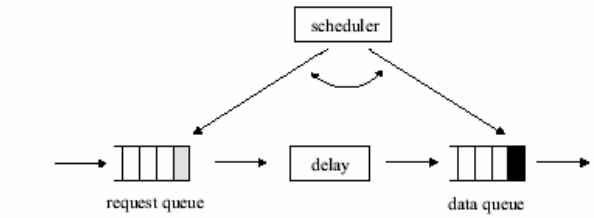

Fig. 2: Schematic view cable access network with N users

results in a cyclic behavior. Serving the request queue for a longer period due to the transmission delay allows relatively many users to get their requests granted. These users are served from the moment that the first user arrives at the data queue, resulting in a burst of data from users with granted requests. This burst of data will lead to requests being held relatively long at the users until all data have been transmitted, again inducing a burst of requests.

Sala et al. [18] compared the priority strategy to strategies that reduce the cycles by forcing upstream capacity to the request queue, even if there is data to be transmitted. They show that these strategies, which give every fixed period some of the capacity to the request queue, lead to a smoother process and may lead to shorter delays. This scheduling effect has also been observed in other simulations of cable access networks, see e.g. Golmie et al. [10] and Pronk et al. [16].

5. Key characteristics and research goal

Let us now summarize some of the characteristics discussed earlier, and relate these to the goals we would like to pursue. For cable access networks regulated by a request-grant mechanism, we aimed at incorporating the following characteristics into our models:

- *Request queue and data queue.* A user first sends a request message to the HE and once this request gets granted, the user is allowed to send the actual message. This leads to the following abstraction. At the moment a user generates a request message, it joins the request queue. Once the request gets granted, the user leaves the request queue and joins the data queue, where it waits until it is allowed to transmit the actual message.
- *Transmission delay*. It takes a while before a signal has been sent from one place to another in the network. The round-trip time is defined as the time it takes to send a signal from the HE to a user and from the user back to the HE. Scheduling instructions sent from the HE to the users are therefore delayed by half the round-trip time. In terms of the abstraction of the request and data queues, it takes half the round-trip time for a user to move from the request queue to the data queue.
- *Centralized scheduling.* At the HE, a scheduler is installed that determines the way in which the capacity of the upstream channel is divided among the users. Using the abstraction of the request and data queues, the upstream capacity is divided among these two queues. The scheduling instructions sent by the HE to the users will be delayed.
- *Forced capacity for the request queue*. Due to specific properties of cable access networks, including the delayed scheduling instructions, it might be favorable to force upstream capacity to the request queue, so that the arrival process of granted requests at the data queue gets smoother. The amount of forced capacity can be seen as a scheduling parameter, and we aim at investigating the impact of this parameter on several performance characteristics.

Our goal also is to analyze the two-stage tandem queue. In doing this, inspired by the simulation results, we focus on investigating the data queue. We take two approaches. As a first approach, we model the request and data queues as a discrete-time system. We incorporate characteristics of the cable access network like periodic scheduling, forced capacity for the request queue and

transmission delay. This approach discussed in Section 6. As a second approach, we analyze the tandem queue with shared service capacity using the theory of boundary value problems. This is discussed in Section 7.

6. Periodic scheduling

Let us consider the request and data queue as a discrete-time packet-based system, where time is divided in slots, and each slot is equal to the time needed to transmit one data packet (or handling requests in multiple mini-slots). The centralized scheduling of the upstream capacity then comes down to deciding for each slot whether it is used to serve the request queue or the data queue. We will present several models for the data queue, where the data queue is defined as the amount of data (in terms of numbers of packets) that belongs to actual messages for which the request message has been granted, but that are still waiting to be transmitted. Clearly, if a slot is used for handling requests (request slot), new packets can enter the queue, and if a slot is used for data transmission (data slot), a packet can leave the queue.

Due to the substantial transmission delay, scheduling decisions must be taken in advance so that they can be communicated to the users. Consequently, there is a time lag between granting a request message and transmitting the data associated with the actual message. Therefore, one is naturally led to consider periodic scheduling, for which slots are grouped together into frames composed of both request and data slots. The designation of each slot in the frame is periodically determined and broadcast to all users, and the timing is such that each user is aware of the layout of a frame before it actually starts.

Fixed and flexible boundary model

We consider two periodic (frame-based) scheduling strategies. The first strategy uses no information about the system's state and constitutes a queueing model that we refer to as f*ixed boundary model*. Each frame (defined as *f* consecutive slots) consists of *c* request slots followed by *s=f-c* data slots. Let the random variable Y_{ti} denote the number of arriving packets during the *i*th request slot of frame *t*, and assume that the Y_{ti} are independent and identically distributed (i.i.d.) for all *t* and *i*, according to a random variable Y. Further assume that packets that arrive during frame *t* cannot depart from the queue until the beginning of frame *t+1*. We then have the following evolution equation that relates the queue lengths at the beginning of two consecutive frames:

$$X_{t+1} = (X_t - s)^+ + \sum_{i=1}^{c} Y_{ti},$$

where $x^+ = \max(0, x)$ and X_t denotes the queue length at the beginning of frame *t* (see Fig. 3). The model essentially divides the upstream capacity among the request and data queues according to fixed fractions *c/f* and *s/f*. Clearly, if the data queue is empty at the beginning of a data slot, this capacity is lost in the fixed boundary model. Therefore, the second model considered

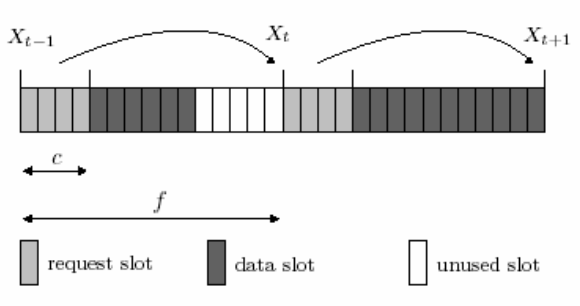

Fig. 3: The fixed boundary model

is one that designates the unused data slots as request slots, and is referred to as *flexible boundary model*, which reflects the fact that the division of a frame into request and data slots can vary from one frame to another. This leads one to consider the recursion

$$X_{t+1} = (X_t - s)^+ + \sum_{i=1}^{c+(s-X_t)^+} Y_{ti}.$$

We refer to the *c* request slots that are scheduled at the beginning of every frame as *forced request slots*, and to the $(s - X_t)^+$ slots as *additional request slots*. Intuitively, the flexible boundary model is more efficient than the fixed boundary model, but one wants to have a clear quantitative understanding of these benefits. We will provide such understanding by analyzing the packet delay in either model.

Periodic scheduling with large round-trip delay

We now introduce the delay parameter *d*, and we assume that the actual message for which the request message gets granted in frame *t* can only be transmitted at the earli-

est in frame *t+1+d*. In other words, sending the request from the user to the HE and transmitting the acknowledgment of a granted request from the HE to the user takes *d* frames. Therefore, the user is informed of the scheduling instructions *d* frames after its request has been sent. This gives rise to the following model for the data queue, referred to as *delayed flexible boundary model*:

$$X_{t+1} = (X_t - s)^+ + \sum_{i=1}^{c+(s-X_{t-d})^+} Y_{t-d,i}.$$

Finding the stationary distribution of this (*d*+1)-dimensional Markov chain is much harder than in case of the one-dimensional Markov chains. An exact solution to the stationary distribution is given in [19].

Our contribution to periodic scheduling
The fixed and flexible boundary model are examples of queueing models with periodic service. We contribute to this field by providing a detailed analysis for the evolution equations. The arrival process depends on the queue length process, which considerably complicates the analysis. For the fixed boundary model we show in [13] that the probability generating function of the stationary queue length follows from the solution of the classical discrete bulk service queue. We next derive, using a more advanced technique, the probability generating function of the packet delay. From these transform solutions, the entire probability distributions can be obtained, as well as explicit expressions for more specific performance characteristics like the mean and variance. For the flexible boundary model we obtain similar results, although the derivation gets slightly more complicated. For both models we investigate in [5] (see also [3]) the impact of the forced arrival slots *c*, in relation with other settings like the frame length and type of arrival process. For the delayed flexible boundary model we derive bounds and approximations to investigate the influence of *c* and *d* on the mean and variance of the stationary queue length. Related results can be found in [1, 4, 11, 12].

7. Tandem queue with shared capacity

We now leave the discrete-time assumption and model the request and data queues as a continuous-time two-stage tandem queue for which the total service capacity should be divided among the two queues.

Although the fixed and flexible boundary models describe dependence between the two queues, these models are relatively easy to analyze. The main reasons for this are the fact that the two-dimensional system of the request and data queues is reduced to a one-dimensional model for the data queue by treating the request queue as a black box, and the fact that the transmission delay is partially ignored. The delayed flexible boundary model could not be solved explicitly. For the continuous-time models we aim at solving the two-dimensional system, where we keep track of both the request and data queues.

Without loss of generality we assume that the service capacity of the upstream channel equals one unit of work per time unit. Then, whenever both the request queue and data queue are nonempty, this capacity should be divided: a proportion *p* of the capacity is given to the request queue, and *1-p* to the data queue.

Let us now translate the discrete-time models introduced in Section 6 into their continuous-time counterparts. In the fixed boundary model, the capacity of the two queues is divided according to fixed fractions *p=c/f* and *1-p=s/f*, irrespective of whether one of the queues is empty. In the flexible boundary model, the unused capacity of the data queue is used for the request queue. So, whenever both queues are nonempty the service capacity is still divided according to *p=c/f* and *1-p=s/f,* but when the data queue is empty, *p* is increased from *c/f* to 1. We will refer to this scheduling discipline as *partial coupling*. Under partial coupling, the service capacity of the request queue depends on the workload of the data queue, and this interdependence between the queues severely complicates the analysis.

A natural extension of partial coupling is then full coupling, where not only the capacity of the request queue is increased from *c/f* to 1 when the data queue is empty, but the capacity of the data queue is also increased from *s/f* to 1 when the request queue is empty. Both partial and full coupling guarantee a minimum rate *p=c/f* for the request queue and *1-p=s/f* for the data queue whenever there is work to be done at the queue in question. However, contrary to partial coupling, full coupling is work-conserving in the sense that the service (upstream) capacity is always fully used, irre-

spective of one of the queues being empty or not.

A service discipline that changes the service rates whenever one of the queues is empty is known in the queueing literature as *coupled processors*. If the coupled processors discipline is work-conserving, it reduces to full coupling. Full coupling is better known as generalized processor sharing (GPS). GPS is a popular scheduling discipline in modern communication networks, since it provides a way to achieve service differentiation among different types of traffic classes.

Boundary value problems
When we assume that users arrive to the request queue according to a Poisson process, and that they require exponential service times at both queues, no coupling results in a tandem queue of two independent M/M/1 queues. Since this is a standard Jackson network, the stationary joint queue length distribution possesses a pleasant product form.

This does not hold for partial and full coupling. These service disciplines give rise to two-dimensional Markov processes that can be solved using the theory of boundary value problems. This is because the joint queue length process can be modelled as a random walk on the lattice in the first quadrant, and belongs as such to the class of nearest-neighbor random walks (only transitions to immediate neighbors may occur). A pioneering study of these types of random walks is the one of Malyshev [15] (see also [7]) whose technique was introduced to queueing theory by Fayolle and Iasnogorodski [6]. They analyzed two parallel queues with coupled processors, each queue having Poisson arrivals and exponential service times. They showed that the functional equation for the probability generating function of the joint queue length distribution can be transformed to a Riemann-Hilbert boundary value problem. Cohen and Boxma [2] have presented a systematic and detailed study of the technique of reducing a two-dimensional functional equation of a random walk or queueing model to a boundary value problem, and discuss in detail the numerical issues involved. In particular, the analytic solution to the boundary value problem requires the determination of some conformal mapping, which can be accomplished via the solution of singular integral equations. In most cases, this requires a numerical approach (see Cohen and Boxma [2], Part IV, and [14, 17]).

Our contribution to tandem queues
For the two-stage tandem queue with coupled processors we show in [14] that the problem of finding the generating function of the joint stationary queue length distribution can be reduced to two different Riemann-Hilbert boundary value problems. We discuss the similarities and differences between the two boundary value problems, and relate them to the computational aspects of obtaining performance measures like the mean queue length and the fraction of time a queue is empty. Our detailed account of the numerical issues that arise when implementing a formal solution to a Riemann-Hilbert boundary value problem, is illustrative and may serve as an example for other types of queues that can be solved using the same technique. For the two-stage tandem queue with partial coupling we show that the problem of finding the bivariate generating function of the joint stationary queue length distribution can be reduced to a Riemann-Hilbert boundary value problem of a slightly different type. The solution to this boundary value problem is more involved than the one for the coupled processors discipline. We indicate in [12] how the solution to the model with partial coupling can be obtained, but we do not discuss all details.

Finally, we derive in [12], Chapter 11, asymptotic expressions for the stationary queue length distribution. With these expressions, one can determine the probability of occurrence of large queue lengths, which is most valuable since these types of events might jeopardize the quality of service. We show that obtaining asymptotic expressions is equivalent to performing an analytic continuation of the bivariate generating function of the joint stationary queue length distribution. A crucial role is then, like in case of the boundary value problems, played by the functional equation that defines the generating function implicitly. By exploiting the specific properties of the functional equation, we can obtain the analytic continuation of the generating function, and thus the asymptotic expressions. Our derivation of the asymptotic expressions fully relies on an analytic approach. An alternative approach would be to apply a type of *large deviations technique* (see [8, 9]). We show that the latter approach is essentially tantamount to our analytic approach.

Acknowledgment
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5. PUBLICATIONS

5.1. Papers in journals and proceedings per programme
5.2. EURANDOM report series

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5.1. Papers in journals and proceedings per programme

Queueing and Performance Analysis (QPA)

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In 2005 the EURANDOM researchers published a total of 141 articles.

Distribution per programme:

QPA	74
RSS	30
SIM	33
SERA / RI	01
BMM	03

	141

5.2. EURANDOM Report Series

The ISSN number for the EURANDOM Report series is: 1389-2355

Report No.	Title	Author(s)
2005-061	Time-dependent behaviour of an alternating service queue	M. Vlasiou B. Zwart
2005-060	Optimal estimation of qubit mixed states with local measurements	R. Gill E. Bagan M. Ballester R. Muñoz-Tapia O. Romero-Isart
2005-059	Optimal Bell tests do not require maximally entangled states	R. Gill A. Ancín N. Gisin
2005-058	Optimal full estimation of qubit mixed states	R. Gill E. Bagan M. Ballester A. Monras R. Muñoz-Tapia
2005-057	Asymptotic information bounds in quantum statistics	R. Gill
2005-056	An Algorithmic and a Geometric Characterization of Coarsening at Random	R. Gill P. Grünwald
2005-055	Convergence results and sharp estimates for the voter model interfaces	R. Sun S. Belhsouari T. Mountford G. Valle
2005-054	Convergence of Coalescing Nonsimple Random Walks to the Brownian Web	R. Sun C. Newman K. Ravishankar
2005-053	Overlap equivalence in the Edwards-Anderson model	C. Giardinà P. Contucci C. Giberti C. Vernia
2005-052	Relative entropy and waiting time for continous-time Markov processes	C. Giardinà J.-R. Chazottes F. Redig
2005-051	A random environment for linearly edge-reinforced walks on infinite graphs	F. Merkl S. Rolles
2005-050	Localization transition for a copolymer in an emulsion	F. den Hollander S. Whittington
2005-049	Asymptotics in empirical risk minimization	L. Mohammadi S. van der Geer
2005-048	Design and Analysis of a Class-aware Recursive Loop Scheduler for Class-based Scheduling	H.P. Tan R. Rom M. Sidi
2005-047	Performance Analysis of Wireless Scheduling with ARQ in Fast Fading Channels	H.P. Tan
2005-046	Battery open-circuit voltage estimation by a method of statistical analysis	I. Snihir W. Rey

		E. Verbitskiy A. Belfadhel-Ayeb P. Notten
2005-045	Stochastic decomposition of the M/G/∞ queue in a random environment	B. D'Auria
2005-044	M/M/∞ Queue with on-off service speeds	B. D'Auria
2005-043	Direct Evaluation of Large Deviation Functions	C. Giardinà J. Kurchan L. Peliti
2005-042	The Ghirlanda-Guerra identities	C. Giardina P. Contucci
2005-041	Bayesian estimation for quantification by real-time Polymerase Chain Reaction	N. Lalam Ch. Jacob
2005-040	Bayesian modelling and analysis of spatio-temporal neuronal networks	F. Rigat M. de Gunst J. van Pelt
2005-039	On a theorem of Breiman and a class of random difference equations	D. Denisov B. Zwart
2005-038	Lace expansion for the Ising model	A. Sakai
2005-037	A Lévy Process Reflected at a Poisson Age Process	O. Boxma O. Kella, M. Mandjes
2005-036	The survival probalility for critical spread-out oriented percolation above 4 + 1 dimensions. II. Expansion	F. den Hollander R. van der Hofstad G. Slade
2005-035	The survival probability for critical spread-out oriented percolation above 4 + 1 dimensions. I. Induction	F. den Hollander R. van der Hofstad G. Slade
2005-034	Local asymptotics for the cycle maximum of a heavy-tailed random walk	D. Denisov S. Shneer
2005-033	A Markovian Growth-Collapse Model	O. Boxma D. Perry W. Stadje S. Zacks
2005-032	Exact solution to a Lindley-type equation on a bounded support	M. Vlasiou I. Adan
2005-031	Organized versus self-organized criticality in the abelian sandpile model	A. Fey F. Redig
2005-030	Ordinal Coding of Image Microstructure	A. Koloydenko D. Geman
2005-029	Adjusted Viterbi training for hidden Markov models	A. Koloydenko J. Lember
2005-028	Data Network Models of Burstiness	B. D'Auria S. Resnick
2005-027	Symmetry Studies (Lecture Notes)	M. Viana
2005-026	Heavy traffic limit for a processor sharing queue with soft deadlines	Ch. Gromoll L. Kruk
2005-025	Renormalization of interacting diffusions: a program and four examples	F. den Hollander
2005-024	Heavy tailed analysis	S. Resnick

2005-023	Annealed asymptotics for the parabolic Anderson model with a moving catalyst	M. Heydenreich J. Gärtner
2005-022	Output Analysis of Multiclass Fluid Models with Static Priorities	E. Tzenova I. Adan V. Kulkarni
2005-021	The G/M/1 Queue revisited	I. Adan O. Boxma D. Perry
2005-020	Testing the irreversibility of a Gibbsian process via hitting and return times	F. Redig J.-R. Chazottes
2005-019	Deviation inequalities via coupling for stochastic processes and random belts	F. Redig J.-R. Chazottes P. Collet C. Külske
2005-018	Infinite volume limits of high-dimensional sandpile models	F. Redig A. Jarai
2005-017	On the equivalence of three estimators for dispersion effects in unreplicated two-level factorial designs	P. van der Ven
2005-016	A Two-Fluid Flow Model	E. Tzenova I. Adan V. Kulkarni
2005-015	A non-increasing Lindley-type equation	M. Vlasiou
2005-014	Empirical Bayesian Test of the Smoothness	F. Enikeeva E. Belitser
2005-013	On Approximate Pattern Matching for a Class of Gibbs Random Fields	E. Verbitskiy J.-R. Chazottes F. Redig
2005-012	On the Variational Principle for Generalized Gibbs Measures	E. Verbitskiy A. van Enter
2005-011	Random graphs with arbitrary i.i.d. degrees	D. Znamenski R. van der Hofstad G. Hooghiemstra
2005-010	Distances in random graphs with finite mean and infinite variance degrees	D. Znamenski R. van der Hofstad G. Hooghiemstra
2005-009	Comparing downside risk measures for heavy tailed distributions	M. Sarma J. Danielsson B. Jorgensen C. de Vries
2005-008	Comparing risk measures	M. Sarma J. Danielsson B. Jorgensen C. de Vries
2005-007	Random walk in random scenery: A survey of some recent results	F. den Hollander J. Steif
2005-006	Sub-additivity re-examined: the case for Value-at-Risk	M. Sarma J. Danielsson B. Jorgensen C. de Vries

2005-005	On the discounted penalty function in a Markov-dependent risk model	H.-J. Albrecher O. Boxma
2005-004	Fourier law in a momentum-conserving chain	C. Giardinà J. Kurchan
2005-003	Characterisation of the tail behaviour of financial returns: studies from India	M. Sarma
2005-002	Phase transitions for the long-time behaviour of interacting diffusions	F. den Hollander A. Greven
2005-001	An exact penalty method for smooth equality constrained optimization with application to maximum likelihood estimation	W. Bergsma T. Rapcsák
2005-000	Adjusted Viterbi Training. A proof of concept.	A. Koloydenko J. Lember

In 2005 the EURANDOM researchers published a total of **62** EURANDOM Reports.

Distribution per programme:

QPA	18
RSS	24
SIM	15
SERA / RI	04
BMM	01

	62

6. ACTIVITIES

6.1. Workshops and Conferences

January 3-7, 2005 RSS

Dynamical Systems, Probability Theory and Statistical Mechanics

Organisers
W.Th.F. den Hollander (TU/e), D. Denteneer (Philips Research) and E. Verbitskiy (Philips Research).

Participants
83

The goal of the conference was to bring together leading researchers in the three areas united by the title of the conference. The programme was a balanced mixture of review talks as well as lectures about recent results. The main topics discussed were:

- Percolation
- Self-interacting random walks
- Gibbs measures
- Z^d-actions and random fields
- Entropy and coding.

The conference activities were not limited to the lectures alone. The schedule was designed so as to stimulate interaction and a good working atmosphere, which resulted in active discussions and exchange of ideas.

The conference was held both at EURANDOM and the Philips High Tech Campus. More than 80 participants attended the meeting and 19 one-hour lectures were delivered. During the conference Mike Keane has been awarded "Knight in the order of the Dutch Lion".

The meeting was supported by EURANDOM, European Science Foundation (RDSES programme), KNAW, Korteweg de Vries Institute, Mathematical Research Institute, NWO, Philips Research, TU Eindhoven, Stieltjes Institute and Wesleyan University.

February 2-5, 2005 QPA

Rare events in communication networks

Organisers
O. Boxma (TU/e) and M. Mandjes (CWI).

Participants
61

Objectives of the workshop
The macroscopic behaviour of modern communication networks, driven by large numbers of essentially random inputs, critically depends on the occurrence of rare ("extreme") events. These events, although taking place at an extremely low frequency, may have disastrous consequences, and are therefore of crucial interest. This observation justifies the considerable body of literature dedicated to rare events, and their application in communication networks.

Two areas of probability theory, each with their own methodology, contribute to the study of rare events. The first is that of classical large deviations theory. Here probability distributions typically have exponentially bounded tails, and extreme events arise as the cumulation of a very large number of relatively small deviations from the norm. This theory has found many applications to the study of complex stochastic systems. In the case of stochastic networks, notably communications networks, a typical problem is that of determining the probability of buffer overflow, and hence packet loss, in a modern packet-switched network.

The second area is that of the study of long-range dependence and of heavy-tailed distributions. These phenomena are again observed in modern communications networks, but now traffic patterns exhibit extreme variability on a wide variety of time-scales, such that extreme events may have consequences with long-range persistence in time. Furthermore, when distributions are heavy-tailed, extreme events usually occur as the result of a single, highly unusual, deviation from the norm (rather than many relatively small deviations).

The primary aims of the workshop were:
(i) the further development of the mathematics of rare events (including effective simulation algorithms), with the focus on applications to communication networks, and (ii) bringing together leading experts on rare event theory and leading experts on broad-

band and mobile networks. The resulting interaction should lead to the solution of existing communication networks performance problems and to the formulation of relevant new problems on large deviations and long-range dependence.

The workshop directly relates to WP.JRA.5.2 - Dynamics of networks under new traffic paradigms.

Outcome of the workshop
The workshop started with a one-day tutorial programme, mainly intended for talented young researchers; the tutorial speakers were Professor Neil O'Connell (University College, Cork, Ireland; Introduction to large deviations theory and its applications to stochastic networks) and Professor Predrag Jelenkovic (Columbia University, NY, USA; Introduction to heavy-tailed models for information networks).

In the remainder of the programme, there were eight 60-minute invited lectures (by leading researchers from inside and outside Euro-NGI) and sixteen 30-minute contributed lectures. Four speakers had an industry-affiliation.

There were 61 participants, about half of whom were not member of Euro-NGI. The workshop was part of the 6th framework European Network of Excellence EURO-NGI (WP.SEA.6.3) that is funded by the European Community. The costs of the workshop were mainly covered by EURO-NGI.

March 14-18, 2005 RSS

Workshop on self-similar random structures Hausdorff dimension and branching

Organisers
A. Klenke (Johannes-Gutenberg Universität Mainz) and P. Moerters (University of Bath)

Participants
38

This has been the second YEP (Young European Probabilists) workshop in a series of three YEP workshops. The first one, held in 2004, was on "Conformal invariance, Scaling limits and percolation". The third one will take place in March 2006 on "Large deviations, random media and random matrices".

The second YEP workshop consisted of two mini-courses of four hours each, by:

- Balint Virag (Toronto) on Trees, groups and randomness
- Russel Lyons (Indiana) on Random walks, tree entropy and unimodularity.

In the mini-courses two subjects of great current interest were presented in an accessible fashion by leading experts in the field. There was also plenty of opportunity to approach the mini-course speakers with individual questions, and these opportunities were well-used by the participants.

The core of the workshop was six problem sessions of 1½ hours, each, by:

- Jochen Blath (Oxford) on Long-term behaviour of branching particle systems,
- Jan Swart (Erlangen) on Pathwise uniqueness for SDEs with non-Lipschitz coefficients,
- Julien Berestycki (Marseille) on Self-similarity in fragmentation and coalescence,
- Gidi Amir (Jerusalem) on One-dimensional DLA,
- Wolfgang König (Leipzig) on Ordered random walks and the corner growth model,
- Elmar Teufl (Graz) on Random walks on fractal like graphs.

In the problem sessions the speakers presented background information, and initiated a discussion on one of their current research topics, for which they are looking for collaborators. Discussions in all six sessions were lively, and feedback from participants shows that people stayed in touch after the meeting. We believe that some fruitful collaborations will emerge from these sessions.

Finally there were also 11 "classical" talks of 45 minutes each, where young probabilists were reporting about their work. The standard of these presentations was very high, and the talks provided a colourful picture of the work done by young researchers in this area.

Altogether the workshop provided a lively forum for discussion and interaction between young researchers in probability all over Europe. There are not too many opportunities like this, which are strongly focussed on the needs of younger scientists and we are very

proud to be able to organise such an occasion with the help of our sponsors.

The workshop attracted altogether 38 participants from ten different countries, including 8 from the Netherlands.

Funding came from ESF (RDSES-programme), NWO, Thomas Stieltjes Institute and EURANDOM.

May 9-10-11, 2005 RI

Risk Measures & Risk Management General Aspects

Organisers
J. Teugels (Emeritus Professor of Catholic University of Leuven, University Center for Statistics), and H. Yang (University of Hong Kong, Department of Statistics and Actuarial Science).

Participants
70

The first speaker, Hans Föllmer (Berlin, Germany), gave an introduction to theoretical aspects of convex measures and robust projections. He was followed by Wlodzimierz Ogryczak (Warsaw, Poland), who reviewed SSD consistency results for risk measures. He classified models according to deviational type risk measures or the complementary achievement type safety measures. After re-examining their convexity properties, he demonstrated that such safety measures become coherent after a simple change of sign.

Hans U. Gerber (Lausanne, Switzerland) discussed optimal dividends in the Brownian motion model with credit and debit interest. The expected discount value of the dividends can be calculated as well as the optimal dividend barrier. As an alternative assumption, he allowed the possibility that business continues after ruin.

Alexander Schied (Berlin, Germany) treated model uncertainty faced by investors. He dealt with a particular class of investor preferences that takes into account the aversion against model uncertainty and risk. He indicated how to construct optimal investment strategies for the resulting utility functionals.

On Monday afternoon Tom Fisher (Edinburgh, Scotland) discussed the applications of the gradient of risk measures that are differentiable with respect to the units of the measured portfolio. In some cases the gradient is the unique fair per-unit allocation principle. In a more practical context, allocation and optimization concepts help when dealing with such problems.

Michel Denuit (Louvain, Belgium) treated axiomatic aspects and applications of distortion risk measures in actuarial science. In particular, he treated sums of correlated or heterogeneous risk such as the pricing of longevity bonds.

Also Werner Hürlimann (Basel, Switzerland) treated distortion risk measures but within the context of economic capital. He argued that such measures should preserve some higher degree stop-loss order. Under appropriate conditions, the resulting measures are coherent and coincide with Wang's right-tail or the expected value measure.
Zinoviy Landsman (Haifa, Israel) suggested to use elliptical tilting as a natural generalization of exponential tilting as a tool for deriving a portfolio decomposition formula. A further weakening of the model restriction leads to elliptical copulas.

The last speaker of the day was Marc Goovaerts (Leuven, Belgium) who argued that there exists a distinction between risk measures and decision principles. Where risk measures quantify risk on a first level, secondary decision principles are derived from them. Economic examples from insurance and financial industry were offered.

The first speaker on Tuesday was Mark Davis (London, UK) who pointed out that there has been a huge increase in the trading of financial risk and in risk redistribution through financial products such as collateral debt obligations. The challenge in dealing with portfolio credit risk is the construction of good models for large credit-risky assets. Copulas can be used to describe the relationship between credit spreads and default probabilities. He then moved to dynamic models aimed at capturing the interaction effects.

Dirk Tasche (Basel, Switzerland) discussed the multi-factor version of the Basel II credit portfolio model. In this simple model the risk weights depend on the credit characteristics, not on the composition of the portfolio. To allow the effects of segmentation, the speaker extends the model slightly. A two-

factor model already indicates substantial reductions of capital requirements.

Freddy Delbaen (Zürich, Switzerland) discussed $L^{\square}$-hedging and a problem of Brownian motion.

Alexandre Adam (Paribas, France) provided a framework for the interest rate risk management of non-maturing deposit accounts. After considering investment strategies in the swap market, he turned to VaR and expected shortfall as alternative strategies in order to improve hedging performance.

Momentum strategies using risk-adjusted stock ranking criteria were then taken up by Svetlozar Rachev (Karlsruhe, Germany). Such strategies are useful when stock returns are not normal. Moreover, they provide ranking criteria that generate more profitable momentum strategies than those based on usual cumulative or total return criterion.

As the first speaker of Tuesday afternoon, Robert Elliott (Calgary, Canada) treated axiomatic aspects and applications of distortion risk measures in actuarial science. Apart from dealing with properties of sums of correlated or heterogeneous risks, an application to the pricing of longevity bonds was given.

Hailiang Yang (Hong Kong, China) dealt with an optimal consumption strategy in a discrete-time model with credit risk. Assuming that the return of a risky asset is credit ranking sensitive, he constructs a Markov chain model with an absorbing default state. An optimal consumption strategy is obtained together with its influencing by credit risk.

A unified view of hedging and risk management was the offered by Soumik Pal (Columbia, U.S.A.). The formulation is in terms of the minimum capital required in order to avoid risk at the end of the trading period. Another example is offered by an alternative derivation of the superhedging price in incomplete markets.

Helmut Mausser (Toronto, Canada) considered an obligor's Var-contribution in a conditional-independence credit framework. The latter, typically estimated by Monte Carlo simulation, captures correlated credit transitions by relating obligors to a common set of factors. L−estimators and importance sampling can be applied to the problem as well.

Thomas Mikosch (Copenhagen, Denmark) criticized the proliferation of the use of copulas within actuarial and financial contexts. He surveyed the gains of using copulas and their relationship with modelling extremes.

On Wednesday morning Hanspeter Schmidli (Cologne, Germany) reconsidered two classical risk processes, i.e. the problem of optimal dividend payments and the minimization of the ruin probability. Via a Hamilton-Jacobi-Bellman approach he circumvented cases where the value function is not necessarily differentiable.

Hansjörg Albrecher (Graz, Austria) treated the sample coefficient of variation and the sample dispersion as examples of widely used measures of variation. In practice, these quantities heavily depend on the existence of sufficiently many moments. The behavior of these measures when such conditions are violated are discussed and illustrated.

In the final regular session of the workshop Jostein Paulsen (Bergen, Norway) developed a pricing model for a marine insurance company. Apart from picking the correct covariates, the models presented are actively used by marine companies both for direct insurance as well as for reinsurance.

Dmitrii Silverstrov (Västerås, Sweden) presented the Reinsurer Analyzer, an experimental program for analysis and comparison of reinsurance contracts. The program is based on choices of claim flow and interclaim time distributions together with a plethora of different reinsurance contracts. Contracts can then be compared by observing the performance of appropriate risk measures.

As the final speaker George Pflug (Vienna, Austria) treated acceptability, risk capital and risk deviation functionals. Convexity properties allow dual representations that give easy characterizations. In an extension to multi-period models it is shown how information decreases risk.
On Wednesday afternoon a Round Table was held. Participants were Mark Davis (chair), Alexandre Adam, Freddy Delbaen, Marc Goovaerts, Jostein Paulsen and Georg Pflug.

There were 70 participants (among them 24 speakers) coming from 17 countries.

The workshop was co-sponsored by NWO, KNAW and industry.

June 24, 2005 SIM

Regional Meeting on Design of Experiments (DOE) and Statistical Process Control (SPC)

Organiser
A. Di Bucchianico (Technical University Eindhoven and EURANDOM).

Participants
30

Design of experiments is an important part of industrial statistics. In spite of the importance of this field, there are relatively few researchers in Western-Europe active in this field. A major part of these researchers live in a region near the Dutch-Belgium-German borders.

In order to strengthen collaboration between these researchers, an informal research meeting was held at EURANDOM on June 24, 2005. In the morning senior researchers from academia (Universities of Leuven, Maastricht, Dortmund) and industry (CQM, TNO, Philips) gave overview talks on various topics, including experimental designs in medical statistics, statistical learning and marketing. In the afternoon a lively poster session was held for junior researchers.

During the day, the senior researchers agreed to take explicit measures to strengthen collaboration. As first action, it was agreed to submit a joint Marie Curie Research Training Network proposal for the 6th Framework Programme of the European Union. This proposal was submitted at the end of 2005, but in spite reasonable referee reports did not survive the first round.

September 20-23, 2005 RSS

Interacting Stochastic Systems

Organisers
R. van der Hofstad (Technical University Eindhoven and EURANDOM) and F. Redig (University Leiden and EURANDOM).

Participants
34

In this workshop, various topics in Interacting Stochastic Systems have been discussed:

(1) Meta-stability. In the workshop, there have been two talks on meta-stability by Scoppola and by Nardi, describing recent work on meta-stability when the dynamics is conserved, and the temperature is low.

(2) Interacting random walks. The basic model of simple random walk (SRW) and or Brownian motion has a lot of exciting and interesting variations, and some of these have been described in the workshop. Both König and Toninelli have spoken about polymer problems, while Rolles discussed recent work with Merkl on linearly edge-reinforced random walks. Interestingly, Rolles and Merkl are closing in on the problem of proving recurrence for two-dimensional ERRW, which has been an open problem for a long time. Further contributions have been around random walk in random environment (Bolthausen).

(3) Interacting and branching diffusion. Greven discussed recent results on interacting and branching diffusions on the hierarchical group, which are an attempt to approximate two-dimensional lattices. Slade has described the recent results relation oriented percolation, a particular form of an interacting branching process, to super-Brownian motion. Gärtner described recent work on the Parabolic Anderson Model, where the random environment was chosen as a voter model or an exclusion process. This work is also related to the work described by Kesten on the existence of a phase transition in some models for the spread of an epidemic.

(4) Spin glasses. Kourkova and Van Enter have given lectures on spin glasses, which are models for disordered magnetic systems. Van Enter has discussed the role of boundary conditions centring around the notion of chaotic size dependence. Kourkova has described recent work on the statistics of energies in random spin systems, and the relation to the so-called REM Conjecture by Bauke and Mertens. Bovier described the related issue of aging. Further contributions were given by Olivieri, Van den Berg, Gantert and Steif.

Over the workshop days there was plenty of opportunity to discuss with the various speakers, as well as with the other participants.

This workshop was co-sponsored by NWO, KNAW, Thomas Stieltjes Institute and Eindhoven University of Technology.

September 23, 2005

Stochastics Afternoon

Subsequently to the workshop, the "Stochastics afternoon" was organised. During this afternoon, both directors stepping down, Frank den Hollander and Henry Wynn, and the new director, Onno Boxma, gave a state of the art lecture on the research within their research areas, with the following titles:

- "Challenges in mathematical statistical physics"
- "Algebraic statistics, the new interface"
- "A few views on queues".

October 3-4-5, 2005 SIM

Modelling in classification and statistical learning

Organisers
R. Gill (University of Utrecht), S. van de Geer (ETHZ), P. Grünwald (CWI), and L. Mohammadi (University Leiden).

Participants
29

This workshop was a continuation of the successful PASCAL workshop "Notions of Complexity: information-theoretic, computational and statistical approaches" which was held in EURANDOM in October 2004. PASCAL is the European Commission's IST-funded Network of Excellence for Multimode Interfaces.

Statistical Learning is one of the research areas at EURANDOM, and a core theme in PASCAL. The workshop in 2004 focussed on interaction between statisticians and computer scientists concerning fundamental concepts in learning. The 2005 workshop concentrated on using prior information in learning through statistical modelling, on learning adaptively in the face of time dependence and time trends, and on using unlabelled data to speed up learning.

The goal of both the workshops was to bring together the statisticians and computer scientists and to give them the chance of discussing, comparing and getting new ideas.

A. Smola, from National ICT Australia and ANU, is working on intelligent data analysis for bioinformatics, reinforcement learning, document analysis, and learning theory. He gave a very interesting talk on nonparametric tests between distributions. Reproducing Kernel Hilbert Spaces have been frequently used by computer scientists and statisticians. He gave concentration of measure bounds for tests for independence of random variables using an easy to compute criterion between spaces of observations.

The computer scientist V. Vovk, from Royal Holloway, University of London, is active on Defensive forecasting, Predictive complexity, Game-theoretic foundations of probability and finance and On-line compression modelling. He described a new technique for designing competitive on-line prediction algorithms and proving loss bounds for them. The goal of such algorithms is to perform almost as well as the best decision rules in a wide benchmark class, with no assumptions made about the way the observations are generated.

J. Langford, from TTI, Chicago, USA, is a technology maker, focusing on learning. He showed in his talk how to use classifiers to minimize any reasonable loss where reasonable means "a bounded set of possibilities each of which incurs a bounded loss". One of the problems in practice is to choose the loss function. The disparity between real-world problems and existing algorithms can be met with a "learning reduction" from the optimization of one loss to the optimization of another. It turns out that any reasonable loss function can be implicitly optimized by the appropriate use of a binary classification algorithm.

M. van der Laan, from the University of California, Berkeley, is in a computational biology group. His talk focussed on unified loss functions and estimating function based learning. He mentioned applications with high dimensional data structures, and the questions of interest corresponded typically with high dimensional parameters of interest. Because in such problems it is typically not possible to a priori pose a model allowing estimation at a parametric rate, he required estimators of non-pathwise differentiable parameters. He presented a general loss based estimation procedure, which is grounded by theory (e.g., minimax adaptive), and generalizes existing estimation problems.

One of the co-organizers of the workshop, P. Grünwald, from CWI Amsterdam gave a talk, joint with John Langford, on suboptimality of MDL and Bayes in classification under mis-

specification. He showed that forms of Bayesian and MDL learning that are often applied to classification problems can be *statistically inconsistent*.

In a session named "Impromptu Results", three of the participants presented short interesting talks. One of them was on Anti-learning. This was an innovation for our workshop and it seemed very popular. There were theoretical results by e.g. L. Mohammadi from EURANDOM and R. Vert from University Paris-Sud. They both focussed on asymptotic properties of classifiers. The former obtained bounds on the risk of penalized empirical risk minimizers and the latter presented an analysis of the asymptotic behaviour of the One-Class support vector machine (SVM), a popular algorithm for outlier detection.

The workshop was co-funded by the PASCAL Network of *Excellence Pattern Analysis, Statistical Modelling and Computational Learning* and NWO.

October 13-14, 2005 RSS

BRG-meeting

Organiser
F. den Hollander (University Leiden)

Participants
21

On 13 and 14 October, EURANDOM hosted the half-yearly meeting of the Bilateral Research Group (BRG) on 'Mathematics of Random Spatial Models from Physics and Biology'. The BRG is a collaboration of the RSS-programme of EURANDOM with four stochastics groups in Germany, headed by A. Bovier (Berlin), E. Baake and F. Goetze (Bielefeld), A. Greven (Erlangen) and A. Wakolbinger (Frankfurt). The BRG is jointly funded by DFG and NWO, and hosts a total of seven postdocs, four in Germany and three at EURANDOM.

The meeting drew 21 researchers in and around BRG. There were 9 talks. Some talks focussed on the development of the seven projects, other talks highlighted related research.

Key topics that were discussed were: branching and coalescence, diffusive clustering, catalytic branching, structural properties of ancestral trees, reinforced random walk, random matrices.

The BRG-meetings provide ample opportunity for discussion of the projects in a larger arena. After each meeting the coordinators get together to plan the organizational aspects.

On December 14th, 2005, a mid-term presentation of the BRG took place at the DFG in Bonn, in front of an international committee invited by DFG and NWO to review BRG. The outcome of the review was very positive. In the course of the Spring of 2006, DFG and NWO will decide whether to continue funding the BRG.

The meeting was facilitated by EURANDOM.

December 12-13, 2005 RI

The Economics & Finance of Extremes

Organizers
J. Einmahl (Tilburg University) and C. de Vries (Erasmus University).

Participants
32

The aim of the workshop was to develop our understanding of the univariate and multivariate extremal behavior of financial and economic data from an economics and statistical perspective. Over time a considerable statistical literature has been developed concerning the tail behavior of financial and economic data. This was evidenced in the contributions by Malevergne, van Marrewijk, and Perry who gave a univariate perspective and by Poon concerning the multivariate and dependency aspects.

More recently, our probabilistic understanding of the dependency in the tail has also increased considerably. The presentations by Mikosch and De Haan considered temporal dependence and the contributions by Resnick and Einmahl investigated spatial dependence, measured by the spectral measure.

Only very recently there is a small but growing number of contributions from the finance and economics fields, which try to explain the tail features from the economic fundamentals. Univariate contributions on this topic were presented by Gabaix and Hyung, a multivariate analysis was presented by de Vries. Khmaladze gave a general exposition on a large number of rare events and linked it to Zipf's law.

The lively discussions after the lectures and in particular during the roundtable at the end of the first day proved how fruitful it was to bring together the statistical, probabilistic, financial and economic perspectives. We are convinced that the workshop will generate new research and collaboration.

Overall more than 30 scientists including a number of EURANDOM post-docs and other young researchers from the Netherlands participated in the meeting.

The workshop was co-funded by NWO and KNAW.

December 16, 2005 RSS

Physics in Ecology

Organiser
M. van Wieren (EURANDOM).

Participants
10

The workshop was intended as an initial informal get together to scout for possible collaborations between people in the Netherlands and Belgium on the subject of applications of physics principles and physical (statistical mechanics) techniques in the context of ecology.

The overall sentiment shared between the participants, is that such an approach can be successful as well as it is desirable. Such an approach could also lead to a more clear understanding and insight into emerging properties and laws for ecological systems, providing an alternative for the mostly intuitive approaches and hypotheses common to the current ecology literature.

It appeared that all participants had a somewhat different background as well as a different point of view, ranging from general theoretical to specific applications. In spite of, or perhaps thanks to this wide scope, it has become clear that in general physics principles and techniques can be successfully applied in a wide range of examples, leaving ample room for future collaborations and workshops for a broader audience.

Presentations were given by:

- Filip Meysman - Thermodynamics and ecology: two fields in a state of confusion?
- Stijn Bruers - Dissipative structures and goal functions for ecosystems
- Emile Apol - Quasi Gaussian Entropy Theory and its Applications in Ecology
- Bart Muys - The ecosystem exergy concept: theory and applications
- Rampal Etienne - Tropical trees as Ehrenfest fleas.

The workshop was facilitated by EURANDOM.

Summary of the workshops

QPA:	1
RSS:	5
SIM:	2
RI:	2

In total 10 workshops were (co)-organised. Total number of participants: 408.

Furthermore, EURANDOM co-sponsored:

March 14-18, 2005 SIM

Symmetry studies

Minicourse by Professor Marlos A. G. Viana, University of Illinois at Chicago, USA; organised by the Euler Institute for Discrete Mathematics and its Applications in collaboration with EURANDOM.

The course started by Arjeh Cohen (Eindhoven University of Technology) who provided the audience with the necessary group theory for Viana's course. This included an introduction to the theory of group representations. The applications of this theory to the statistical analysis of structured data was the content of the last part of the mini-course by Marlos Viana.

The aim of the mini-course was introducing the theory and methods of symmetry studies, including the notions of structured data and data reduction by symmetrically equivalent components. The motivation is derived from a variety of disciplines, including physics, chemistry and molecular biology, where notions of symmetry play a significant role proposing natural models, and from the intent of applying these principles to the analysis of experimental data. With the language and methods of symmetry studies, newer questions and potential answers may eventually be identified. The course introduced new algebraic methods to systematically decompose a varied of large,

structured sets of data with the purpose of simplifying and better understanding these data. Specialized computing tools were also introduced to facilitate the practicing of these analysises.

6.2. Lectures and Seminars

EURANDOM organises, on a regular basis, the following seminars:

- Joint Stochastic Operations Research (SOR) and Queueing and Performance Analysis (QPA) seminar (15)
- Random Spatial Structures (RSS) seminar (26)
- Statistical Information and Modelling (SIM) seminar (13)
- EURANDOM Postdoc and PhD (EPPS) seminar (15)
- Seminars given by the EURANDOM Chair (7)

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Joint Stochastic Operations Research (SOR) – Queueing and Performance Analysis (QPA) seminar

B. D'Auria
University of Salerno, Fisciano (SA), Italy
Limit processes in fluid queueing networks
January 13, 2005

M. Squillante
IBM Research Division, USA
Stochastic bin-packing
January 21, 2005

H.P. Tan
EURANDOM
Analysis of Performance Tradeoffs with Wireless Scheduling
January 25, 2005

A. Makowski
University of Maryland, U.S.A.
The output of a cache under the independent reference model - Where did the locality of reference go?
February 22, 2005

A. Makowski
University of Maryland, U.S.A.
Locality of reference in streams of requests: Modeling temporal correlations via stochastic orderings
February 23, 2005

B. Zwart
Eindhoven University of Technology, The Netherlands
Exponential functionals of compound Poisson and other Levy processes
March 8, 2005

H. Daduna
University of Hamburg, Germany
Stochastic networks with unreliable components
March 15, 2005

D. Gamarnik
T.J. Watson Research Center, USA
Validity of Steady-state Heavy Traffic Approximations in Generalized Jackson Network
April 5, 2005

I. Adan
Technical University Eindhoven and EURANDOM, The Netherlands
Analysis of a Simple Markovian Re-Entrant Line with Infinite Supply of Work under the LBFS Policy
April 19, 2005

B. D'Auria
EURANDOM, The Netherlands
Fractional Brownian motions and Lévy motions in fluid networks
June 7, 2005

D. Raz
Tel Aviv University, Israel
Locality of Reference and the use of Sojourn Time Variance for Measuring Queue Unfairness
September 12, 2005

O. Kella
Hebrew University of Jerusalem
A Levy process reflected at an age process
September 26, 2005

D. Miorandi
CREAT-NET, Italy
From technology to nature and back: BIONETS, BIONETICS and beyond
December 6, 2005

D. Miorandi
CREAT-NET, Italy
Limiting Performance of Ad Hoc Networks with Topology-Transparent Scheduling Schemes
December 8, 2005

C. Flores
Universität Karlsruhe, Germany
Intensity-Duration-Frequency (IDF) curves and random multiplicative cascades
December 13, 2005

Furthermore, the QPA group organised a Reading Seminar about the book *Applied Probability and Queues* of S. Asmussen.

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Random Spatial Structures (RSS) seminar

N. Pétrélis
University of Rouen, France
Random Pinning
January 11, 2005

J. Gärtner
Technische Universität Berlin, Germany
On the Parabolic Anderson Model
January 25, 2005

A. Collevecchio
University G. D'Annunzio, Pescara, Italy
Limit Theorems for Reinforced Random Walks on Certain Trees
February 7, 2005

N. Zygouras
ETH Zürich, Switzerland
A central Limit Theorem for a randomly Driven Semilinear Parabolic Equation
February 22, 2005

M. van den Berg
University of Bristol, United Kingdom
Heat flow, Brownian motion and Newtonian capacity : a refinement of theorems by F. Spitzer and S.C. Port
March 8, 2005

G. Hooghiemstra
University of Technology Delft, The Netherlands
Distances in random graphs with i.i.d. Degrees
April 5, 2005

J. Kurchan
ESPCI, France
Hidden symmetry of Kramers' equation and the problem of finding reaction paths
April 6, 2005

A. Gaudillier
Paris Sud, France and Roma Tor Vergata, Italy
Nucleation pattern at low temperature for local Kawasaky dynamics in two dimensions
May 10, 2005

M. Deijfen
Free University of Amsterdam, The Netherlands
Random graphs with prescribed degree distribution
May 17, 2005

R. Sun
EURANDOM, The Netherlands
Voter model, Potts model, coalescing random walks and the Brownian web
May 24, 2005

B. Núñez B. de Lima
UFMG, Belo Horizonte, Brazil
On the truncation of Percolation systems with long range interactions
June 21, 2005

K. Petersen
University of North Carolina Chapel Hill, NC, USA
Factors Maps on Shifts of Finite Type and Measures
June 24, 2005

G. Guadagni
The College of William and Mary, Department of Mathematics, Williamsburg, U.S.A.
Finite range decompositions and Renormalization Group Finite range decompositions
August 17, 2005

M. van Wieren
Instituut voor Theoretische Fysica, Katholieke Universiteit Leuven, Belgium
The time-symmetric part of the stochastic action
August 18, 2005

P. Contucci
University of Bologna, Italy
The Ghirlanda-Guerra Identities
September 16, 2005

M. Luczak
London School of Economics, UK
A simple solution to the k-core problem
September 14, 2005

L. Pimentel
EPFL, Lausanne, Switzerland
Roughening and inclination of competition interfaces
September 29, 2005

A. Sakai
EURANDOM, The Netherlands
Lace expansion for the Ising model I. Expansion
October 7, 2005

A. Sakai
EURANDOM, The Netherlands
Lace expansion for the Ising model II. Bounds on diagrams
October 21, 2005

P. Trapman
Vrije Universiteit Amsterdam, The Netherlands
Epidemics on networks
November 11, 2005

N. Sidorova
University of Oxford, UK
Weak and almost sure limits for the parabolic Anderson model in single peak case
November 11, 2005

A. Collevecchio
University G. D'Annunzio, Pescara, Italy
On the transience of processes defined on Galton-Watson trees
November 18, 2005

W. Kager
Universiteit van Amsterdam, The Netherlands
Mini-course, Part I; Introduction to Stochastic Loewner Evolution (SLE)
November 25, 2005

J. Swart
UTIA, Academy of Sciences of the Czezch Republic
Renormalization of catalyctic Wright-Fisher diffusion
December 9, 2005

F. Camia
Vrije Universiteit Amsterdam, The Netherlands
Mini-course, Part II; Introduction to Stochastic Loewner Evolution (SLE)
December 13, 2005

J. Swart
UTIA, Academy of Sciences of the Czech Republic
The contact process seen from a typical infected site
December 16, 2005

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Statistical Information and Modelling (SIM) seminar

F. Rigat
EURANDOM, The Netherlands
Binary Neuronal Networks
January 20, 2005

R. Gill
EURANDOM/Utrecht University, The Netherlands
Missing data and biased sampling versus quantum non-locality
January 8, 2005

W. Bergsma
EURANDOM, The Netherlands
On a new type of correlation, its eigenvalue decomposition and associated tests of independence
February 22, 2005

E. van der Heuvel
NV Organon Statistics Department, The Netherlands
Evaluation of an Affymetrix High-density Oligonucleotide Microarray Platform as a Measurement System
March 10, 2005

M. Banerjee
University of Michigan, USA
Inference for conditionally parametric response models
April 5, 2005

M. Lupparelli
University of Florence, Italy
Bi-directional graph models for contingency tables
April 7, 2005

J. Goeman
Leiden University, The Netherlands
Testing against a high-dimensional alternative
April 21, 2005

N. Lalam
EURANDOM, The Netherlands
Statistical modelling of gene expression data from confocal scans of Drosophila embryos
May 3, 2005

L. Birgé
Université Paris VI, France
A general approach to model selection via testing
May 23, 2005

M. Huskova
Charles University, Prague, Czech Republic
Control Charts Based on Alternative Hypotheses
June 14, 2005

M. Meise
Universität Duisburg-Essen, Germany
Approximating Data with Splines
June 22, 2005

S. Vidal Puig
Technical University of Valencia, Spain
Multivariate statistical process control
November 8, 2005

T. De Bie
KU Leuven, Belgium
Optimal experiment design for kernel ridge regression, and the minimum volume covering ellipsoid
December 20, 2005

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EURANDOM Postdoc and PhD seminar (EPPS)

V. Kulikov
Decoding aggregated profiles using dynamic calibration of machine vibration data
January 13, 2005

D. Denisov
Random walks with heavy-tailed increments
January 27, 2005

R. Messikh
Percolation, Ising model and large deviations
February 17, 2005

S. Ladoucette
Asymptotic results in large claims reinsurance
February 22, 2005

L. Mohammadi
Rates of convergence in threshold-estimation
March 24, 2005

H.P. Tan
Analysis of Performance Tradeoffs with Wireless Scheduling
March 31, 2005

C. Giardinà
Heat Conduction in 1-dimensional lattices
April 14, 2005

F. Enikeeva
Empirical Bayesian Test of the Smoothness
April 28, 2005

M. Sarma
Sub additivity re-examined: a case for Value-at-Risk
May 12, 2005

B. D'Auria
Fluid models for data flows and their limit behaviour
May 26, 2005

W. Bergsma
Some aspects of statistical dependence modelling
June 27, 2005

D. Znamenski
From Internet to Random graphs with i.i.d.degrees. Diameter estimates
September 27, 2005

M. van Wieren
A particle model for mass and energy flows in organisms
November 1, 2005

P. van de Ven
EURANDOM, The Netherlands
Identifying location and dispersion effects using unreplicated two-level factorial designs
November 24, 2005

J. van Leeuwaarden
The acquisition queue
December 8, 2005

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EURANDOM Chair 2004/2005

Professor Baccelli (INRIA, Rocquencourt and ENS, Paris, France) has been appointed EURANDOM Chair for six months starting October 2004. He gave a public lecture on November 23, 2004 with the title *Mean-Field Interaction Models for Large TCP Networks* and a Mini-course on *Stochastic Geometry and Wireless Network Modeling*..

The Mini-course, consisting of a series of 5 lectures, took place on October 26, December 14, 2004 and February 8, March 29 and June 8, 2005.

The geometry of the location of nodes (mobile users, base stations, access points etc.) plays a key role in several classes of wireless communication networks, since it determines the signal to noise or signal to interference ratio for each potential communication and hence the possibility of establishing simultaneously some set of communications at a given bit rate.

Stochastic geometry provides a natural way of defining and computing macroscopic properties of such networks, by some averaging over all potential geometrical patterns for the nodes, in the same way as queuing theory provides averaged response times or congestion over allpotential arrival patterns within a given parametric class.
The series of lectures surveyed recent results obtained by this approach on two classes of wireless networks:

- Mobile adhoc networks (MANETs), where all nodes are essentially of the same type;
- Cellular networks, where one distinguishes two or more types of nodes: concentration nodes and terminal nodes.

The aim of the lectures was to show how stochastic geometry allows one to analyze key features of these wireless networks such as:

- Coverage and connectivity;
- Power, admission and multiple access control;
- Routing, diffusion or concentration of informations.

Lecture 1

Signal to Interference Ratio Cells of a Poisson Point Process

Consider a marked point process of the Euclidean space, where the mark of a point is a positive random variable that represents its "transmission power". Assume that the power radiated from a point decays in some isotropic way with Euclidean distance.
Define the signal to interference ratio (SIR) cell of a point to be the region of the space where the reception power from this point is larger than some increasing function of the interference. In this definition, the interference at some location of the space is just the sum of the reception powers from all other points.
This lecture analyzed a few basic stochastic geometry questions pertaining to such SIR cells in the case with independent marks:

- The volume and the shape of the typical cell;
- The properties of the coverage of the space by SIR cells, such as volume fraction;
- The law of the number of cells that cover a given location;
- The connections between these SIR cells and classical objects of stochastic geometry such as the Boolean model and Voronoi tessellations.

This lecture was based on the paper "On a Coverage Process Ranging from the Boolean-Model to the Poisson-Voronoi Tessellation", *Advances in Applied Probability*, **33**, 293-323, 2001, co-authored by B.Blaszczyszyn.

Lecture 2

Connectivity of MANETs

This lecture studied the impact of interferences on the connectivity of large-scale adhoc networks, using percolation theory. The set of nodes is represented by a Poisson pointprocess of the plane. Assume that a connection can be set up between two nodes if the signal to noise and interference ratio at the receiver is larger than some threshold. The interference is the sum of the contributions of interferences from all other nodes weighted by a coefficient y which could be seen as the inverse of the processing gain in a CDMA (Code Division Multiple Access) context, and the noise is an external random field.
We showed that there is a critical value of y above which the network is made of disconnected and finite clusters of nodes. We also prove that if y is non zero but small enough, there exist node spatial densities for which the network almost surely contains an infinite cluster of nodes, enabling distant nodes to communicate in multiple hops.
The shape of the region where such an infinite cluster exists is a function of the intensity of nodes and the parameter. It was in particular shown that increasing the density of nodes may disconnect such a network, namely drive the network from the infinite cluster case to the disconnected finite cluster case.

This lecture was based on the paper "Impact of Interferences on the Connectivity of Ad Hoc Networks", *IEEE Trans. Networking*, Vol. 13, number 2, 425–436, co-authored by O. Dousse and P. Thiran.

Lecture 3

Power Control in Cellular Networks

Cellular networks involve a bivariate point-process for representing the location of concentration nodes (e.g. base stations) and that of terminal nodes (users). The terminal node point processes is often assumed to be Poisson whereas the concentration node point process is either Poisson or periodic. In the simplest models, the terminal nodes associated with a given concentration node are those located in its Voronoi cell w.r.t. the point process of concentration nodes.
This lecture focused on the case where terminal nodes require a fixed bit rate, and where-power is controlled so as to maximize the number of terminal nodes that can be served by such a cellular network. In this case, powers become functionals of the underlying point processes.
We first showed how to estimate the number of terminal nodes that have to be rejected

from a static Poisson configuration because of power control infeasibility.
We then studied a pure-jump Markov generator which can be seen as a generalization of the spatial birth-and-death generator and which allows to represent the arrival, mobility and departure of terminal nodes, and which can be used to model the dynamics of such-power controlled cellular wireless communication networks. From the analysis of this generator, we deduced an expression for the blocking probability in such wireless networks. This expression can be seen as a spatial version of the classical Erlang loss formula.

This lecture was based (among others) on the paper "Blocking Rates in Large CDMA Networks via a Spatial Erlang Formula", *Proceedings of IEEE Infocom'05* (2005). Miami. Co-authored by B. Blaszczyszyn and M. Karray.

Lecture 4
Multiple Access Control in MANETs

In this lecture, we analyzed an Aloha type access control mechanism for large MANETs. The access scheme is designed for the multihop context, where it is important to find a compromise between the spatial density of communications and the range of each transmission. More precisely, the analysis aims at optimizing the product of the number of simultaneously successful transmissions per unit of space (spatial reuse) by the average range of each transmission. The optimization is obtained via an averaging over all Poisson configurations for the location of interfering nodes, where an exact evaluation of signal over noise ratio is possible. The main mathematical tools are spatial versions of the so-called additive and max shot noise processes. The resulting MAC protocol exhibits some interesting properties. In particular, its transport capacity is proportional to the square root of the density of nodes.

This lecture was based on the paper "An Aloha Protocol for Multihop Mobile Wireless Networks", IEEE Transactions on Information Theory, Vol. 52, No. 2, 421-436 (2006). Co-authored by B. Blaszczyszyn and P. Muhlethaler.

Lecture 5
Routing

In this lecture, we analyzed a class of spatial random spanning trees built on a realization of a homogeneous Poisson point process of the plane. This tree has a simple radial structure with the origin as its root. This class of spanning trees has applications in:

- Multihop diffusion from a given node in MANETs;
- Multihop routing to a given node in MANETs;
- Concentration in wireless sensor communication networks where information has to be gathered at a central node.

We first showed how to use stochastic geometry arguments to analyze local functionals of the random tree such as the distribution of the length of its edges or the mean degree of its nodes. Far away from the origin, these local properties are shown to be close to those of the directed spanning tree introduced by Bhatt and Roy.

We then used the theory of continuous state space Markov chains to analyze some non local properties of the tree such as the shape and structure of its semi-infinite paths ot routes or the shape of the set of its nodes less than k generations away from the origin. We also stressedthe differences that existbetween several types of averages like path averages and space averages.

This lecture was based on the paper "The Radial Spanning Tree of a Poisson Point Process", Proceedings of the 43th Allerton Conference (2005). Illinois University at Urbana Champaign, submitted to *Annals of Applied Probab*. Co-authored by C. Bordenave.

EURANDOM Chair 2005

In 2005 professor S. Resnick (School of Operations Research and Industrial Engineering, Cornell University, USA), has been appointed EURANDOM Chair.

On May 17, 2005 he gave a Public lecture with the title *Multivariate heavy tails, asymptotic independence and beyond*.

A random vector having a distribution which is multivariate regularly varying at infinity can have a dependence structure which is hard to specify in practice. One extreme but not uncommon case is ''asymptotic independence'' which roughly describes the situation where the random vector's components are not si-

multaneously large. In the absence of further assumptions, estimation of the probability of extreme risk sets yields estimates which are null. One way to remedy this is through hidden regular variation which measures variables on a different scale. Another is via conditioning on one component being large and using a limiting distribution as the conditioning variable is pushed to infinity. We discuss detection of hidden regular variation along with other extensions into conditional models. An application to network data is provided.

Professor S. Resnick also gave a Mini-course, consisting of a series of four lectures, on *Heavy tailed* analysis. The Mini-course took place on May 24, 31, June 7 and 14.

The series surveyed the mathematical, probabilistic and statistical tools used in heavy tail analysis. Heavy tails are characteristic of phenomena where the probability of a huge value is relatively big. Record breaking insurance losses, financial log-returns, file sizes stored on a server, transmission rates of files, are all examples of heavy tailed phenomena. The modeling and statistics of such phenomena are tail dependent and much different than classical modeling and statistical analysis which give primacy to central moments, averages and the normal density, which has a wimpy, light tail. An organizing theme is that many limit relations giving approximations can be viewed as mere applications of continuous maps.

Topics

May 24, 2005

- Introduction
- Survey of the theory of regular variation
- Survey of weak convergence (spaces: R, sequences, C, D, measures and point measures; vague convergence; relation with regular variation)

May 31, 2005

- Tail empirical measure Hill
- Pickands estimators of tail indices

June 7, 2005

- Asymptotic normality of the tail empirical measure; application to Hill estimator
- Applications of the Poisson process; the infinite source Poisson model

June 14, 2005

- Laplace functional
- Poisson transform; point process method
- Transformations for heavy tails
- Sample of topics not covered

The complete course has been published as EURANDOM report (2005-024).

6.3. EURANDOM visitors in 2005

January 2005

19	F. Baccelli	INRIA & ENS	France	Chair
03-10	J. Steif	Chalmers University of Technology	Sweden	RSS
10-14	N. Pétrélis	University of Rouen	France	RSS
17-29	J. Gärtner	Technische Universität Berlin	Germany	RSS
20-21	M. Squillante	IBM Thomas J. Watson Research Centre	USA	QPA
29-Febr. 1	M. de Lourdes Centeno	ISEG	Poland	RI

February 2005

07-11	E. Bolthausen	University of Zurich	Switzerland	RSS
14-18	E. Bolthausen	University of Zurich	Switzerland	RSS
04-08	F. Baccelli	INRIA & ENS	France	Chair
21-25	A. Makowski	University of Maryland	USA	QPA
21-24	N. Zygouras	ETH Zürich	Switzerland	RSS
21-23	A. Sleptchenko	Tuck School of Business at Dartmouth	USA	QPA

March 2005

07-11	M. van den Berg	University of Bristol	UK	RSS
02	S. Kuhnt	Dortmund University	Germany	SIM
10-24	M. Viana	University of Illinois at Chicago	USA	SIM
13-15	H. Daduna	Universität Hamburg	Germany	QPA
28-30	F. Baccelli	INRIA & ENS	France	Chair

April 2005

02-09	D. Gamarnik	T.J. Watson Research Center	USA	QPA
04-18	M. Lupparelli	University of Florence	Italy	SIM
05-06	J. Kurchan	ESPCI	France	RSS
05	M. Banerjee	University of Michigan	USA	SIM

May 2005

07-18 June	S. Resnick	Cornell University	USA	Chair
09-11	E. Scoppola	Università degli Studi 'Roma Tre'	Italy	RSS
09-11	A. Gaudillier	Università degli Studi 'Roma Tre'	Italy	RSS
16-19	E. Saada	PMC Polytechnic	France	RSS
23	L. Birgé	Université Paris VI	France	SIM

June 2005

07-09	F. Baccelli	INRIA & ENS	France	Chair
09-21	M. Huskova	Charles University Prague	Czech Republic	SIM
11-26	V. Shneer	Heriot-Watt University	UK	QPA
20-24	B. Nunez B. de Lima	UFMG, Belo Horizonte	Brasil	RSS
22-25	K. Petersen	University of North-Carolina and Chapel Hill	USA	RSS
22	M. Meise	Universität Duisburg-Essen	Germany	SIM

August 2005

01-Sept. 30	O. Kella	Hebrew University of Jerusalem	Israel	QPA Stieltjes Chair
03-27	L. Chen	Academia Sinica, Taipei	Taiwan	RSS
29-08 Sept.	J. Gärtner	Technische Universität Berlin	Germany	RSS

September 2005

01-15	M. Luczak	London School of Economics	UK	RSS
11-15	D. Raz	Tel Aviv University	Israel	QPA
11-24	P. Contucci	Università di Bologna	Italy	RSS
12-23	G. Slade	University of British Columbia	Canada	RSS
24	F. Baccelli	INRIA & ENS	France	Chair
27-30	L. Pimentel	EPFL Lausanne	Switzerland	RSS
29-30	E. Baake	Universität Bielefeld	Germany	RSS
29-30	N. Zint	Universität Bielefeld	Germany	RSS

October 2005

20-Dec. 21	S. Vidal Puig	Technical University of Valencia	Spain	SIM

November 2005

05-14	N. Sidorova	University of Oxford	UK	RSS
11-Dec. 12	A. Collevecchio	University G. d'Annunzio, Pescara	Italy	RSS
20-Dec. 2	M. Deijfen	Chalmers University of Technology	Sweden	RSS
28	H.-J. Albrecher	Graz University	Austria	RI

December 2005

04-10	D.Miorandi	University of Padova	Italy	QPA
05-16	J. Swart	UTIA	Czech Republic	RSS
06-12	E. Khamaladze	Victoria University	New Zealand	SIM
08-09	D. Perry	University of Haifa	Israel	QPA
12-16	G. Elsner	Universität Bielefeld	Germany	RSS

19-20	T. de Bie	KU Leuven	Belgium	SIM
23	E. Baake	Universität Bielefeld	Germany	RSS
23	N. Zint	Universität Bielefeld	Germany	RSS

In total **45** researchers visited EURANDOM in 2005 (from several days up to 2 months). Total residence time: 66 weeks.

Distribution over the programmes:

Programme	Number of visits	Weeks
QPA	09	16
RSS	28	32
SIM	10	17
SERA/RI	02	01
TOTAL	**49**	**66**

The QPA as well as the SIM programme both welcomed a long term visitor (for approx. 2 months). These visits are included in the above mentioned numbers.

EURANDOM Chair

EURANDOM Chair	Number of visits	Weeks
2004/2005	5	2
2005	1	6
TOTAL	**6**	**8**

7. (INTER)NATIONAL COOPERATION and FUNDING

7.1. International Cooperation

As the previous sections show, international cooperation is flourishing through among others workshops and the visitors programme. Many international organisations are supporting the activities of EURANDOM by sending their researchers to attend workshops or to spend time as a visitor.

EURANDOM is member of ERCOM, the European Research Centres on Mathematics, a committee under EMS (European Mathematical Society), consisting of mathematical institutes that frequently host visitors and workshops. Through members of the Scientific Council and members of the Steering Committees, as well as scientists active at EURANDOM and postdocs who left the institute, many contact lines continue to tie EURANDOM to mathematical institutes and universities all over the world.

EURANDOM continued tightening the Alumni network. A second meeting was organised in September 2005.

The former scientific director of EURANDOM, Prof.dr. W.Th.F. den Hollander, chairs the ESF Scientific Programme on 'Random Dynamics in Spatially Extended Systems' involving 13 European countries.

EURANDOM participates in a Network of Excellence, PASCAL, "to build a Europe-wide Distributed Institute that will pioneer principled methods of pattern analysis, statistical modelling and computational learning as core enabling technologies for multimodal interfaces that are capable of natural and seamless interaction with and among individual human users". EURANDOM also participates in EURO-NGI 'Design and Engineering of the Next Generation Internet', which main target is "to create and maintain the most prominent European centre of excellence in Next Generation Internet design and engineering, leading towards a leadership in this domain".

EURANDOM is one of the four partners in a NEST activity (New and Emerging Science and Technology): MATHFSS. The project aims at identifying future research opportunities on the interface between mathematics and suitable areas of medicine and social sciences. The participants organise a series of workshops and round table discussions.

Although the German Schwerpunkt 'Interagierende stochastische Systeme hoher Komplexität' has been ended, cooperation with German scientists continues. Furthermore, there is close cooperation with German scientists through the Dutch-German Bilateral Research Group on 'Mathematics of Random Spatial Models from Physics and Biology'.

7.2. Cooperation in The Netherlands

There are formal agreements of cooperation with EIDMA (the Euler Institute for Discrete Mathematics), the Thomas Stieltjes Institute for Mathematics and the Mathematical Research Institute.

There are intensive links with the Department of Mathematics in Eindhoven through joint seminars, visitors, researchers working together etc. and, on a less intensive level, with the Departments of Technology Management, Chemical Engineering and Chemistry and Biomedical Technology. Some postdocs were involved in teaching activities at the TU/e.

7.3. Funding

On the national level, basic financial support of EURANDOM is provided by NWO and TU/e (both up to 2007) based on the 'EURANDOM Business Plan 2003-2007'.

EURANDOM continued attempts to secure additional basic funding from European research councils. However, these efforts so far were not successful. European science foundations declared their willingness to cooperate, but not to co-fund a European institute. Grants can only be obtained through national researchers. With DFG

and FWO such cooperation is ongoing. Already several times young researchers received incidental, personal granting and the institute received co-funding for workshops.

During the year 19 junior researchers were (co-)financed by external funds. These funds came from NWO (9, directly and/or via appointments at TU/e or other universities), from the European Commission (1 Marie Curie Fellowship) and from Philips Electronics Nederland BV (1 PhD position for cooperation in the area of cable access networks). After the PhD defence of the junior researcher (June 2005) a follow-up of this project started in December.

The project with Philips and the Department of Chemical Engineering within the framework of the EET (Economy, Ecology, Technology)-programme of the Ministry of Economic Affairs on 'Modelling and Management of Batteries, which started in 2000, was partly continued with external funding (1 PhD student until September) and partly out of the basic funding as a bridge towards a new EET-application.

The research project with Flextronics on *Signature Analysis* has been continued until April 2005 and is also EET-funded (1 Postdoc, 1 PhD student and additional support for scientific guidance).

One postdoc position was paid out of an industry contract with Vodafone, and another postdoc position was paid out of an industry contract with Philips Medical Systems.

Through the Department of Mathematics, BRICKS (Basic Research in Informatics for Creating the Knowledge Society, a six-year programme partially funded by the Dutch BSIK (Besluit Subsidies Investeringen Kennisinfrastructuur) theme ICT (Information and Communication Technology), co-funded 1 postdoc position. Another postdoc position was partly paid out of the VIDI grant (NWO) of Prof.dr.ir. G. J. Woeginger (TU/e).

Furthermore, NWO, KNAW, MRI, Stieltjes, RDSES, TU/e, Weslyan University, Korteweg de Vries Institute – University of Amsterdam and the financial industry (co)-financed workshops in 2005.
EURO-NGI and PASCAL (both Network of Excellence) financed both a workshop in February and October and paid for visits of young researchers to colleagues abroad and/or for their workshop participation.

Two long term visits, by O. Kella and S. Vidal Puig, were funded by respectively the Stieltjes institute, The Netherlands and the University of Valencia, Spain. O. Kella was Stieltjes Chair 2005, and gave a Mini-course at the VU and a public lecture at CWI.

8. FACILITIES

8.1. Computing and Communication

EURANDOM has ample computing facilities. Desktop equipment consists of personal computers that offer access to the Windows / NT and the Unix servers. The personal computers are connected through a high-speed network to these servers and to the Internet. EURANDOM has its own Unix computing server with 4 processors (SGI 200) and uses the NT servers of TU/e. If needed, computing time can be bought on the supercomputing facilities of NCF. The mathematical software that is available consists of Mathematica, Maple, TEX, S-plus, Matlab, R, and programming languages such as C++, C and Visual Basic.

8.2. Library

A modest in-house library is available. As with computing power and software, EURANDOM follows the policy to acquire books and journals only when they are frequently needed. EURANDOM has a working library, not a complete coverage of journals in the field of stochastics. Full-scale libraries are available for EURANDOM staff at TU/e, especially at the Department of Mathematics, and access is given to the Dutch academic library system. Via the library of TU/e EURANDOM researchers have the possibility to access among others J-STOR.

8.3. Housing

EURANDOM provides well-equipped office space, meeting rooms and seminar rooms, a common room, and lunch facilities for its staff in its own building.

All other facilities of TU/e may be used; this includes a sports centre on campus, where staff can participate in various kinds of sports.

Upon special request of the postdocs and PhD students the institute has at its disposal since December 2005 a microwave oven and a table tennis table.

9. EXPENDITURE

The sum of the expenditure is based on the audited financial report.

Expenditure (in K euro)

Staff	1290
Advisors	114
Travel	61
Visitors	23
Housing	122
Workshops, Seminars	98
Books, Journals, Software	14
Depreciation costs	21
General costs	59
ICT Support	32
TOTAL	1834

Furthermore post-docs with a grant, visitors and workshop participants with their own grants deliver an essential part of the EURANDOM activities. Based on average cost estimates. This contribution in "natura" represented this year a money value of 413 K Euro. The total expenditure amounts 2247.