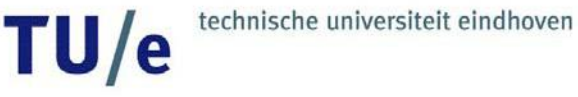
EURANDOM

Annual Report 2006

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.

European Institute for
Statistics, Probability, Stochastic Operations Research and their Applications
Location: Eindhoven University of Technology
P.O.Box 513, 5600 MB Eindhoven, The Netherlands
Telephone: +31 40 247 8100, Telefax: +31 40 247 8190
E-mail: office@eurandom.tue.nl
http://www.eurandom.tue.nl

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PREFACE OF THE BOARD

In this Annual Report the institute reports on the activities of the institute, and the realization of its mission. As stated by the evaluation panel, whose report appeared early 2006, the institute plays a key role in the development of stochastics, both in the Netherlands and in Europe.

Elements of the mission:

- *Recruiting and training talented young researchers and helping them to find their way to tenured positions in academia and industry.* This resulted in 2006 in an outflow of 17 more experienced researchers, from which about one third (6 researchers) found (tenured) positions in The Netherlands.
- *Carrying out and facilitating research through postdoctoral and graduate appointments, visitor exchange and workshops.* As documented in this report, also the visitor and workshop programme flourished and attracted many international researchers to EURANDOM (41 visitors and 423 workshop participants).
- *Taking initiatives for collaborative research at the European level.* The majority of the researchers and visitors come from all over the world; an international Scientific Council oversees the activities of the institute; researchers from abroad are also involved in the Steering Committees. Links are actively established in bilateral collaborations as well as in European programmes of different nature. Via the alumni of the institute, the worldwide network is strengthened constantly.

EURANDOM is a foundation, governed by a Board, consisting of three members. Two persons take part on behalf of the main funding organisations, TU/e and NWO; together both parties appoint the third member, chairing the Board. Official meetings take place twice or three times a year (this year on May 29, and December 4, 2006). In these meetings formal decisions concerning plans, budget, and annual account and reporting are made. Special subject this year was the appointment of the managing director.

Apart from the official meetings, there is frequent informal contact with and among the members. Furthermore, on August 23, 2006 the Board, together with the directors, visited the General Board of NWO. The most important reason for this meeting, as well as for the other consults and individual activities of the Board members, was securing the funding for the institute, after the ending, at the end of 2007, of the current agreements with NWO and TU/e. In 2006 this has been one of the main issues on the agenda of the Board of EURANDOM. Although this concern continues to rule early 2007, we are confident in securing funds for the valuable contribution of the institute to stochastics in The Netherlands and in Europe.

On behalf of the Board of EURANDOM

Dr.ir. J.M.M. Ritzen, chair

1. INTRODUCTION

The year 2006 was yet another very lively year at EURANDOM. A year with many workshops and visitors; a year in which we sadly saw quite a few young researchers leave and gladly welcomed several new ones. It was also a year of discussions with various parties - Eindhoven University of Technology (TU/e), NWO (Netherlands Organisation for Scientific Research), the Dutch Ministry of Education, Culture and Science - about the future funding of EURANDOM. The contributions of TU/e and NWO are guaranteed until the end of 2007. Both have the intention to allow EURANDOM to continue its operation, but their financial support will be reduced. At the time of writing, optimism that the Ministry of Education, Culture and Science will supply additional funds seems justified. In addition, EURANDOM and the Department of Mathematics and Computer Science are strengthening their collaboration, which in due time will lead to a reduction of the costs of EURANDOM.

Scientific activities

Scientifically, EURANDOM continues to flourish. The first half year of 2006 has been extremely busy with many visitors and 9 workshops. Again EURANDOM was successful in acquiring additional funding for most of its workshops as well as for some of the positions of young researchers (22 postdocs and PhD students with a grant).
September 25, 2006 Maria Vlasiou, one of the PhD students at EURANDOM, defended her thesis 'Lindley-Type Recursions' at the TU/e. That same month, Johan van Leeuwaarden, postdoc and former PhD student at EURANDOM, received the Beta prize, a prize for the best PhD thesis of the research school Beta in the period 2004-2005. And shortly thereafter Seva Shneer, who joined us in November, received the MacFarlane prize for best PhD thesis of the year in Heriot-Watt University, Edinburgh.
Adam Wierman received the SCS (School of Computer Science) Student Award of Carnegie Mellon University (Pittsburgh, USA) within the Carnegie Mellon Siebel Scholars Program. This program was established 'to recognize the most talented students at the world's leading graduate schools of business and computer science (a.o. Harvard, MIT and Stanford). The Siebel Scholars are selected on the basis of academic performance and qualities of leadership'.
EURANDOM hosted two long term visitors in 2006. In May and June: Professor Uri Yechiali (Tel Aviv University, Israel), holder of the BETA Chair of the Research School for Operations Management and Logistics. He gave two talks on 'A Random Walk through my O.R. life'. And in September: Professor Offer Kella (Hebrew University of Jerusalem, Israel).

Board

In 2006 we welcomed Prof.dr. F.A. van der Duyn Schouten (Rector Tilburg University) on the board as successor of prof.dr. J.K. Lenstra (Director of CWI).

Scientific Council

Peter Bickel (Professor of Statistics in Berkeley, California) has been the chairman of the Sientific Council of EURANDOM for the first 6 years, and has played a major role in getting EURANDOM started. At the conference "Frontiers of Statistics" in his honor, held at Princeton University, Peter Bickel was appointed to the knightly grade of Commander in the Order of Oranje Nassau by her Royal Highness Queen Beatrix of The Netherlands. The royal decoration took place on May 19, 2006 and was conferred by her Excellency the Consul General of the Netherlands in New York. Professor Bickel was nominated for his efforts in the development of mathematical statistics in The Netherlands.

The Scientific Council met on September 2, 2006. New member as of July 1, 2006: Professor J. Beirlant (Katholieke Universiteit Leuven, Belgium).

Directors

After close to 10 years as managing director at EURANDOM and 40 years at the TUE/e, Ir. Wim Senden retired. Wim Senden played a very important role in the installation of EURANDOM, and strongly contributed to making it the place it presently is, by always putting science number one but at the same time being very keen on the personal well-being of the junior researchers and advisors. His retirement was marked with an afternoon of lectures and a reception on November 23, 2006. Ir. Wim Senden has been succeeded by Drs. Connie Cantrijn.

Advisors

Frank den Hollander, on sabbatical leave from January until August 2006 at the University of British Columbia, Vancouver, Canada, was nominated on the PIMS (Pacific Institute for the Mathematical Sciences) Distinguished Chair. Furthermore, he has been appointed as member of the Scientific Advisory Board of the Korteweg-de Vries Institute for Mathematics in Amsterdam and he is representing EURANDOM in the Board of the Thomas Stieltjes Institute for Mathematics in Leiden. He also became IMS (Institute of Mathematical Statistics) Council member. At his return at Leiden University, Frank den Hollander gave his inaugural lecture on October 27, 2006: 'Toeval in focus'.

As of July 1st, 2006 Richard Gill has been appointed professor in Mathematical Statistics at the Mathematical Institute of the University of Leiden. He will continue his activities as scientific advisor of EURANDOM. In March 2006 Marie-Colette van Lieshout (CWI) and Laurie Davies (University Essen and TU/e) started as scientific advisor for the SIM programme at EURANDOM. In November of this year Wim Schoutens and Jef Teugels (Catholic University Leuven) started as scientific advisors of a new theme within the QPA programme: Multivariate Risk Modelling. Two postdocs simultaneously joined this programme: Henrik Jönsson (with a Marie-Curie fellowship) and Vika Masol (with a grant from FWO, the Flanders Research Foundation, Belgium). Finally, Remco van der Hofstad, advisor in the RSS programme, delivered his inaugural lecture 'Random networking: between order and chaos' on Friday September 22, 2006, at the TU/e.

The Annual Excursion on June 28, 2006 did not just bring us a nice afternoon together, but as a result of a creative workshop, young researchers, advisors, visitors and directors jointly produced a painting on canvas. Pieces of it can be found scattered throughout the report. The enthusiasm, energy and creativity that was not only displayed at that excursion but that is so obviously present in the institute, make us look positively into the future.

Onno Boxma
Scientific director
June 2007

2. THE INSTITUTE

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.ir. C.J. van Duijn (member);
- Professor dr. J.K. Lenstra (member) until May 1, 2006;
- Professor dr. F.A. van der Duyn Schouten (member) since May 1, 2006.

Directors

- Professor dr.ir. O.J. Boxma (TU/e & EURANDOM), scientific director;
- Ir. W.J.M. Senden, managing director until December 1, 2006;
- Drs. C.M.M. Cantrijn, managing director since December 1, 2006.

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 (Aarhus University, Sweden)
- Professor F. Baccelli (École Normale Supérieure, Paris, France)
- Professor E. Bolthausen (University of Zürich, Switzerland)
- Professor S. Borst (TU/e and Lucent, Murray Hill, USA)
- Professor D. Dawson - Chair (Carleton University, Ottawa & McGill University, Montreal, Canada)
- Professor F. Delbaen (Eidgenössische Technische Hochschule Zürich, Switzerland)
- Professor A. Frigessi (University of Oslo, Norway)
- Professor P. Green (University of Bristol, United Kingdom)
- Professor A. Greven (Friedrich-Alexander Universität, Erlangen-Nürnberg, Germany)
- Professor P. Hall (Australian National University, Canberra, Australia)
- Professor P. Massart (Université Paris Sud XI, Orsay, France)
- Professor V. Schmidt (Ulm University, Germany)
- Professor N. Veraverbeke (Hasselt University, Diepenbeek, Belgium)

New member as of July 1, 2006:

- Professor J. Beirlant, Katholieke Universiteit Leuven, Belgium

The Scientific Council of EURANDOM met on September 2, 2006. Main item on the agenda: plans with regard to the future research structure of EURANDOM.

2.3. Scientific Advisors and Steering Committees

The research of EURANDOM is structured according to 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.ir. I.J.B.F. Adan (TU/e)
- Professor R.J. Boucherie (Universiteit Twente)
- Professor O.J. Boxma (TU/e)
- Professor M.R.H. Mandjes (CWI & Universiteit van Amsterdam)
- Professor W. Schoutens (Katholieke Universiteit Leuven, Belgium)
- Professor J. Teugels (Katholieke Universiteit Leuven, Belgium)

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 - Chair (Cambridge University, United Kingdom)
- Professor G. Koole (Vrije Universiteit Amsterdam)
- Professor J. Wessels (TU/e)

Random Spatial Structures (RSS)

Scientific advisors

- Professor R. van der Hofstad (TU/e)
- Professor W.Th.F. den Hollander (Leiden University)
- Dr. F. Redig (Leiden University)

Steering committee

- Professor E. Bolthausen (Universität Zürich, Switzerland)
- Professor A. Bovier (Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany)
- Professor A.C.D. van Enter (Universiteit Groningen)
- Professor G.R. Grimmett (University of Cambridge, United Kingdom)
- Professor C. Maes (Katholieke Universiteit Leuven, Belgium)
- Professor R.W.J. Meester (Vrije Universiteit Amsterdam)
- 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 P.L. Davies (TU/e and University of Essen, Germany)
- Professor R.D. Gill (Universiteit Leiden)
- Dr. M.C.M. de Gunst (Vrije Universiteit Amsterdam)

- Professor C.A.J. Klaassen (Universiteit van Amsterdam)
- Dr. M.N.M. van Lieshout (CWI, Amsterdam)

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 Southern California, Los Angeles, United States of America)
- Professor A. Tsybakov (Université Paris VI, France)

In addition to these programmes one project is running since the beginning of 2006:

Integrated Batteries (i-BAT)

Scientific advisor
- Professor P.H.L. Notten (Philips Research Laboratories, Eindhoven, The Netherlands)

2.4. Scientific Staff

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

During the year 22 junior researchers were (co-)financed by external funds, from which:

In natura:
- NWO-VIDI grant Professor R. van der Hofstad: 1 PD (until April 2006) and 1 PD (since September 2005) via an appointment at the Dept. of Mathematics and Computer Science, TU/e;
- NWO-VICI grant Professor R.J.W. Meester: 1 PhD via an appointment at the Vrije Universiteit Amsterdam;
- NWO-Open Competition grant Professor W.Th.F. den Hollander: 1 PD via an appointment at Leiden University;
- NWO-Open Competition grant Dr. A. Di Bucchianico: 1 PhD via an appointment at the Dept. of Mathematics and Computer Science, TU/e;
- NWO-Open Competition grant Dr. F. Redig: 1 PD via an appointment at Leiden University (until December 2006);
- NWO-Open Competition grant Professor S. van der Geer: 1 PD via an appointment at Leiden University (until November 2006);
- FWO grant Professor W. Schoutens: 1 PD (since November 2006) via an appointment at the Katholieke Universiteit Leuven, Belgium;
- Philips contract: 1 PhD.

Industry:
- Vodafone: 1 PD (until April 2006);
- Philips-EET contract: 1 PD (since May 2006).

Other:
- Marie Curie Intra-European Fellowship (since November 2006): 1 PD;
- NWO-Open Competition grant Professor W.Th.F. den Hollander: 1 PD;
- NWO-Open Competition grant Professor W.Th.F. den Hollander: 1 PD (until March 2006);

- NWO-Open Competition grant Professor R. van der Hofstad and Dr. G. Hooghiemstra: 1 PD (until August 2006);
- NWO-Talent grant: 1 PD (until September 2006);
- Network of Excellence PASCAL grant: 1 PD (until December 2006);
- BRICKS grant via Dept. of Mathematics and Computer Science, TU/e: 1 PD;
- STW grant Dr. I.J.B.F. Adan (Dept. of Mathematics and Computer Science, TU/e) and Dr.ir. L.F.P. Etman (Dept. of Technology Management, TU/e): 1 PD (until December 2006);
- EURO-NGI grant: 1 PD;
- Joint employment with the Dept. of Mathematics and Computer Science and the Dept. of Technology Management, TU/e: 1 PhD;
- Joint employment with the Dept. of Mathematics and Computer Science: 1 PD.

On December 31, 2006, **18** 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 Professor R. van der Hofstad.

Queueing and Performance Analysis

Postdocs
- Bernardo D'Auria (until September 2006)
- Denis Denisov
- Adriana Gabor (until September 2006)
- Henrik Jönsson (since November 2006)
- Johan van Leeuwaarden (until August 2006)
- Andreas Löpker (since September 2006)
- Vika Masol (since November 2006)
- Vsevolod Shneer (since November 2006)
- Hwee Pink Tan (until July 2006)
- Adam Wierman (July-December 2006)

PhDs
- Paul Beekhuizen
- Josine Bruin (since May 2006)
- Maria Vlasiou (until October 2006)

Research Fellow
- Nelli Litvak (Universiteit Twente)

Random Spatial Structures

Postdocs
- Sebastien Blachère (since September 2006)
- Mia Deijfen (February-August 2006)
- Cristian Giardinà (until December 2006)
- Mark Holmes
- Wouter Kager (since March 2006)
- Gregory Maillard (until February 2006)
- Tobias Müller (since October 2006)
- Nicolas Pétrélis
- Akira Sakai (until April 2006)
- Cristian Spitoni (since November 2006)

- Rongfeng Sun (until November 2006)
- Maarten van Wieren

PhD
- Anne Fey-den Boer

Statistical Information and Modelling

Postdocs
- Nicolas Brunel (September-December 2006)
- Nadia Lalam (until November 2006)
- Leila Mohammadi (until December 2006)
- Fabio Rigat (until October 2006)

PhDs
- Isaac Corro Ramos
- Talía Figarella Gomez (until September 2006)
- Peter van de Ven

Research Fellows
- Luis Artiles Martinez (freelance consultant)
- Peter Grünwald (CWI Amsterdam)
- Madalin Guta (Radboud Universiteit Nijmegen) (until September 2006)
- Patrick Lindsey (Universiteit Maastricht)

i-BAT

Postdoc
- Dmitry Danilov (since May 2006)

PhD
- Iryna Snihir (until June 2006)

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. (Marlies) Brangers - management assistant (0,9 fte)
- Drs. C.M.M. (Connie) Cantrijn - policy officer (until December 2006; 0,8 fte)
- Mrs. L. (Lucienne) Coolen-van Will - workshop officer (0,7 fte)
- Ms. A. (Annabel) Goth, workshop assistant (until October 2006; 0,05 fte)
- Drs. J.J. (Jonelleke) Kamperman - personnel officer (0,8 fte)
- Mrs. P.M. (Patty) Koorn - administrative officer (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 **25** persons were employed by TU/e - EURANDOM on December 31, 2006, including the scientific director, the managing director and the support staff.*

In addition 16 senior scientists were associated with EURANDOM as scientific advisor and 5 junior scientists were associated as research fellow.

In 2006 11 researchers started to work at EURANDOM, 17 researchers 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), Michel Mandjes (CWI and Universiteit van Amsterdam), Wim Schoutens (Katholieke Universiteit Leuven) and Jef Teugels (Katholieke Universiteit Leuven).

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, and to the analysis of multivariate risk models. The programme consists of four themes:

- Queueing Theory
- Performance Analysis of Production Systems
- Performance Analysis of Communication Systems
- Multivariate Risk Modelling

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. Accord-

ingly, 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.

Multivariate Risk Modelling (MVR)
This new project lies at the interface of economics, finance and insurance. In the framework of a dynamic financial analysis, there is a strong need to investigate financial and economic issues that are relevant with respect to risk modelling.

The MVR-project will develop multivariate Lévy models that will be applied to different kinds of financial derivatives written on a portfolio of assets. These financial derivatives can be viewed as insurance / financial contracts, where the holder of the derivative receives protection against, from the holder's viewpoint, unfavourable events (e.g., default), in return for a premium (the price of the derivative).

The proposed project aims to exploit the close mathematical similarities between models and methods used in queueing theory and in insurance / risk analysis. It is part of the QPA program that houses a vast expertise in queueing theory and in mathematical tools like Markov processes and Lévy processes. The project is being run in collaboration with the group of professors Wim Schoutens and Jef Teugels from the University of Leuven (Belgium). It has already acquired some external funding, via a two-year Marie Curie Fellowship of the European Community, and a one-year fellowship from the Flemish Science Foundation FWO.

The QPA 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. There are also several interactions with researchers from the groups at the Katholieke Universiteit Leuven, CWI, Universities of Amsterdam and Twente, and the Vrije Universiteit Amsterdam.

Former post-doc Nelli Litvak was associated to the QPA programme as Research Fellow. At the official introduction of the third mathematics cluster Geometry and Quantum Theory (GQT), October 10, 2006 she was invited to join a panel of foreign mathematical researchers with a successful position in The Netherlands to discuss the subject ‘brain-gain’.

QPA also hosted from September to December 2006 four Master students of Dr. I.J.B.F. Adan and Professor O. Boxma: Richard Bakker, Martin van Jole, Peter van de Ven and Dennis Vos.

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

Ivo Adan. Together with E. Tzenova, M. Mandjes (UvA) and W. Scheinhardt (UT) I. Adan continued to work on the asymptotics for networks of two fluid queues. Together with J. Vissers (Erasmus MC, Prismant) and N. Dellaert (TU/e) he studied admission planning in hospitals. Further, with V. Kulkarni (UNC) he worked on fluid risk models and with M. Haviv (University of Jerusalem) he studied the problem of conditional ages and residuals in an M/G/1 queue. Together with R. Foley (Georgia Tech) and D. McDonald (University of Ottowa) he worked on asymptotic results for the stationary queue-length distribution of a two-machine production system.

Bernardo D'Auria's research has focused mainly on three different topics: queueing processes in a Random Environment (RE), dynamical behavior of queues and queueing models for telecommunications networks. As for queues in a RE, he investigated the behavior of Markovian queues with infinite servers immersed in a Semi-Markov RE. As for the second topic, he studied mainly the relaxation time of an M/M/1 queue when the speed of the server switches during a short time from one value to a second and slower one. Finally as for telecommunication networks, together with S. Resnick, he extended the model in D'Auria and Resnick (2006) [Adv. App. Prob. 38(2), pp. 373-404], by considering an M/G/∞ model with sessions having the transmission rates independent of the transmission durations rather than of their sizes.

Paul Beekhuizen. Techniques to reduce queueing networks to single queueing systems have been around since the 1960s, starting with reductions of very specific networks up to general theorems in 2005. However, most of these results apply to the total number of customers in a network. We studied reduction techniques in a network where the last server has multiple queues so that information about the number of customers can be gathered conditioned on one of the queues of this server.

Onno Boxma. Various studies with EURANDOM researchers D. Denisov, A. Gabor, H.P. Tan and M. Vlasiou. With visitor S. Bar-Lev: queueing models for blood banks are being developed and analyzed. With visitor O. Kella and advisor M. Mandjes: several studies on Lévy processes and queues. With visitors D. Perry, W. Stadje and S. Zacks: analysis of a queueing model with quasi-restricted accessibility. With visitor V. Sharma: a discrete-time queueing model with random service rate, with applications in wireless communications, has been studied. With visitor U. Yechiali: jointly with J. van der Wal, a polling model with batch gated service is being analyzed; and a text for an encyclopedia was written. With visiting PhD student A. Wierman and E. Winands: scheduling in polling systems is being studied.

In addition, jointly with Bekker, O. Kella and J. Resing, a few studies on queueing models and Lévy processes with adaptable parameters were initiated. Finally, a consultancy project has been done, jointly with CEMAS and the Stochastic Operations Research group of the Department of Mathematics and Computer Science. It concerned the cash register operations (queue management) of a large foreign company.

Richard Boucherie. Research of R.J Boucherie concentrated on mathematical models for spare part inventory systems, and wireless communications systems. For inventory systems, globally optimal resource allocations and distribution of revenue to the participants have been studied via a queueing theoretic and game theoretic approach. Research on wireless networks focuses on mathematical models and algorithms for joint capacity and rate allocation in UMTS networks and in multi-hop ad-hoc networks, and on the impact of the interference structure of the underlying network graph on end-to-end Quality of Service measures such as throughput. Typical methods and techniques include a combination of networks of queues, and discrete mathematics.

Josine Bruin investigates the performance of a one-step improvement approach in multi-type production systems, based on a fixed cycle. The question is how to find a good fixed cycle. R. Haijema applied the same approach on a traffic light system and found good results. The question how to find a good cycle is interesting, because a production system can make to stock. An optimal decision level for the stock level per product is derived and results for the partitioning of a cycle are not yet found.

Denis Denisov. Together with A. Sapozhnikov (University College Cork), D. Denisov studied time-dependent properties of the M/G/1 queue with symmetric service discipline. They showed that the queue length distribution at any time is identical for all symmetric disciplines if the queue starts empty and service requirements have an Erlang distribution. Furthermore, together with V. Shneer he has finished their work on tail asymptotics for first passage times of Levy processes and random walks. As corollary to these results, they have obtained asymptotics for the busy period of the M/G/1 queue.

Adriana Gabor. Together with R.J. Boucherie and A.I. Endrayanto (University of Twente), A. Gabor has been investigating the properties of the rate allocation that maximizes the throughput in a two cell CDMA network. Based on these properties, they have developed a polynomial time algorithm for finding the optimal rate allocation for the problem with continuous rates and limited powers at the base stations, thus extending previous results regarding one cell. Currently, they are investigating possibilities of extending this algorithm to multiple cells.

Together with O. J. Boxma and R.J. Boucherie, A. Gabor has done research on the queuing problem where given a system of two M/M/∞ queues, a new customer joins the queue with the least number of customers in service. Furthermore, she has been cooperating with J.K. van Ommeren (University of Twente), on designing improved approximation algorithms for multilevel facility location problems.

Henrik Jönsson. Together with W. Schoutens (Katholieke Universiteit Leuven, Belgium) H. Jonsson has been working on the development of a multivariate local Lévy model for modelling portfolios of assets, by the technique of a common time change, since November 2006. Some progress has been made and the continuation of the project looks promising.

Johan van Leeuwaarden focusses on several topics in applied probability, queueing theory in particular. His main research assignment is concerned with obtaining asymptotics through functional equations for certain 2-dim. Markov processes (funded by a Veni grant of NWO). On this topic he cooperates with F. Guillemin. Other recent and current research deals with transient behavior of certain stochastic processes (with A. Löpker), 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 I. Adan and D. Denteneer), lattice path counting for QBD processes (with E. Winands and M. Squillante), cyclic production systems (with J. Bruin and J. van der Wal), three-dimensional QBD's (with I. Adan and Y. Zhao) and cycle maxima of random walks (with D. Perry and W. Stadje). The latter project was sponsored by NWO through a TALENT stipendium, with which Johan has spent 4 months in Osnabrueck, Germany.

Andreas Löpker mainly worked on martingale methods for Markov processes. On the basis of Dynkin's formula, he derived a general martingale that comprises some well known martingales used in various fields of applied probability. This martingale can be utilized e.g. to determine moments and Laplace transforms of hitting times and to study exponential functionals of Levy processes. He further did some research on certain

piecewise deterministic Markov processes. The aim is to give a generalized treatment for the analysis of one-dimensional real-valued Markov processes which are increasing between downward jumps. Such processes occur naturally in queuing and risk theory applications. Using the process' generator this general framework allows for analyzing the stationary as well as the transient behavior of the process. A particular model with applications to the TCP protocol has been studied with emphasis on the transient behavior (with J.S.H. v. Leeuwaarden).

Vika Masol. Together with W. Schoutens (Katholieke Universiteit Leuven, Belgium), V. Masol has been investigating the question of pricing a synthetic CDO using the generic one-factor Levy model. In particular, she has been implementing an algorithm for such pricing for the model based on Meixner and Shifted-Gamma processes.

Jef Teugels and **Wim Schoutens.** The risks present in the credit risk market are huge. Typically it involves events (default) that occur with very low probability but that involve huge amounts of money (Enron's default involved more than 100 billion USD losses). Moreover, the products traded nowadays are of an unprecedented complexity. Nominally they are insurance against defaults, but they encourage greater gambles and credit expansion, which are moral hazards.

Fundamental mathematical models that realistically capture the necessary stylized features are for the moment still under development, but the market is already taking huge positions.

Recent figures of the International Swap and Derivatives Association indicate that the notional outstanding in this markets has grown to over 26 trillion USD, with the last years a yearly growth of more than 100 percent. In comparison, the traditional equity (stock and indices) market "only" represents around 6.4 trillion USD. Warren Buffett has called credit derivatives "financial weapons of mass destruction". It is of utmost importance for financial institutions, regulators and the society that the essential and important risks in dealing with credit risk instruments and derivatives are thoroughly investigated.

There are essentially two well-accepted approaches for the modelling of credit risk. The first approach is a structural one, linking the occurrences of default directly with the firm's value behaviour. Default happens if the firm's value falls below a certain low threshold. The approach uses techniques and stochastic processes that are also used in equity modelling. The other approach is an intensity based approach where default happens exogenously. One models in a sense the stress on a company and defaults happens at the jump time of a counting process driven by this (stochastic) stress or intensity process. The processes employed and techniques used in these setting are very related to interest rate and volatility modelling (positive mean-reverting processes).

Stylized feature of financial data in a credit risk setting are non-normal (Gaussian) returns, heavy tailedness and very importantly jump dynamics. Defaults and credit risk are driven by shocks in the economy or individual firm. Modelling default risk without jump dynamics is not realistic and clearly severely underestimates the risks present. Therefore, standard models built out Normal distributions, Brownian Motions and Gaussian copulas are not able of making a correct assessment of the risks involved.

In order to have a better and more realistic modelling in the credit and default products markets, more advanced modelling using jump processes is needed. These jump models (Lévy models) have been very successful in other fields in finance, like equity, interest rate and volatility modelling.

In order to be of practical use a model must allow for a fast pricing of standard liquid credit risk products (CDS, CDO, Index spreads). This is crucial for the calibration of the model on market data. Calibration algorithms return the best estimate of the model's parameters (representing the current market view of default probabilities and correlation). Numerical aspects and optimalisation of computer code is of great importance. Once fast pricing and calibration algorithms are in place, one can price exotic credit risk products and portfolios by Monte-Carlo methods or other advanced numerical techniques. As such one obtains a series of tools for realistic assessment of the risk of credit derivatives.

The research carried out at EURANDOM involves:
- fast pricing and calibration on CDS data under firm's value or intensity models driven by jumps;
- the pricing of options on single name CDSs under jump models;
- modelling correlated spread dynamics of credit indices under tractable multivariate jump models;
- pricing and management of exotic credit index derivatives;
- assessing the gap risks in CPPI and CPDOs under jump dynamics.

Seva Shneer was involved in 2006 in joint work with D. Denisov on finding the asymptotics for the tail distribution of the first-passage times over a fixed level of a Levy process or a random walk. Another project he participated in together with D. Denisov and T. Dieker concerns the description of the big-jump domain for the large deviations of sums of subexponential random variables. He also started working with C. Bordenave and S. Foss on stability problems for different stochastic multiple-access protocols with spatial interactions between users.

Hwee Pink Tan
- Admission Control for Differentiated Services in 3G Cellular Networks with O. Boxma, R. Núñez Queija and A. Gabor.

UMTS is a Third Generation cellular network that is expected to support a large variety of applications, which are commonly grouped into two broad categories: (a) elastic flows correspond to the transfer of digital documents (e.g. web pages, e-mails, stored audio/video), and are characterized by the volume of the document to be transferred. These flows are flexible, or "elastic" towards rate fluctuations, with the total transfer time being a typical performance measure; (b) streaming flows correspond to the real-time transfer of various signals (e.g. voice, streaming audio/video). They are characterized by their duration as well as their transmission rates. For streaming applications, stringent transmission rate requirements are necessary to ensure real-time communication.

While Markovian models have been developed for the exact analysis of the integrated-services system, they can be numerically cumbersome. Hence, a fluid modeling approach is proposed to provide closed form limit results and approximations. These results can serve as performance bounds, and hence, yield useful insight. Using time-scale decomposition, we develop 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.

- Architecture and communication protocols for underwater sensor networks with W.K.G. Seah.

Wireless sensor networks are expected to be deployed in harsh environments characterized by extremely poor and fluctuating channel conditions. With the generally adopted single-sink architecture, be it static or mobile, such conditions arise due to contention near the sink as a result of multipath data delivery. The compactness of sensors with limited energy resources restricts the use of sophisticated FEC or ARQ mechanisms to improve the reliability of transmissions under such adverse conditions.

We propose a novel virtual sink architecture for wireless sensor networks that mitigates the near-sink contention by defining a group of spatially diverse physical sinks. Reliability and energy efficiency is achieved through multipath data delivery to the sinks without the need for sophisticated FEC or ARQ mechanisms. This architecture is especially suitable for indoor environments, where channel conditions are harsh due to severe multipath fading, as well as emerging applications like underwater sensor networks where the predominant physical layer is acoustic communications, which is characterized by long propagation delays and severely fluctuating link conditions.

Maria Vlasiou has concluded her Ph.D. research programme, which was focused on Lindley-type recursions. In particular, she 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 and O. Boxma she has studied various dependence schemes between the random variables involved and has derived the steady-state waiting-time distribution. M. Vlasiou collaborated with U. Yechiali, who was the Beta Chair Professor for 2006, on a joint project during Prof. Yechiali's extended visit to EURANDOM. Together, they have worked on an infinite-server polling model, for which they have studied the steady-state queue length distribution at polling instants and the sojourn time of a customer joining the system.

Adam Wierman's research focuses on understanding the performance of scheduling policies in a variety of queueing settings. Together with O. Boxma and E. Winands, he has studied the behavior of a wide variety of scheduling policies, including Shortest Remaining Processing Time, in the context of polling systems. Together with M. Nuyens, he has studied a variety of performance metrics for single server queues governed by the Foreground Background discipline, including deriving the moment conditions for response time for single server queues, and together with B. Zwart studying the tail asymptotics of response time under both heavy-tailed and light-tailed service distributions. He is also working with M. Nuyens and M. Harchol-Balter to characterize the impact of common scheduling heuristics on response time and fairness metrics in single server queues. Outside of the analysis of scheduling policies, he is working with I. Adan, P. Etman, M. van Vuuren, and A. Kock on the development of aggregate models for production lines in manufacturing systems.

3.1.2. Research activities

Workshops and conferences

- March 6-8, 2006
  Risk Measures and Risk Management for High-Frequency Data

- March 13-14, 2006
  Queues, Fluid Queues and Extremes

- June 19-20, 2006
  Performance Analysis of Manufacturing Systems

- November 11, 2006
  EURO-NGI workshop Transfer Control with Delayed Feedback

See Chapter 6, section 6.1 for more detailed information.

Lectures and Seminars
34, including the two talks given by Professor U. Yechiali (Beta Chair 2006).
See Chapter 6, section 6.2 for more detailed information.

EURANDOM visitors
QPA hosted 21 visitors, including the Beta Chair (long term visitor for 3 months); altogether 38 weeks.
See Chapter 6, section 6.3 for more detailed information.

General remarks
Josine Bruin joined QPA in May 2006. Josine is working on a PhD-project with the Department of Mathematics and Computer Science and with the Department of Technology Management. In July 2006 Adam Wierman started working at EURANDOM. Adam worked for the STW-project 'The Effective process time: Quantifying operational time variability for queueing network performance analysis of discrete manufacturing systems' (projectnumber ewv6462) with the Department of Mechanical Engineering and with the Department of Mathematics and Computer Science. Andreas Löpker started in September 2006. In November three new people started: Seva Shneer, Henrik Jönsson and Vika Masol. Henrik Jönsson obtained a Marie Curie Individual Fellowship and Vika Masol is working at EURANDOM with an FWO-grant.

Hwee Pink Tan is currently working as post-doctoral research fellow at the Center for Telecommunications Value-Chain Research (CTVR) in the Emerging Networks strand at the Lloyd Institute, Trinity College, Dublin, Ireland. He left EURANDOM in July 2006. In September 2006 Bernardo D'Auria started a new job as Assistant Professor at the Universidad Carlos III in Madrid, Spain. Adriana Gabor and Johan van Leeuwaarden both started working at the TU/e in September 2006. In the same month Maria Vlasiou successfully defended her thesis *Lindley-Type Recursions*. She is now working as postdoctoral fellow at Georgia Institute of Technology, Atlanta, USA. Adam Wierman left in December to return to the USA for his thesis defence at Carnegie Mellon University, Pittsburgh.

3.1.3. External contacts / cooperation
Internationally, the QPA program maintains strong ties with the Catholic University Leuven, in the MVR project. It is also involved in an EC Network of Excellence (Euro-NGI and its successor Euro-FGI), which gave rise to several visits to and from EURANDOM researchers, and some small funded projects. Via Jef Teugels, QPA is also involved in MATHFSS. The MATHFSS (Mathematics for Science and Society) project is a Support Action of the New and Emerging Science and Technology (NEST) programme of the European Commission (Sixth Framework Programme). The NEST programme aims at integrating and strengthening the European Research Area. The MATHFSS-project started in December 2005 and will last for 24 months. It aims to stimulate interaction between advanced research workers and to explore ways of training doctoral-level researchers in key areas where Mathematics will have a newly prominent role in science and society.

Nationally, there were close ties with Philips and Vodafone, who respectively funded a PhD and a PD position. Participation in BRICKS (Basic Research in Informatics for Creating the Knowledge Society) involved close cooperation with CWI and Twente University, and the funding of a postdoctoral fellowship.

Locally, there are many interactions with the TU/e Department of Mathematics and Computer Science, and growing interactions with the Department of Technology Management (with a jointly funded PhD student) and the Department of Mechanical Engineering. Together with the members of these three departments, the PALS (Performance Analysis of Logistics Systems) seminar was organised. We also started a reading seminar on Lévy processes, studying the book *Introductory Lectures on Fluctuations of Lévy processes with Applications* of A.E. Kyprianou.

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), Frank den Hollander (Leiden University) and Frank Redig (Leiden University).

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

Sebastien Blachère. Together with P. Haïssinsky and P. Mathieu (Paris), we studied asymptotic properties of Random Walks on groups in terms of a new metric, the Green metric, with which the group itself has some interesting geometric properties. Together with F. den Hollander and J. Steif, we study the existence (or not) of bad configurations for random walk in random scenery on the line (the random walk has a drift and the random scenery is an i.i.d. color record). We have proved that no bad configurations exist for large drift.

Mia Deijfen has been working at EURANDOM as a post-doc from February - July 2006, financed by a joint NWO grant of R. van der Hofstad and G. Hooghiemstra. The problem that they have been working on concerns models for generating random graphs with prescribed degree distribution. In so-called preferential attachment models, a new vertex is added to the graph at each time step, and this vertex is connected to the old vertices in the graph in such a way that vertices with high degree are more likely to be connected to. This means that the oldest vertices tend to have the highest degrees. In the generalised random graph, on the other hand, a vertex is born with a certain weight, and this weight determines the degree of the vertex. In reality, both the time of creation of the vertex and an initial weight may play a role in the final success of a vertex. Therefore, we have tried to formulate and analyze models that combine these two effects. The work is still in progress and will result in a paper.

Anne Fey-den Boer. Together with F. Redig (Leiden) and R. Meester (VU Amsterdam), A. Fey-den Boer has been studying the sandpile model. They have compared the abelian sandpile model to a related parameter-driven model, to investigate if the stationary sandpile indeed corresponds to a phase transition. The results have been published. Furthermore, together with C. Quant (VU Amsterdam) she has studied Zhang's sandpile model, a non-abelian variant. Zhang conjectured that in the limit of infinite volume, the stationary state tends to that of the abelian sandpile model. They managed to prove this in one dimension. She has also studied the sandpile model as a growth model. Re-

lating this model to the rotor router model has led to a number of new limiting shape results. At the moment, she is studying the sandpile model as a percolation model.

Cristian Giardinà. In collaboration with F. Redig (Leiden) and J. Kurchan (Paris), Cristian studied a stochastic model for heat conduction for a system in contact with two heat reservoirs. They derived the dual process and obtained an exact epression for the energy correlations functions in the stationary state. Furthermore, he continued his work on rare-events (currently finalizing a paper on matching with shift for Gibbs measure) and on spin glasses (he performed a detailed numerical study on ultrametricity in collaboration with G. Parisi (Rome).

Remco van der Hofstad has worked on several problems in random graph theory, both for scale-free network models, and for percolation-type models on high-dimensional finite tori. On scale-free random graphs, his work focusses on distances in such graph, which quantify the 'small-world phenomenon', and on the degrees of such graphs. For percolation models, his work focusses on the behaviour of connected components close to criticality. Further problems are the investigation of the survival probability for spread-out oriented percolation above 4 spatial dimensions, as well as the study of several random walk problems (self-interacting random walks and problems involving the local times of continuous-time random walk). R. van der Hofstad also has several collaborations with electrical engineers.

Frank den Hollander. During the period January-August 2006, F. den Hollander spent a sabbatical leave at the Mathematics Department of the University of British Columbia and the Pacific Institute for the Mathematical Sciences, Vancouver, Canada. During this period, 4 postdocs from EURANDOM visited him, each for one month: G. Maillard, R. Messikh, N. Pétrélis, and R. Sun.

In 2006, Frank den Hollander has been working on the following research topics:

- Intermittency in catalytic random media, with J. Gaertner (Berlin) and G. Maillard (EPFL, Switzerland)
- Wulff shape for metastable critical droplets, with A. Bovier (Berlin) and R. Messikh (EPFL, Switzerland)
- Copolymers in emulsions, with N. Pétrélis
- Renormalization of hierarchically interacting two-type populations, with D. Dawson (Ottawa), A. Greven (Erlangen), R. Sun and J. Swart (Prague)
- Random walk in random scenery, with S. Blachère and J. Steif (Gothenburg)
- Quenched large deviation principle for words cut out randomly from a random sequence of letters, with M. Birkner (Berlin) and A. Greven (Erlangen)
- A stochastic model for T-cells in the immune system, with E. Baake (Bielefeld) and N. Zint (Bielfeld)
- Metastability for Kawasaki dynamics in large volumes at low density and low temperature, with A. Gaudillière (Rome), F. Nardi (TU/e), E. Olivieri (Rome) and E. Scoppola (Rome)
- Invasion percolation on trees, with O. Angel (Toronto), J. Goodman (Vancouver) and G. Slade (Vancouver).

Mark Holmes. Mark Holmes completed (and extended) joint work with Akira Sakai on recurrence/transience and (non)diffusive behaviour of senile-reinforced random walks under certain reinforcement regimes. He is currently investigating the full scaling limit (in path space) of senile-reinforced random walks. In general the scaling limit is a random time change of Brownian motion. With Remco van der Hofstad, Mark developed an expansion for self-interacting random walks and used it to prove a central limit theo-

rem for excited random walk in high dimensions and for once edge-reinforced random walk with drift.

Wouter Kager. Together with R. van der Hofstad, Wouter has found new results concerning the ratio between the numbers of occurrences of two distinct patterns on large percolation clusters. These results lead to a simple and clarifying proof of the ratio limit theorem for percolation, and can be generalized to Markov random fields. Furthermore, inspired by work of M. Holmes and A. Sakai, he has found alternative derivations of the diffusion constants for senile and memory-2 random walks, using a random time-change and martingale techniques.

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

Tobias Müller. Tobias started working at EURANDOM in October 2006. He investigates the largest component of the Erdos-Renyi random graph in the critical window, together with R. van der Hofstad and W. Kager.

Nicolas Pétrélis. In 2006 the research activity of N. Pétrélis has been focussed on the study of random polymers at random interfaces, especially on the model of a copolymer in an emulsion that has been introduced by F. den Hollander and S. Whittington in 2005 and that is being further developed with F. den Hollander.

Frank Redig. Work focussed on concentration inequalities for random fields and non-uniformly hyperbolic dynamical systems. Relations with Poincaré and log Sobolev inequalities. Relaxation speed of low-temperature dynamics (joint work with J.R. Chazottes(Paris), P. Collet(Paris) and E. Verbitsky(Philips Eindhoven). Zhang's model: a continuous variant of the abelian sandpile model, work with Anne Fey, C. Quant(Utrecht), R. Meester(Amsterdam). Waiting times and relative entropy for continuous-time processes, work with J.R. Chazottes, C. Giardina. Duality and correlations in models of heat conduction, joint work with C. Giardina and J. Kurchan(Paris). Other problems in the area of sandpiles: freezing transitions in non-fellerian processes (with C. Maes(Leuven) and E. Saada(Rouen)) and shape theorems for the cluster of toppled sites (with A. Fey).

Akira Sakai. Work focussed on critical behavior and the limit distribution for long-range oriented percolation (with L.-C. Chen(). Convergence of the critical finite-range contact process to super-Brownian motion above the upper critical dimension: The higher-point functions (with R. van der Hofstad). Mean-field behavior for long- and finite-range Ising model, percolation and self-avoiding walk (with M. Heydenreich(Eindhoven) and R. van der Hofstad).

Cristian Spitoni started to work at EURANDOM in November 2006 under the direction of F. den Hollander. His main research topic has been metastability. In particular, he started to work on homogeneous nucleation for Glauber and Kawasaki dynamics in large volumes at low temperatures, in collaboration with F. den Hollander and A. Bovier (Berlin). Furthermore, he continued to work with E.N.M. Cirillo (Rome) and F.R. Nardi(Eindhoven) on metastability for a model of Probabilistic Cellular Automata, completing an article started during his PhD.

Rongfeng Sun worked with D. Dawson(Ottawa), A. Greven(Erlangen), F. Hollander and J. Swart(Prague) on renormalization analysis of hierarchically interacting two-type branching models. With suitable constraints, they identified the family of fixed points and their domains of attractions, which constitute the universality classes of this model. In collaboration with J. Swart, he constructed and studied a generalization of the Brownian web with branching, which they call the Brownian net. The Brownian net has interesting connections with many areas of probability, including interacting particle systems, stochastic flows, and statistical mechanics. Both projects above have resulted in a preprint that has been submitted. R. Sun also worked with A. Greven and A. Winter(Erlangen) on scaling limits of genealogies of one-dimensional spatial Moran model. This is still work in progress.

Maarten van Wieren's research focussed on the description of an artificial cell. He focussed mainly on the dynamics of the membrane, since it determines possible spontaneous cell division and therefore the overall behaviour of the replication of the cell. For this reason he has run simulations on a discretized version of a two-dimensional membrane that yielded insight in the influence of the non-equilibrium character of the model, which works through the equilibrium fluctuations that vary with intrinsic curvature. On the other hand, he has worked on a discrete-time mapping that investigates the stationary population distribution under the assumption of quasi-equilibrium without noise. This investigation has yielded that, although all finite moments of the size remain finite, the fraction of large and non-reproducing cells approaches a positive constant suggesting diminishing efficiency for such processes.

3.2.2. Research activities

Workshops and conferences

- March 20-24, 2006

YEP (Young European Probabilists) 2006, Large Deviations, Random Media, and Random Matrices

- March 29-31, 2006

Self-Interacting Random Walks

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

Lectures and seminars

24.

See Chapter 6, section 6.2 for more detailed information.

EURANDOM visitors

RSS hosted 15 visitors; altogether for 18 weeks.

See Chapter 6, section 6.3 for more detailed information.

General remarks

Mia Deijfen started at EURANDOM in February 2006 on a position financed by the NWO-VIDI grant of Remco van der Hofstad, TU/e. Wouter Kager started at EURANDOM in March 2006, Sebastien Blachère in September 2006, Tobias Müller in October 2006 and Cristian Spitoni in November 2006. Cristian Spitoni holds an NWO-Open Competion grant at Leiden University, doing research mainly at EURANDOM.

Gregory Maillard left EURANDOM in February 2006. He is now working as a researcher at the Ecole Polytechnique Fédérale in Lausanne, Switzerland. Akira Sakai left in April 2006. He is now working as Lecturer in Mathematics at the Department of Mathematical Sciences, University of Bath, United Kingdom. In August, after finishing the NWO project *Statistical Analysis of Internet Data*, Mia Deijfen returned to Sweden. In October 2006 Rongfeng Sun started a new job at the Technische Universität Berlin, Germany. At the end of the year Cristian Giardinà started working at the TU/e.

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". The activities of the group received a positive mid-term review by DFG and NWO in the Spring of 2006, and will continue running until March 2009.

Together with German research groups, in 2006 again a YEP (Young European Probabilist) workshop was organized on "Large deviations, random media, and random matrices". Also, a workshop on "Self-interacting random walks" was organized within the RSS program by two former EURANDOM post-docs (Franz Merkl and Silke Rolles) now both working in Germany.

Frank den Hollander chairs the ESF Scientific Programme "Random Dynamics in Spatially Extended Systems" (RDSES), which involves 13 European countries. RDSES will end in the Summer of 2007.

In the Summer of 2006, the proceedings of the Les Houches Summer School on "Mathematical Statistical Physics" have appeared, edited by A. Bovier (Berlin), F. Dunlop (Paris), A. van Enter (Groningen), F. den Hollander (Leiden) and J. Dalibard (director of the school). The proceedings (over 800 pages long) are a road map for the field.

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 Laurie Davies (University of Essen, Germany), (Alessandro Di Bucchianico (TU/e), Richard Gill (Universiteit Leiden), Mathisca de Gunst (Vrije Universiteit, Amsterdam), Chris Klaassen (Universiteit van Amsterdam) and Marie-Colette van Lieshout (CWI, Amsterdam).

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 Signal and Image Analysis
- Statistics in Biology
- Statistics in Industry

Statistical Signal and Image Analysis
This project concentrates on signal extraction for time series, and on the analysis of two- and three dimensional images. The brains of human beings are excellently equipped for pattern recognition tasks. For a computer, however, such tasks are very hard indeed, and to date no automatic procedures exist that come even close to the performance of the human visual system. In an increasingly digital world, though, there is a great need for tools in this area that are semi-automatic and limit or guide human involvement, e.g. smart camera surveillance where the system raises the alert when unusual action occurs, fingerprint or iris scan identification at airports, visual search machines for the web, or computer assisted diagnosis based on medical scans. In all these applications, the main challenge is to describe the relevant semantic content of the image mathematically and to develop efficient and robust statistical learning algorithms to carry out the task at hand. The aim of the proposed project is to do exactly this, focusing on theoretical evaluation of the performance of procedures and algorithms by subjecting them to mathematical analysis.

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

Former post-docs Luis Artiles Martinez, Peter Grünwald, Madalin Guta and Patrick Lindsey were associated to the SIM programme as Research Fellow.

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

Nicolas Brunel. Ordinary differential equations (ODE's) are widespread models in physics, chemistry and biology. In particular, this mathematical formalism is used for describing the sets of interactions in cell regulatory networks and typically consists of high-dimensional and non-linear sets of coupled differential equations. In this setting, C. Klaassen (EURANDOM-UVA) and N. Brunel have proposed a general method for estimating the parameters indexing ODE's from time series. The method is able to alleviate some of the computational difficulties encountered by the classical parametric methods due to the implicit definition of the model. It is based on the use of a nonparametric estimator as a first-step for the construction of an M-estimator, and we have shown the consistency of the derived estimator under general conditions. In the case of spline estimators, we have proved asymptotic normality, and we derive the rate of convergence. Some perspectives of this work are the amelioration of this estimator in order to get a root-n rate, and its adaptation to various sampling schemes encountered in practice.

Isaac Corro Ramos. Together with L. Hakobyan (TU/e, LaQuSo) and under the supervision of K.M. van Hee and A. Di Bucchianico. The goals of the project are clearer in general. We use state machines to model software. I. Corro Ramos focusses on the following points: graph generation and testing strategy. New ideas, especially about the walking strategy, are now being developed, supported by the experiments we make with our tool Stresser. During this period, based on the technical report we published in May, we wrote a paper (status: submitted to a journal). Together with C. Onete (TU/e master

student) and M. Boon (TU/e) and under the supervision of A. Di Bucchianico, I. Corro Ramos continued working on the software reliability tool for the company Refis.

Laurie Davies' research has been in the area of robust statistics, non-parametric regression and image analysis. In the area of robust statistics work has been done on the concept of breakdown point and its relationship to invariance under a group. Research in non-parametric regression has been done on the construction of honest, non-asymptotic and universal confidence sets with applications to the construction of honest confidence bounds under shape and smoothness restrictions. Further work in this area has been concerned with the non-parametric estimation of the drift and diffusion terms of a diffusion process and with the estimation of volatility and long term trends in financial data. In the area of image analysis, work has been done on inhomogeneous diffusion smoothing with the inhomogenities being controlled by means of a multiresolution analysis of the residuals.

Alessandro Di Bucchianico worked on several topics in 2006. With P. van de Ven he initiated research on applying commutative harmonic analysis on finite groups to experimental design. They finished a technical report in which they provided rigorous proofs of the equivalence of several definitions of regular fractions of factorial designs. A visit of M. Viana (University of Chicago) was very helpful to get started on applying non-commutative harmonic analysis to more sophisticated designs for micro-array experiments.

In the NWO funded STRESS project, A. Di Bucchianico worked with K. van Hee (TU/e, Department of Computer Science) and the PhD students I. Corro Ramos (TU/e) and L. Hakobyan (TU/e and LaQuSo) on statistical certification procedures based on Petri net models of software. A technical report was written on connectivity properties on SMWf nets, a subclass of Petri nets.

Together with I. Corro Ramos, A. Di Bucchianico also worked on black-box models for software reliability growth models. An R package together with a Java interface is being developed in collaboration with the Refis company. Together with Mrs. Brandt and Henzen from Refis, an invited paper on two software reliability case studies has been prepared for a special issue of the journal Quality Engineering.

Finally, A. Di Bucchianico continued working with S. Kuhnt (Dortmund and since September 2006 TU/e) on extending the data feature approach of L. Davies to conditional Gaussian models. A framework for constructing suitable metrics on probability spaces has been completed and is now being applied to analyse a real-life data set on housing prices.

Talía Figarella. The research of T. Figarella concentrated on finding a wavelet-based approach to the singularity detection of a motor current signal. Together with Maarten Jansen, she developed and analyzed an on-line algorithm based on the Continuous Wavelet Transform to detect the wear in the brushes of a DC motor. The results were published in a paper in Mechanical Systems and Signal Processing.

Richard Gill. Collaboration was started with the Netherlands Forensic Institute on DNA matching. The probability models used to compute the probability that a DNA profile found in a sample associated with a crime, matches the DNA of a potential suspect, appear to be quite inappropriate and lead to grossly overexaggerated confidence in the significance of the match.

Research on the reconstruction of quantum states in collaboration with the group of Bagan et al. at Barcelona resulted in two papers [1], [2], giving (for the first time) the

definitive solution for qubits, allowing arbitrary collective measurements [1], and when restricting to separable measurements only [2]. New quantum Cramér-Rao inequalities were developed in order to establish these results.

Mathisca de Gunst. In 2006 M. de Gunst worked on several projects concerning stochastic modelling and statistical analysis of biological data. One project, with F. Rigat, R. Jansen (Department of Mathematics, Vrije Universiteit Amsterdam), J. van Pelt (Netherlands Institute for Brain Research, Amsterdam), A. Brussaard and A. van Ooyen (Department of Experimental Neurophysiology, Vrije Universiteit Amsterdam), concerns the analysis of spatio-temporal patterns in neuronal networks. In particular, a dynamic Bayesian network model for the connectivity structure of neuronal cells in vitro was further developed and statistical methods were designed to analyse multi-electrode array data with this model. Furthermore, several analysis techniques were investigated for their usefulness in the analysis of multi-electrode data from brain slices in vivo.

Another project, with G. Geeven (Department of Mathematics, Vrije Universiteit Amsterdam), G. Smit and R. van Kesteren (Molecular and Cellular Neurobiology, Vrije Universiteit Amsterdam) focusses on modelling the gene network underlying neuronal outgrowth. Here we continued with the statistical analysis of different types of genetic data using Bayesian networks. The first results of combining gene expression microarray data and genomic search data for transcription factor binding sites were obtained.

Finally, with B. van Duijn (TNO-voeding, Leiden), and O. Shcherbakova (Department of Mathematics, Vrije Universiteit Amsterdam), research was performed on the statistical analysis of ion channel kinetics. During the past year the research concentrated on several mathematical issues concerning the asymptotic behaviour of Bayesian posteriors for hidden Markov models.

Chris Klaassen. The research project with N. Lalam in collaboration with the bioinformatics group of J. Kaandorp (UvA) has resulted in proofs of the $\sqrt{n}$-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 progress has been made in the semiparametric analysis of this statistical model involving an unconventional deconvolution problem.

N. Brunel has visited EURANDOM for half a year and his research also concerns estimation of the parameters of differential equations, but in a different setting than Lalam's. For his parametric estimation problem with implicitly defined parameters he has developed an estimator based on nonparametric techniques. It has been shown that this estimator can be improved to a $\sqrt{n}$-consistent estimator. Some support was given to L. Mohammadi in her research on the asymptotics of classification problems in machine learning.

Nadia Lalam. The research project of N. Lalam focussed on a problem of statistical inference in systems biology. The project was investigated in collaboration with C. Klaassen (UvA) for the mathematical aspects and with J. Kaandorp (UvA) for the biological aspects. Relying on gene expression data, the aim was to decipher a gene regulatory network defined by differential equations and defining the phenomenon of early Drosophila embryo development. Results on the asymptotic behavior of the estimators of the parameters characterizing the gene network were obtained. N. Lalam was also interested in molecular biology and she investigated quantitative methods to determine the initial amount of DNA molecules replicated by Polymerase Chain Reaction.

Marie-Colette van Lieshout. Since March 2006, EURANDOM hosts a research theme 'Statistical Signal and Image Analysis'. In 2006, most attention focussed on recruitment of postdoctoral researchers, three of whom are expected to arrive early in 2007. Furthermore, a workshop on 'Image analysis and inverse problems' was organised in collaboration with R. Duits (TU/e) in Eindhoven from 11-13 December. The goal was to introduce the research theme, and to foster collaboration with the image analysis and statistics groups at the Technical University Eindhoven as well as with the different schools in image analysis and inverse problems (variational methods, the Bayesian framework, and partial differential equations). To this end, thirteen invited lectures were presented by internationally renowed researchers from all three schools. The programme was augmented by short presentations by participants.

Leila Mohammadi has shown that the nonnegative garrote estimator is a suitable competitor to subset selection. Asymptotically, it is equivalent to other methods such as ridge, subset selection, least squared, hard and soft thresholding. In small samples, in some cases it has smaller mean-square-error and is less sensitive to small perturbations in the data. In some cases, it has smaller bias and overall mean-square-error. Unlike ridge, it is scale invariant and gives tight minimax bounds. We defined the nonnegative garrote estimator in a binary classification problem and obtained the rate of convergence of the nonnegative garrote estimator under some conditions, like Tsybakov's margin condition. In classification we consider a class of base functions and as a classifier, we consider all linear combinations of the base functions. We require four conditions. Under these assumptions, we obtain a bound on the prediction error of the nn-garrote.

Asymptotic normality of the time delay estimates. This is a joint work with J. C. Cuevas-Tello (University of Birmingham). A novel approach is presented by Cuevas-Tello et al. (2006) to estimate the time delay between light curves of multiple images in a gravitationally lensed system based on Kernel methods in the context of machine learning. They perform various experiments with artificially generated irregularly sampled data sets to study the effect of the various levels of noise and the presence of gaps of various size in the monitoring data. Using some empirical process theory techniques, we prove that the time delay estimates are consistent and are asymptotically normal. We obtain the exact form of the covariance matrix.

Bulletproof math. This is a joint work with some researchers in the workshop SWI-2006. In order to compare two fibres in Teijin Twaron Company, we need to know the velocity at which p percent of the bullets pass through the vest. We found some point estimators and confidence intervals for this velocity.

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. Together with A. Di Bucchianico he has been considering factorial designs within the framework of harmonic analysis. This framework gives a unified way of looking at full factorial designs (including mixed-level factorial designs). It also gives a method for analyzing the data obtained in factorial experiments. They used the framework of harmonic analysis for showing the equivalence of the different definitions of regular fraction that exist in literature. In addition, they established a link between factorial designs and orthogonal arrays by showing that any regular fraction of a mixed-level factorial design is an orthogonal array.

3.3.2. Research activities

Workshops and conferences

- January 16-18, 2006

Statistics for Biological Networks

- December 11-13, 2006

Image Analysis and Inverse Problems

See Chapter 6, section 6.1 for more detailed information.

Lectures and seminars

23.

See Chapter 6, section 6.2 for more detailed information

EURANDOM visitors

SIM hosted 4 visitors, altogether 4,3 weeks.

See Chapter 6, section 6.3 for more detailed information.

General Remarks

In July 2006 Nicolas Brunel started working for five months at EURANDOM on a position financed with a grant from the Network of Excellence PASCAL (Pattern Analysis, Statistical Modelling and Computational Learning) and of the University of Evry, France. Nicolas left in December 2006.

In August 2006 Talía Figarella left EURANDOM for a position at the ABN-AMRO bank in Amsterdam, The Netherlands. Fabio Rigat left in September 2006. He is now working as a research fellow within CriSM (Centre for Research in Statistical Methodology) at the University of Warwick, United Kingdom. In November 2006 Nadia Lalam and Leila Mohammadi left EURANDOM. Leila Mohammadi is now working as postdoctoral researcher at Leiden University Medical Centre (LUMC), The Netherlands. Nadia Lalam is postdoctoral researcher at Chalmers University, Gothenburg, Sweden.

3.3.3. External contacts / cooperation

EURANDOM did put a lot of effort in the EU FP6. Since December 1, 2003 the SIM programme participates in the Network of Excellence called PASCAL - Pattern Analysis, Statistical Modelling and Computational Learning -.

Apart from this EU Network the SIM group also participates in the MATHFSS (Mathematics for Science and Society) project. The MATHFSS project is a Support Action of the New and Emerging Science and Technology (NEST) programme of the European Commission (Sixth Framework Programme). The NEST programme aims at integrating and strengthening the European Research Area. The MATHFSS-project started in December 2005 and will last for 24 months. It aims to stimulate interaction between advanced research workers and to explore ways of training doctoral-level researchers in key areas where Mathematics will have a newly prominent role in science and society. The MATHFSS project is a collaborative action of the Centre de Recerca Matemàtica (CRM) in Spain, the Emmy Noether Research Institute for Mathematics (ENI) in Israel, the European Institute for Statistics, Probability and Stochastic Operations Research (EURANDOM) in The Netherlands, and the Institut des Hautes Études Scientifiques (IHÉS) in France, promoted by the European Research Centres on Mathematics (ERCOM) committee of the European Mathematical Society.

The members of the SIM group have contacts with industrial partners, among others via the *i*-BAT project with Philips. 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. Integrated Batteries (*i*-BAT)

The *i*-BAT project is a cooperation of Philips Research Laboratories, TU/e (Department of Chemical Engineering and Chemistry) and EURANDOM. Projectleader is Prof.dr. Peter Notten (TU/e and Philips Research Laboratories).

Small rechargeable batteries are nowadays of crucial importance for our "portable" society. Examples of portable applications are mobile phones, laptop computers, telephones, digital cameras and wireless shavers. In addition, the use of rechargeable batteries will broaden towards, on the one hand, very large applications and, on the other hand, very small applications. The present success of the so-called *hybrid cars* is evidencing such successful large-scale application. On the other outer end of the "spectrum", small-sized integrated batteries are expected to become more and more important in our daily life to "feed" the numerous wireless *Autonomous devices*, which will control our future offices and houses. This new electronic revolution is generally denoted as *Ambient Intelligence* and is considered as the next challenging development in the so-called *Knowledge age*, which we entered only a few decades ago.

Characteristic for *Autonomous devices* is that these have to operate independently. This means that the energy supply must be guaranteed wirelessly. Evidently, rechargeable batteries will play a key role in these future devices. As the energy consumption will be rather small, this opens up the possibility to integrate all-solid-state rechargeable batteries, enabling a high degree of IC integration.

The contribution of EURANDOM will be in modelling and simulation using the knowledge built up in the previous Battery Modelling and Management project (BMM).

3.4.1. Summary of the research by members of the *i*-BAT project

Dmitry Danilov. Together with the members of the Electrochemical group of Professor P.H.L. Notten research has been done on two main topics. The first topic is a simulation of All-Solid-State planar and 3D integrated Li-ion batteries. The second topic is simulation of gas-phase and electrochemical hydrogen storage in classical and advanced hydrid-forming alloys. Implications of the introduction of new alloys into industrial batteries have also been investigated (joint work with A. Ledovskikh). In 2006 a patent has been obtained: Voltage-prediction method for State-of-Charge indication algorithm. Patent PH006795EP1, ID 692529 by H.J. Bergveld, V. Pop, D. Danilov and P.H.L. Notten.

Iryna Snihir. The goal of the work of I. Snihir during 2006 was to propose a statistical method applicable for the indication of the battery State-of-Charge under conditions that are closer to the real user's behavior (the charging and discharging of the battery is operated according to the specially designed scheme of "varying-currents") and estimate the amount of charge presented in the battery under these operational conditions.

To be able to extract information on SoC from the shape of voltage curves adapted to the different current regimes, we used Single-Index model's (SIM) theory. Basic techniques, existing estimators and a new approach for the estimation of the index-

coefficients by solving L1-problem under the monotonicity constraints were investigated and analysed through the "varying-current" experiment. Working together with prof. L. Davies, we illustrated the performance of the proposed procedure for some simulated data sets, comparing the results with the existing methods, and applied it directly to our main problem of estimating State-of-Charge of the battery.

Our new approach offered a very simple and effcient way of estimating index-coefficients and appear to be computationally feasible. Results, obtained after applying this procedure to the problem of SoC estimation, confirm that information on SoC is present in voltage curves of the "varying-current" experiment and allow to conclude that the dynamic response of the system while the battery is under operation can be used for the reliable State-of-Charge indication.

See Chapter 5, section 5.1 and 5.2 for more information about their publications.

General Remarks
May 2006 Dmitry Danilov started working at EURANDOM for the *i*-BAT project. Iryna Snihir left EURANDOM in June 2006. She is now working at the Rabobank International, Utrecht, The Netherlands. On November 1, 2006 she defended successfully her Master's thesis 'Mathematical Strategies and Experimental Aspects for State-of-Charge Estimation of the NiMH Rechargeable Battery'.

3.4.2. External contacts / cooperation
Through the advisor there is a close cooperation with Philips Research Laboratories.

4. EXAMPLE OF RESEARCH: Senile reinforced random walks

M. Holmes and A. Sakai

Abstract

Modelling the motion of particles has been and remains a source of inspiration in mathematics. In probability, often random walks are used to describe the irregular motions of particles, like dust particles in a glass of water. In many applications, the decision of where to step to depends on the details of the path, i.e., the transition rules depend on the history of the path. Think of a person exploring a new city. This person is likely to prefer to traverse a street which he/she has already traversed, simply because it is familiar. Another example is a certain type of bacteria that produces a slime, of which it prefers to slide. In the past decades, such problems have attracted enormous attention, the basic question being how the details of the dependency on the history influence the characteristics of the motion, e.g., does the walker get stuck on a single edge, does every site get visited, or does the walker visit the starting point infinitely often?

In this paper, we study an extremely simple version of this problem, by considering random walks with transition probabilities depending on the number of consecutive traversals n of the edge most recently traversed. Such walks may get stuck on a single edge, or have every vertex recurrent or every vertex transient, depending on the reinforcement function $f(n)$ that characterises the model. We prove recurrence/transience results when the walk does not get stuck on a single edge. We also show that the diffusion constant need not be monotone in the reinforcement.

This is a brief description of the article that will appear in "Stochastic Processes and their Applications".

1. Introduction

Random walks with edge reinforcement were introduced by Coppersmith and Diaconis [1]. Many problems that are simple to state remain unsolved for edge-reinforced random walks on $\mathbb{Z}^d$, however there are also many interesting existing results in the general theory of reinforced random walks. There are strong results for example in 1 dimension [2], for linear reinforcement on finite graphs [7] and for once-reinforcement on trees [3]. In the case of linear reinforcement there is also an interesting connection with random walk in a random environment (see for example [11]). The most recent survey that we know of is [12].

A nearest-neighbour *senile reinforced random walk* on $\mathbb{Z}^d$, $\{S_n\}_{n\geq 0}$ begins at the origin and initially steps to one of the $2d$ nearest-neighbours with equal probability. Subse-

quent steps are defined in terms of a function $f : \mathrm{N} \to [-1, \infty)$ such that if the current undirected edge $\{S_{n-1}, S_n\}$ has been traversed m consecutive times in the immediate past, then the probability of traversing that edge in the next step is $\frac{1+f(m)}{2d+f(m)}$ with the rest of the possible $2d-1$ choices being equally likely. The reinforcement of the current edge continues until a new edge is traversed, at which point the reinforcement of the previous edge is forgotten (i.e. the weight of that edge returns to its initial value). The special case $f \equiv C$, which we might call *once-reinforced* senile random walk, or *memory-1 reinforced random walk*, is among the class of walks considered by Gillis [4] and others. A crucial ingredient in much of this literature is the fact that these models can be described in terms of finite state Markov chains. For example, for memory-1 models the sequence of increments of the walk is a Markov chain on the space of allowable steps. This is not true for senile random walks in general, although it is implicit in our analysis and explicit in [5] that the senile random walk observed at certain stopping times does have this property.

At the completion of our work we were made aware of two papers [6, 10] in which a different model with a similar flavour was studied. Their model has the property that the walk prefers (as defined by the reinforcement function) to continue in the same direction, rather than traverse the same edge, and as such we might call their model *senile persistent random walk*. Our methods are somewhat different to those used in [6,10], and it should be noted that both the recurrence/transience criteria and the appropriate scaling limits of these two models are not the same in general.

Let S be a finite subset of $\mathbf{Z}^d$ such that $o \notin \mathrm{S}$, $\{y \in \mathrm{Z}^d : |y| = 1\} \subseteq \mathrm{S}$ and $x \in \mathrm{S} \Rightarrow -x \in \mathrm{S}$. We say that there is an edge between $x \in \mathrm{Z}^d$ and $y \in \mathbf{Z}^d$ if $x - y \in \mathrm{S}$. Formally, a senile random walk ($SeRW_{f,\mathrm{S}}$) is a sequence $\{S_n\}_{n \geq 0}$ of $\mathbf{Z}^d$-valued random variables on a probability space $(\Omega, \mathrm{F}, \mathrm{P}_f)$ (with corresponding filtration $\{\mathrm{F}_n = \sigma(S_0, ..., S_n)\}_{n \geq 0}$) defined by:

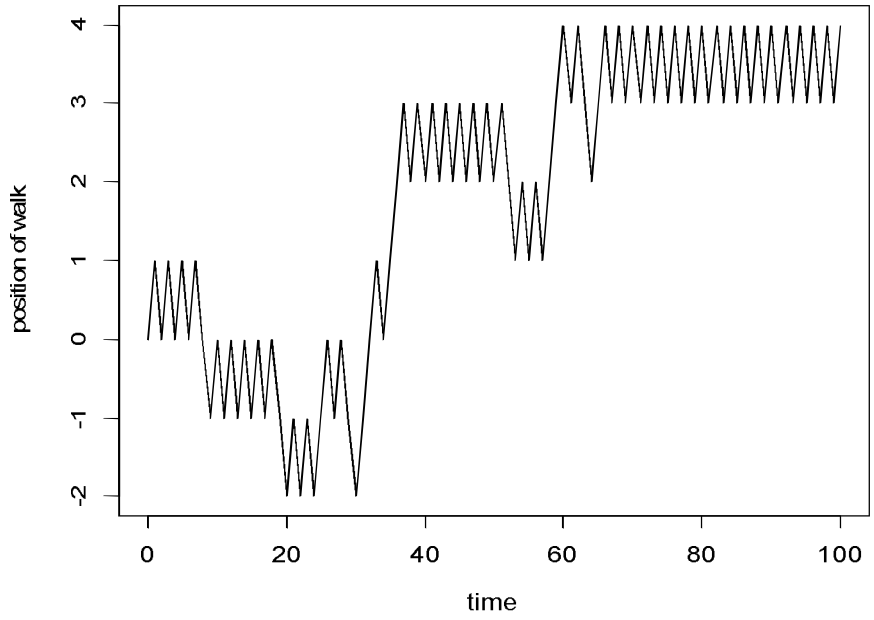
- The walk begins at the origin of $\mathbf{Z}^d$, i.e. $S_0 = o$, P_f-almost surely,
- $\mathrm{P}_f(S_1 = x) = D(x)$, where $D(x) = \frac{1}{|\mathrm{S}|} 1_{\{x \in \mathrm{S}\}}$.
- For $n \in \mathrm{N}$, $e_n = \{S_{n-1}, S_n\}$ is a random *undirected* edge (F_n-measurable) and

$$m_n = \max\{k \geq 1 : e_{n-l+1} = e_n \text{ for all } 1 \leq l \leq k\} \tag{1.1}$$

- is an N-valued (F_n-measurable) random variable.
- For $n \in \mathrm{N}$ and $x \in \mathrm{S}$,

$$\mathrm{P}_f(S_{n+1} = S_n + x \,|\, \mathrm{F}_n) = \begin{cases} \dfrac{1+f(m_n)}{|\,\mathrm{S}\,|+f(m_n)}, \text{if } \{S_n, S_n+x\} = e_n, \\ \dfrac{1}{|\,\mathrm{S}\,|+f(m_n)}, \text{if } \{S_n, S_n+x\} \neq e_n. \end{cases} \tag{1.2}$$

Examples of D satisfying the above definition include the nearest-neighbour model, where S is the set of unit vectors in $\mathbf{Z}^d$ and the spread-out model where S is the closed ball in $\mathbf{Z}^d$ of radius L for some $L \geq 1$. For notational convenience we often write P for P_f when there is no ambiguity.



A senile random walk with reinforcement function f(n)=n in one dimension.

If $f \equiv 0$ then the model is nothing but random walk on $\mathbf{Z}^d$ with transition kernel given by D. If in addition S is the set of unit vectors in $\mathbf{Z}^d$ we arrive at nearest-neighbour simple random walk.

Let N_x denote the number of times the walk S_n visits x. If $\mathrm{P}(N_x = \infty) = 1$ for all x we say that the walk is recurrent (I). If $\mathrm{P}(N_x = \infty) = 0$ for all x we say that the walk is transient (I). If $\mathrm{E}[N_x] = \infty$ for every x then we say that the walk is recurrent (II), and if $\mathrm{E}[N_x] < \infty$ for every x then we say that the walk is transient (II). For simple random walk (equivalently senile random walk with $f \equiv 0$) the two characterisations of recurrence/transience are equivalent and it is standard that simple random walk is recurrent for $d \leq 2$ and tran-

sient otherwise. For senile reinforced random walks the two notions of recurrence need not be the same.

Let $\tau = \sup\{n \geq 1 : S_m = o \text{ or } S_1 \forall m \leq n\}$ denote the (random) number of times that the walk traverses the first edge before leaving that edge for the first time. Note that τ is not a stopping time (however $\tau + 1 = \inf\{n \geq 2 : S_n \neq S_{n-2}\}$ is a stopping time). Intuitively if the overall effect of the function f is one of *positive reinforcement* but such that the probability it gets stuck on the first edge it traverses is 0, then the walk should in some sense be more recurrent than simple random walk. Similar intuition suggests that if the overall effect of the function f is one of *negative reinforcement*, the senile random walk should in some sense be more transient than simple random walk.

By definition of τ we have for all $n \geq 1$,

$$\mathrm{P}(\tau = n) = \prod_{l=1}^{n-1} \frac{1 + f(l)}{|\mathrm{S}| + f(l)} \frac{|\mathrm{S}| - 1}{|\mathrm{S}| + f(n)}, \quad \mathrm{P}(\tau \geq n) = \prod_{l=1}^{n-1} \frac{1 + f(l)}{|\mathrm{S}| + f(l)}, \tag{1.3}$$

where an empty product is defined to be 1. Moreover the probability that the senile random walk gets stuck on the first edge it traverses without ever traversing another edge is

$$\mathrm{P}(\tau = \infty) = \prod_{l=1}^{\infty} \frac{1 + f(l)}{|\mathrm{S}| + f(l)}. \tag{1.4}$$

When $f(l) = -1$ for some l, the walk cannot traverse the same edge more than l times in succession (so does not get stuck), and the definition of the function on integer values greater than l is irrelevant. If $f(1) = -1$ then the walk never traverses the same edge on two consecutive steps, a model that is sometimes called *memory-2 self-avoiding walk*. In particular for the nearest-neighbour model when $d = 1$, there are only two possible paths for the walk, and the path is determined by the first step.

Obviously if $f \geq g$ then $\mathrm{P}_f(\tau \geq n) \geq \mathrm{P}_g(\tau \geq n)$, and similarly the probability of being stuck on an edge is monotone in the reinforcement function f.

2. Results

As a first step towards recurrence/transience type results, the following proposition immediately implies that the senile random walk visits either $0, 2$, or all vertices infinitely often.

Proposition 2.1. *Let A_i be the event that the senile random walk traverses exactly i edges infinitely often and let A_{Z^d} be the event that every edge in the edge set of Z^d*

generated by S *is traversed infinitely often. Then* $\mathrm{P}_f(A_0)+\mathrm{P}_f(A_1)+\mathrm{P}_f(A_{Z^d})=1$ *and each is a 0-1 event. Furthermore,* $\mathrm{P}_f(A_1)=1$ *if and only if* $(1+f(l))^{-1}$ *is summable.*

The last statement of Proposition 2.1. is consistent with the results of [8, 9, 13] for the edge reinforced random walk. The following theorem is one of the two main results of the paper.

Theorem 2.2. *For* f *satisfying* $\mathrm{P}_f(\tau=\infty)=0$, *but excluding the degenerate case where* $|\mathrm{S}|=2$ *and* $f(1)=-1$, *we have the following*:

1. $SeRW_{f,\mathrm{S}}$ *is recurrent (I)/transient (I) if and only if* $SeRW_{0,\mathrm{S}}$ *is recurrent (I) / transient (I).*
2. *When* $\mathrm{E}_f[\tau]<\infty$, $SeRW_{f,\mathrm{S}}$ *is recurrent (II) / transient (II) if and only if* $SeRW_{0,\mathrm{S}}$ *is recurrent (II) / transient (II).*
3. *When* $\mathrm{E}_f[\tau]=\infty$, $SeRW_{f,\mathrm{S}}$ *is recurrent(II).*

Our proof of Theorem 2.2. is via a time change of the process and ultimately by comparison of the Green's functions $G_z(x)=\sum_{n=0}^{\infty} z^n \mathrm{P}(S_n=x)$ for $SeRW_{f,\mathrm{S}}$ and $SeRW_{0,\mathrm{S}}$.

Definition 2.3. *The diffusion constant* $v=v_f\geq 0$ *is defined as*

$$v=\lim_{n\to\infty}\frac{1}{n}\mathrm{E}[|S_n|^2]=\lim_{n\to\infty}\frac{1}{n}\sum_{x\in Z^d}|x|^2\,\mathrm{P}(S_n=x), \tag{2.1.}$$

whenever this limit exists.

Note that when $f\equiv 0$ (simple random walk), S_n is a sum of independent random variables with mean squared displacement $\sigma^2=\sum_x |x|^2 D(x)$, and thus $v_0=\sigma^2$ (=1 for the nearest-neighbour model).

The second main result of the paper is the following Theorem.

Theorem 2.4. *Suppose that there exists* $\varepsilon>0$ *such that* $E[\tau^{1+\varepsilon}]<\infty$. *Then the limit (2.1.) exists, and is given by*

$$v=\frac{\mathrm{P}(\tau \text{ odd})}{1-\frac{2}{|\mathrm{S}|}\mathrm{P}(\tau \text{ odd})}\frac{\sigma^2}{\mathrm{E}[\tau]}. \tag{2.2}$$

In the degenerate case where $|\mathrm{S}|=2$ and $f(1)=-1$ we have $|S_n|^2=\sigma^2 n^2$, P_f-almost surely, and (2.2) should be interpreted as $\infty=1/0$. Our proof of Theorem 2.4 is based on the formula for the Green's function, and a standard Tauberian theorem. An interesting consequence of Theorem 2.4 is that the diffusion constant is not monotone in the reinforcement function. In particular, for each even j there exist f,g both strictly positive and non-decreasing with $f(m)=g(m)$ for $m\neq j$ and $f(j)<g(j)$ but $v_g>v_f$.

Interestingly, when $f(l)=l$, special hypergeometric functions become relevant and various well known properties of these functions enable a proof of the following proposition.

Proposition 2.5. For the nearest-neighbour model with $f(l)=l$ and $d=1$,

$$\lim_{n\to\infty}\frac{\log n}{n}\mathrm{E}[|S_n|^2]=\frac{1-\log 2}{2\log 2-1}. \tag{2.3}$$

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5.2. EURANDOM report series per programme

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In 2006 the EURANDOM researchers published a total of 144 articles.

Distribution per programme:

QPA	76
RSS	50
SIM	18

	144

5.2. EURANDOM Report Series

The ISSN-number for the EURANDOM Report Series is: 1389-2355. Reports and abstracts can be downloaded from the EURANDOM website at: http://www.eurandom.tue.nl.

Queueing and Performance Analysis

2006-008
On queues with service and interarrival times depending on waiting times
M. Vlasiou, O. Boxma

2006-009
On the distribution of the number of customers in the symmetric M/G/1 queue
D. Denisov, A. Sapozhnikov

2006-011
Sojourn time asymptotics in processor-sharing queues
S. Borst, R. Núñez-Queija, B. Zwart

2006-012
Fluid limits for processor sharing queues with impatience
C. Gromoll, Ph. Robert, B. Zwart

2006-014
Delay analysis for the fixed-cycle traffic-light queue
J. van Leeuwaarden

2006-017
Asymptotics for first passage times of Lévy processes and random walks
D. Denisov, V. Shneer

2006-019
Performance analysis of a fluid queue with random service rate in discrete-time
O. Boxma, V. Sharma, D. Prasad

2006-022
The influence of dependence on data network models of burstiness
B. D'Auria, S. Resnick

2006-024
On a queueing model with service interruptions
O. Boxma, M. Mandjes, O. Kella

2006-025
Analysis of a tandem network model
P. Beekhuizen, D. Denteneer, I. Adan

2006-026
The foreground-background queue: a survey
A. Wierman, M. Nuyens

2006-027
Stationary remaining service time conditional on queue length
U. Yechiali, K. Sigman

2006-028
Queue with service speed adaptations
R. Bekker, O. Boxma, J. Resing

2006-036
On some martingales for Markov processes
A. Löpker

Random Spatial Structures

2006-003
Polymer pinning at an interface
N. Pétrélis

2006-004
Bounding a random environment for two-dimensional edge-reinforced random walk
F. Merkl, S. Rolles

2006-005
On the 2d Ising Wulff crystal near the critical point
R.J. Messikh, R. Cerf

2006-006
Weak convergence of measure-valued processes and r-point functions
M. Holmes, E. Perkins

2006-007
Random graph asymptotics on high-dimensional tori
M. Heydenreich, R. van der Hofstad

2006-010
How T-cells use large deviations to recognize foreign antigens
F. den Hollander, E. Baake, N. Zint

2006-015
Intermittency on catalysts: symmetric exclusion
F. den Hollander, J. Gärtner, G. Maillard

2006-016
Functionals of Brownian bridges arising in the current mismatch
M. Heydenreich, R. van der Hofstad, G. Radulov

2006-020
Invasion percolation on regular trees
F. den Hollander, O. Angel, J. Goodman, G. Slade

2006-021
Senile reinforced random walks
M. Holmes, A. Sakai

2006-029
Phase transitions for the longterm behaviour of interacting diffusions (revised)
F. den Hollander, A. Greven

2006-031
The renormalization transformation for two-type branching models
R. Sun, D. Dawson, A. Greven, F. den Hollander, J. Swart

2006-032
The Brownian net
R. Sun, J. Swart

2006-033
Weak coupling limit of a polymer pinned at interfaces
N. Pétrélis

2006-037
Identifying codes in (random) geometric networks
T. Müller, J.-B. Sereni

2006-038
Variational bounds for the generalized random energy model
C. Giardinà, S. Starr

2006-039
Ultrametricity in the Edwards-Anderson model
P. Contucci, C. Giardinà, C. Giberti, G. Parisi, C. Vernia

Statistical Information and Modelling

2006-001
Minimax and adaptive estimation of the Wigner function in quantum homodyne tomography with noisy data
L. Artiles, C. Butucea, M. Guta

2006-002
Penalized empirical risk minimalization
L. Mohammadi

2006-013
Estimation of the reaction efficiency in polymerase chain reaction
N. Lalam

2006-018
Pseudo maximum likelihood estimation for differential equations
N. Lalam, C. Klaassen

2006-023
Factorial designs and harmonic analysis on finite abelian groups
P. van de Ven, S. Di Bucchianico

2006-030
Minimax estimation of the Wigner function in quantum homodyne tomography with ideal detectors
L. Artiles Martinez, M. Guta

2006-034
Bullet-proof math
L. Mohammadi

2006-035
On nonnegative garrote estimator in a linear regression model
L. Mohammadi

In 2006 the EURANDOM researchers published a total of **39** EURANDOM Reports.

Distribution per programme:

QPA	14
RSS	17
SIM	08

	39

6. ACTIVITIES

6.1. Workshops and Conferences

January 16-18, 2006 ***Statistics for Biological Networks*** - SIM

Organisers
Professor R. Gill (Universiteit Utrecht), Dr. M. de Gunst (Vrije Universiteit Amsterdam), Professor C. Klaassen (University of Amsterdam), Dr. N. Lalam (EURANDOM) and Dr. F. Rigat (EURANDOM).

Participants
80.

Networks play an important role in genomics. For example, at the cellular level, the functioning of living organisms is defined by networks of genes, proteins, small molecules and their mutual interactions. The wide variety of data, e.g. microarrays, proteomic or neuronal data, presents challenging problems requiring specific statistical analyses. The members of the Statistics for Biology group organized a three days workshop centered around the fastly growing field of statistics for biological networks. EURANDOM hosted the workshop Statistics for Biological Networks which was held on January 16-18, 2006 at Eindhoven.

The addressed problems were at the interface of statistics and biological networks, with special emphasis on gene regulatory networks (January 16, 2006), neuronal data analysis (January 17, 2006), and graphical models and Bayesian networks (January 18, 2006).

The workshop was designed to bring together statisticians and biologists interested in the analysis of biological networks. This provided the opportunity for collaborations between statisticians and experimentalists at the national and international levels. The three days workshop featured 12 invited talks and 13 contributed talks given by researchers from diverse fields within the statistical and computational biology community. The speakers gave lectures focussing on developments of statistical methodologies for the study of biological networks: 45 minutes were allocated to each invited speaker, and 15 minutes to each contributed talk.

The invited speakers were internationally renowned experts in their fields. For the gene regulatory networks session, they were: Jaap Kaandorp (University of Amsterdam, The Netherlands), Korbinian Strimmer (University of Munich, Germany), Lorenz Wernisch (Birbeck College, United Kingdom) and Michael Stumpf (Imperial College London, United Kingdom). For the statistical analysis of neuronal data session: Arjen Brussard (Vrije Universiteit Amsterdam), Murat Okatan (Neurostat Lab, USA), Ya'acov Ritov (Hebrew University of Jerusalem, Israel), Uri Eden (Massachussets General Hospital, USA). For the graphical models and Bayesian networks session: Rainer Dahlhaus (University of Heidelberg, Germany), Adrian Dobra (Duke University, USA), Darren Wilkinson (University of Newcastle, United Kingdom) and Chris Holmes (University of Oxford, United Kingdom).

The workshop provided a scientific programme of high quality with many lectures in an educational vein, useful for researchers in the national and international genomics field. Participants coming from all over the world attended the workshop. Fruitful interactions between participants contributed to the success of the workshop.

The meeting was supported by EURANDOM, NWO, KNAW, SenterNovem, Thomas Stieltjes Institute for Mathematics and the EC Network of Excellence PASCAL (Pattern Analysis, Statistical Modelling and Computational Learning).

January 30-February 3, 2006 ***55th European Study Group Mathematics with Industry (SWI 2006)*** - RSS

Organisers
Dr. G. Prokert, Professor M. Peletier, Professor R. van der Hofstad, T. Mussche, Professor E. Fledderus, E. Jochemsz, Professor J. Molenaar.

Participants
83

The 55th European Study Group Mathematics with Industry is an industrial-academic week where mathematics is used to tackle industrial problems. The formula of setting aside a week for intensive study of a few real world problems originated in Oxford in 1968 and has since spread around the world.

This year the event was co-organised by the Faculty of Mathematics and Computer Science, TU/e and EURANDOM.

The following problems were discussed in teams and introduced by:

- Martijn van Noordenburg (ASML) - "Divide and Conquer"
- Aad Schaap (Teijin Twaron - DSM) - "Bullet-proof Math"
- Jos Verbeek (Nederlands Meetinstituut) - "Measure under Pressure"
- Jeroen Schuurman (Nucletron) - "Radiological Needlework"
- Alexander Stroeks (DSM) - "Catching Gas with Droplets"
- Bert Bos (Chess) - "Gossiping to Optimality"

This event was sponsored by STW (Technology Foundation - the Dutch funding agency for university research) and ECMI (European Consortium for Mathematics in Industry).

March 6-8, 2006 ***Risk Measures and Risk Management for High-Frequency Data*** - QPA

Organisers
Professor O.E. Barndorff-Nielsen (University of Aarhus, Denmark), Professor W. Polasek (IHC Vienna, Austria), Professor J.L. Teugels (Katholieke Universiteit Leuven, Belgium) and Professor H. Wynn (London School of Economics, United Kingdom).

Participants
30 participants.

The workshop gathered experts and young researchers in the field of high-frequency (HF) stochastics and statistics. The majority of the participants were from European universities or research institutes, while four were from the USA or Japan.

New results regarding finite aggregates and multivariate extreme value distributions were presented by M. Dacorogna from Converium Ltd. Based on these results, the conclusions were that regular varying rather than elliptic distributions are suited for capturing dependence structure in the tails; that HF data increase quality of the estimates of extreme events and can be used to analyze dependence between various risks; that from high frequency estimates, it is possible to scale up the risk on longer time horizon; and that optimal portfolio against extreme risk should be analyzed with HF data using expected shortfall as risk measure.

A talk on the conditional Gaussian assumption, which is often used in finding estimators for high frequency financial data, was given by P. Mykland from University of Chicago. He advocated the usefulness of the assumption and gave some more structure to what one can do with it. In particular, approximations involving locally constant volatility processes were considered, and a general theory for this approximation developed. As applications of the theory, an improved estimator of quarticity, an ANOVA for processes with multiple regressors, and an estimator for error bars on the Hayashi-Yoshida estimator of quadratic covariation were proposed.

The significance of the instantaneous causality effects when dealing with high frequency estimates was argued in the talk by E. Renault. Based on a joint paper with D.J.M. Werker, the talk considered a structural approach to identify instantaneous causality effects between quote-to-quote durations and stock price volatility. In particular, a structural continuous time model for the analysis of the instantaneous causality relations between price volatility and durations, in addition to possible Granger causality, were discussed. The speaker emphasized that these instantaneous causality effects are significant and that failure to take them into account may lead to severely biased volatility estimates and, consequently, possibly inadequate risk management.

A new estimation procedure for estimating the (integrated) covariance/correlation for two non-synchronously observed diffusion-type processes was proposed in the talk of T. Hayashi (Columbia University). Based on a "overlapping scheme" procedure that does not depend on any "synchronization" of the original data, and which yields consistency of the resulting estimators as the mesh size shrinks, asymptotic normality of the covariance estimator, joint with the realized volatilities, and the asymptotic normality of the correlation estimators were discussed. The extension to a general setup where the processes are continuous semimartingales and the observation times are stopping times were given. The talk was based on the joint work with N. Yoshida (University of Tokyo).

Different approaches for modelling high-frequency data and applications of the models were presented. In particular, linear ISAR(p) – ISAR(q) models, obtained by extending the lag patterns of AR(p) and ARCH(q) models to continuous linear lag response functions, were presented by W.Polasek. The lag response functions were estimated by the irregularly spaced time series. S. Mittnik, in the joint talk with F. Corsi and Ch. Pigorsch, proposed a strategy for modelling and predicting (daily) volatility by using standard time series, e.g. ARFIMA, models and constructing realized volatility series from intraday transaction data. It was shown that the residuals of the commonly used time-series models for realized volatility exhibit non-Gaussianity and volatility clustering; the distributional assumption for residuals plays a crucial role in density forecasting.

A comparison of in-sample estimations and out-of-sample forecasts of quadratic variation given by the two scales realized volatility (TSRV) estimator and the realized

volatility (RV) estimator, under several different dynamics of the volatility process, was presented by L. Mancini. Overall, the different volatility models account for well-known empirical stylized facts of volatility processes, like volatility clustering and long memory features. In Monte Carlo experiments the TSRV estimator largely outperforms the RV estimator, and an empirical application to the IBM stock confirms the simulation results.

The advantage of having a continuous model was advocated at the meeting. Such a model can provide better applications for high-frequency or irregularly observed data. A continuous time GARCH (p,q) model driven by a single Levy process was presented in the joint talk by A. Linder, P. Brockwell, and E. Chadraa. The model extends many of the features of discrete time EGARCH (p,q) processes to a continuous time setting. Among others, an exponential continuous time GARCH (p,q) process, defined as a continuous time extension of the discrete time EGARCH (p,q) process, was proposed. It was shown that it is able to model the leverage effect and a long memory effect.

The dynamics, return distributions, and dependence structure of intraday diversified world stock indices, using the growth optimal portfolio (GOP) as a benchmark, were discussed by W. Breymann. Empirical findings identify a simple and realistic model for a world stock index (WSI) that reflects its historical evolution reasonably well by using only a few constant parameters. The return distributions are fitted with multidimensional symmetric generalized hyperbolic distributions and the dependence structure of deseasonalised returns at different time horizons is analyzed through different copulas. Applications are, for example, short term options pricing, hedging, and portfolio management.

J.H.C. Woerner proposed to include the fine structure into the analysis of the tail-behaviour of the log-returns, which makes it possible to distinguish between semimartingales and fractional Brownian motion on the one hand and determine on the other hand the fine structure of either process in terms of the Blumenthal-Getoor index or the Hurst exponent. From the point of view of modelling or risk analysis this gives insight into which process is suitable, depending on the time scale. A class of easily computable estimators for the Blumenthal-Getoor index and the Hurst exponent, respectively, based on high-frequency data, and consistency and distributional results for these estimators were presented.

N. Yoshida from University of Tokyo gave a talk on a certain polynomial-type large deviation inequality for a statistical random field. From this result, it is possible to obtain weak convergence of the statistical random field, and asymptotic properties of statistics related to it. The application to quasi-likelihood analysis for sampled stochastic differential equations showed that Yu. Kutoyants' scheme to apply Ibragimov-Hasminskii's theory to stochastic processes such as semimartingales was finally correct.

Examples of high-frequency statistics in other fields than finance were also given. T. Mikosch presented a Poisson cluster model for high frequency arrivals used in teletraffic. I. Grosse spoke about the problem of the integrative analysis and modelling in computational biology when the data used is multivariate.

L. Gulyas gave an overview of the various issues and challenges of Agent-Based modelling (ABM) – a new branch of computer simulation suited for modelling complex social systems. ABM focuses on micro rules, i.e., it has a bottom-up-approach where each individual is modelled with its idiosyncrasies, imperfections, and unique interactions, and seeks to understand the emergence of macro behaviour. Finally the simi-

larities between processes observed in turbulence and finance were considered by two speakers.

This event was sponsored by the European Commission as part of the MATHFSS (Mathematics for Science and Society) contract, number 15661.

March 13-14, 2006 ***Queues, Fluid Queues and Extremes*** - QPA

Organisers
Professor O.J. Boxma (TU/e) and Dr. J.A.C. Resing (TU/e).

Participants
31.

The workshop was devoted to the study of queues, with special attention to fluid queues and to extremes. During the workshop 15 lectures were presented. Among the speakers were several leading experts in the field.

The study of performance measures for queues and fluid queues often leads to questions about extremes of a stochastic process. This can be illustrated by considering Lindley's equation, which appears for instance when studying waiting times and amount of work in the system. Essentially, Lindley's equation is a reflected stochastic process which is pushed back to zero whenever the corresponding free stochastic process becomes negative. One way to study the solution of the equation is by analyzing the running maximum of the free process. The above example is an illustration of the often close relation between queues, fluid queues and extremes.

The program of the workshop consisted of 30-minutes and 45-minutes lectures. Speakers: V. Kulkarni (University of North-Carolina, USA), I. Norros (VTT, Finland), Z. Palmowski (University of Wroclaw, Poland), D. Perry (University of Haifa, Israel), T. Rolski (University of Wroclaw, Poland), V. Sharma (Indian Institute of Sciences, India), W. Stadje (Universität Osnabrück, Germany), S. Zacks (University of Binghampton, USA), I. Adan (TU/e), S. Borst (CWI, The Netherlands), B. D'Auria (EURANDOM), T. Dieker (CWI, The Netherlands), R. Egorova (CWI, The Netherlands), J. van Leeuwaarden (EURANDOM) and M. Mandjes (University of Amsterdam, The Netherlands).

This workshop has been sponsored by NWO and by EURANDOM. The Beta Research School for Operations Management and Logistics sponsored two speakers of this workshop.

March 20-24, 2006 ***Large Deviations, Random Media, and Random Matrices*** - RSS

Organisers
Professors M. Löwe (Universität Münster, Germany) and P. Eichelsbacher (Ruhr-Universität Bochum, Germany).

Participants
41.

The YEP (Young European Probabilists) Workshop 2006 is the third in a series of three YEP workshops. The two other YEP workshops were held in 2004 and 2005 on the

topics of "Conformal invariance, scaling limits and percolation" and "Self-similar random structures, Hausdorff dimension and branching".

The YEP Workshop 2006 was held on three topics which have been extremely popular in the recent past: large deviations, disordered systems/random media, and random matrices. Ever since Donsker and Varadhan in the 1970s gave a general foundation to the (even older) theory of large deviations, there has been a constantly strong interest in this field and the probability of an extraordinarily large deviation from their expected behavior has been studied for many families of random variables. In this workshop the focus will be on applications of large deviation theory to two areas that have been coining modern probability theory in the recent past. One is the field of disordered systems, the other one is the theory of random matrices.

Since the description of magnetic substances by spin models (e.g. the famous Ising model) had proven to be very successful, physicists were tempted to also try these models for a description of amorphous substances, such as glass, or to explain the unconventional magnetic behavior of certain materials. Their models pointed toward a new branch of probability theory concerning the collective behavior of large families of random variables with random correlations, for which one hopes to find new order structures. In particular, the so called spin glass phase of the most famous of these models, the Sherrington-Kirkpatrick model, seems to be very exciting and complicated.

Random matrices is an active field of mathematics and physics. Initiated in the 1920s-1930s by statisticians and introduced to physics in the 1950s-1960s by Wigner and Dyson, the field has been very active since the end of 1970s under impulses from quantum mechanics, probability theory, combinatorics, operator theory, and number theory. The theory deals with integrals over matrix measures defined on various sets of matrices of an arbitrary dimension. The integrals can often be interpreted in spectral terms related to eigenvalues and eigenvectors of random matrices, whose probability law is a matrix measure entering the integral.

The workshop incorporated two mini-courses of four hours by invited senior researchers in the field, talks of 45 minutes by the participants, focusing on a particular model and the relevant techniques. The workshop was also open for short contributions about large deviations, statistical mechanics and random matrices, given by young European researchers.

Problem sessions chaired by selected participants in which new projects for cooperation were presented (excellent experience has been made with such problem sessions in the previous years). Main speakers: Franz Merkl (Universität München, Germany), Wolfgang König (Universität Leipzig, Germany), Cristian Giardinà (EURANDOM) and Jamal Najim (LTCI/ENST Paris, France). Time was also given for individual meetings of participants following the problem sessions to exchange ideas and prepare collaborative problem solving efforts.

This workshop has been sponsored by the Volkswagen Stiftung, the ESF (European Science Foundation) scientific programme RDSES (Phase Transitions and Fluctuation Phenomena for Random Dynamics in Spatially Extended Systems) and by EURANDOM.

March 29-31, 2006 ***Self-Interacting Random Walks*** - RSS

Organisers
Professor F. Merkl (University of Munich, Germany) and Dr. S. Rolles (Technical University of Munich, Germany).

Participants
34.

During the past decade, there has been an increasing interest in studying random walks with self-interactions. The workshop at EURANDOM was one of the first in Europe which brought together leading experts in this field from all over the world. In particular, many researchers working on reinforced random walks presented their work. This was complemented by talks on related subjects such as percolation, statistical mechanical systems, and longest common subsequences.

Each of the following researchers delivered a 50-minutes talk at the meeting:

- Rob van den Berg (CWI and Vrije Universiteit Amsterdam): *Self-destructive percolation in the plane*
- Marek Biskup (University of California at Los Angeles, USA): *A quenched invariance principle for random walk on percolation clusters*
- David Brydges (University of British Columbia, USA): *A combinatorial generalisation of Cramers Rule*
- Andrea Collevecchio (University D'Annunzio, Italy): *On the transience of processes defined on trees and other graphs*
- Burgess Davis (Purdue University, USA): *Vertex reinforced jump processes*
- Olle Häggström (Chalmers University of Technology, Sweden): *Optimization, evolution, and the two kinds of applied mathematics*
- Remco van der Hofstad (TU/e and EURANDOM): *An expansion for self-interacting random walks*
- Mark Holmes (EURANDOM): *Senile reinforced random walks*
- Vlada Limic (Marseille, France): *Attracting edge: does it happen and if so when?*
- Henry Matzinger (Georgia Institute of Technology, USA): *Some recent developments in the LCS-problem and Optimal Alignment*
- Brian Skyrms (University of California, USA): *Learning to Signal*
- Jeff Steif (Chalmers University of Technology, Sweden): *Statistical mechanical systems on complete graphs, infinite exchangeability and finite extensions*
- Masaki Takeshima (Osaka University, Japan): *Recurrence of once edge-reinforced random walks with exponential weights on trees*
- Pierre Tarres (University of Oxford, United Kingdom): *Reinforced Random Walks*
- Martin Zerner (University of Tübingen, Germany): *Excited random walks.*

This workshop has been sponsored by the Sonderforschungsbereich (SFB) 701, Spektrale Strukturen und Topologische Methoden in der Mathematik (Collaborative Research Centre 701, Spectral Structures and Topological Methods in Mathematics) and by EURANDOM.

June 19-20, 2006 ***Performance Analysis of Manufacturing Systems. Bridging the gap between industry and academia?*** - QPA

Organisers
Dr. I.J.B.F. Adan, Professor O.J. Boxma, Dr. L.F.P. Etman, Dr. A.A.J. Lefeber and Professor J.E. Rooda (TU/e).

Participants
55

This workshop was organized by EURANDOM in the framework of its research programme Queueing and Performance Analysis and the STW project `The Effective Process Time.'

In discrete manufacturing systems, throughput and flow time are key performance measures. Throughput refers to the number of finished parts per unit of time and flow time refers to the time a part needs to go through the complete sequence of process operations. For a successful improvement of throughput and flow time performance, insight in Factory Physics, i.e. the main factors that are responsible for capacity losses, is essential. Even small reductions of capacity loss may yield significant benefits, and therefore, industry puts great efforts in identifying and reducing the sources of capacity loss.

Nowadays, the overall equipment effectiveness (OEE) is widely used to quantify capacity losses in manufacturing equipment. The OEE directly relates to utilization, i.e., the fraction of time a workstation is busy. However, the performance of manufacturing systems is not only determined by utilization, but also by the variability in production processes. By only focussing on utilization one may overlook opportunities for performance improvement by reduction of variability.

A way to quantify both utilization and variability is by means of the Effective Process Time (EPT). This is the clean process time including other sources of additional waiting, such as setups, operator unavailability and machine failures. From an operational point of view it is very important to be able to measure EPTs without the need to identify all sources that cause capacity losses. Additionally, an aggregate modeling framework is required to beneficially use the measured EPT data for understanding the Factory Physics and to identify sources of capacity loss.

The aim of this workshop was to bring together industry and academia to discuss the performance analysis of discrete manufacturing systems, for which discrete-event simulation models and analytical queueing models provide a common tool. Theoretical developments in this area as well as applications to manufacturing received attention. Emphasis was on aggregate models for manufacturing systems, as well as on incorporating manufacturing data into these models.

The flavour of the first day was application oriented; the emphasis of the second day was on theoretical developments. Both speakers from industry and academics were invited.

The workshop consisted of 1 keynote lecture, 8 invited lectures and 6 contributed lectures. The keynote speaker was S. Gershwin (MIT, USA), and the other invited speakers were: D. Armbruster (Arizona State University and TU/e), F. Nijsse (VDL Steelweld BV), S. Resing (CQM BV), O. Rose (Dresden University of Technology, Germany), B.

Scholz-Reiter (University of Bremen, Germany), E. Van Campen (Philips Semiconductors), J. van der Eerden (ASML), and G. Weiss (University of Haifa, Israel).

This workshop has been sponsored by NWO, STW (Technology Foundation - the Dutch funding agency for university research), EC Network of Excellence Euro-NGI and by EURANDOM.

November 11, 2006 ***Euro-NGI workshop "Transfer Control with Delayed Feedback"*** - QPA

Organisers
Professor O.J. Boxma (TU/e) and Dr. R. Núñez Queija (CWI-TU/e).

Participants
15

This workshop was a satellite meeting of the Euro-NGI workshop Stochastic Performance Models for Resource Allocation in Communication Networks, held 8-10 November at CWI. This workshop was organised within a special project of Euro-NGI on "Transfer Control with Delayed Feedback" involving speakers from INRIA (K. Avrachenkov), Tel-Aviv University (U. Yechiali), the University of Gent (S. De Vuyst), CWI (R. Núñez Queija) and TU/e (J. van Leeuwaarden, J. Resing). Several local and external researchers attended the workshop.

December 11-13, 2006 ***Image Analysis and Inverse Problems*** - SIM

Organisers
Professor P.L. Davies (University of Essen, Germany & TU/e), Dr. R. Duits (TU/e) and Dr. M.N.M. van Lieshout (CWI, Amsterdam).

Participants
54.

Since March 2006, EURANDOM hosts a research theme 'Statistical Signal and Image Analysis'. The goal of the workshop was to introduce the research theme, and to foster collaboration with the image analysis and statistics groups at the Technical University Eindhoven as well as with different schools in image analysis and inverse problems (variational methods, the Bayesian framework, and partial differential equations). To this end, thirteen invited lectures were presented by internationally renowned researchers from all three schools. The programme was augmented by a half hour talk by Dr. Wittich (TU/e) and by five short presentations by participants.

The conference attracted participants from all over Europe, including representatives from the target audiences at EURANDOM, TU/e, and Philips, a large proportion of which were young researchers.

The workshop was a great success with productive interactions between the various groups. The talks were varied, a common theme being models and algorithms for finding patterns in complex, often high-dimensional data ranging from time series, video sequences, astronomical data, medical images, to urban planning, forestry, surface representations. The talks were often followed by lively discussions, continued

during the breaks. Many participants expressed their wish that a similar conference could be organised at a future date. The organisers are considering to do so in 2008.

This workshop has been sponsored by NWO, KNAW, the Thomas Stieltjes Institute for Mathematics, the EC Network of Excellence PASCAL (Pattern Analysis, Statistical Modelling and Computational Learning) and by EURANDOM.

Summary of the workshops

QPA	4
RSS	2
SIM	2
Gen.	1

Total	9

In total **9** workshops were (co)-organised. Total number of participants: **423**. Furthermore, EURANDOM co-sponsored in 2006 the 5th European Congress of Mathematics (14-18 July, 2008).

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 (32)
- Random Spatial Structures (RSS) seminar (24)
- Statistical Information and Modelling (SIM) seminar (23)
- EURANDOM Postdoc and PhD (EPPS) seminar (10)

In addition, in 2006 there were 2 seminars given by the Beta Chair.

Abstracts and presentations can be downloaded from the EURANDOM website.

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

Ph. Robert
INRIA & Ecole Polytechnique, France
Stochastic networks with multiple stable points
January 16, 2006

M. Haviv
Hebrew University of Jerusalem
The price of anarchy: the case of an exponential multi-server
February 21, 2006

A. Sleptchenko
Erasmus University Rotterdam, The Netherlands
Maintenance system with dynamic priorities
March 21, 2006

M. Pihlsgard
Lund University, Sweden
Loss rates for Lévy processes with two reflecting barriers
April 11, 2006

Y.Q. Zhao
Carleton University, USA
Geometric decay in a generalized join shortest queue model – Matrix-analytic method for a non-positive recurrent case
April 11, 2006

S. Shneer
Heriot-Watt University, Edinburgh, United Kingdom
Asymptotics for first passage times of Levy processes and random walks
May 9, 2006

J. Blanchet
Harvard University, USA
Counting, rare-events and efficient importance sampling
May 30, 2006

N. Likhanov
Institute for Information Transmission Problems, Moscow, Russia
Asymptotic overflow probability for queueing system with balancing load
June 13, 2006

Y. Kerner
Hebrew University of Jerusalem, Israel
On the joint distribution of the queue length and the residual service time in the Mn/G/1 queue
June 27, 2006

A. Löpker
University of Osnabrück, Germany
Some martingale methods for piecewise deterministic Markov processes
June 29, 2006

L. Ormeçi
Koç University, Istanbul, Turkey
Effects of system parameters on the optimal policy structure in a class of queueing control problems
August 30, 2006

S. Bar-Lev
Israel Institute of Technology, Haifa, Israel
Group testing models with incomplete identication and their applications in medical and industrial problems
September 19, 2006

A. Wierman
EURANDOM and Carnegie Mellon University, Pittsburgh, USA
Fairness in queues
September 28, 2006

D.P. Kroese
University of Queensland, Australia
Solving difficult optimisation and counting problems via the cross-entropy method
October 2, 2006

N. Popescu
University of Bucharest, Rumania
Probability models in finance
October 9, 2006

B. Fralix
Georgia Institute of Technology, USA
Using Palm measures to analyze transient properties of queueing systems
October 11, 2006

T.D. Frank
University of Münster, Germany
Random walks subjected to mean field forces and memory effects
October 23, 2006

A. Löpker
EURANDOM
Martingales, generators and piecewise deterministic Markov processes
November 7, 2006

P. Pennesi
JEF Montegranaro, Italy
Supply chain management from data to decisions - Modelling, control and optimization methods for the supply chain
November 16, 2006

A. Richards
Heriot-Watt University, Edinburgh, United Kingdom
Two topics concerning sub-exponential distributions
November 22, 2006

J. van Leeuwaarden
TU/e, The Netherlands
The M/D/s queue, the Halfin-Whitt regime and the Gaussian random walk
November 28, 2006

V. Shneer
EURANDOM
Stability of some random multiple-access protocols with spatial interactions
December 12, 2006

The QPA group also organised a Reading Seminar about the book *Applied Probability and Queues* of S. Asmussen. 8 meetings took place on: January 10, January 24, February 7, February 21, March 7, April 4, May 2 and June 13, 2006.

On November 1, 2006 the Multivariate Risk Modelling project started within the QPA programme. Within the framework of this new activity a series of seminars on Levy processes in finance and queueing has been organised. The serie started with a three-

hour Mini-course by W. Schoutens on November 21, 2006. Title: *Levy processes in finance*. On December 7, 2006 O. Boxma gave a one-hour lecture on *Levy processes and queues*.

Random Spatial Structures (RSS) seminars

T. Schmitz
ETH Zentrum, Switzerland
Ballistic diffusions in random environment
January 16, 2006

S. Blachère
Centre de Mathématiques et Informatique, France
Internal diffusion limited aggregation on discrete groups having exponential growth
February 8, 2006

F. Camia
Vrije Universiteit, Amsterdam, The Netherlands
The scaling limit of near-critical two-dimensional percolation
March 14, 2006

A. Dorogovtsev
Institute of Mathematics Ukrainian AS
Stochastic flows with interaction and related calculus
April 4, 2006

M. Heydenreich
TU/e, The Netherlands
Random graph asymptotics on high-dimensional tori
(joint work with R. van der Hofstad)
April 11, 2006

P. Collet
Ecole Polytechnique, Paris, France
Exponential and Devroye inequalities, applications to dynamical systems
April 19, 2006

P. Collet
Ecole Polytechnique, Paris, France
Asymptotic of entrance times in small sets for dynamical systems and related problems
April 20, 2006

C. Boutillier
CWI, Amsterdam, The Netherlands
The bead model and limiting behaviours of dimer models
May 9, 2006

W. Kager
EURANDOM, The Netherlands
On Vdovichenko's solution of the two-dimensional Ising model
May 16, 2006

J. Dubbeldam
Max-Planck-Institute for Polymer Research, Mainz, Germany
Multilayer Markov chains and their application to polymer physics
June 14, 2006

F. Caravenna
University of Zurich, Switzerland
Pinning models with Laplacian interactions in (1+1)-dimernsion
(joint work with J.-D. Deuschel)
July 13, 2006

M. Deijfen
EURANDOM & TU Delft, The Netherlands
Spatial random graphs with prescribed degree distribution
July 14, 2006

T. Müller
University of Oxford
Two-point concentration in random geometric graphs
August 28, 2006

C. Spitoni
Università degli Studi 'La Sapienza', Roma, Italy
Metastability for reversible probabilistic cellular automata with cross interaction
September 12, 2006

A. Fey
EURANDOM & Vrije Universiteit Amsterdam, The Netherlands
Limiting shapes for deterministic internal growth models
September 26, 2006

P. Trapman
Universiteit Utrecht & Vrije Universiteit Amsterdam, The Netherlands
Generalised random graphs as a model for infection spread in a heterogeneous population
October 3, 2006

P. Contucci
Università di Bologna, Italy
A statistical mechanics approach to social sciences
October 19, 2006

M. van Wieren
EURANDOM, The Netherlands
Discussing a discrete stochastic model for artificial cells
October 31, 2006

R. van Mourik
TU/e, The Netherlands
Fractal phenomena in fracture
November 7, 2006

A. Gaudillière
Roma Tor Vergata, Italy
Random walks approximation for diluted gas under Kawasaki dynamics
November 21, 2006

G. Maillard
EPFL Lausanne, Switzerland
Phase-transitions in hierarchical chains
(joint work with R. Fernandez)
November 23, 2006

F. Nardi
TU/e, The Netherlands
Metastability for Ising model with the Glauber dynamics
November 28, 2006

F. Nardi
TU/e, The Netherlands
Metastability for anisotropic Ising model with the Glauber dynamics
December 5, 2006

F. Nardi
TU/e, The Netherlands
Metastability and nucleation for conservative dynamics
December 19, 2006

Statistical Information and Modelling (SIM) seminar

E. Khamaladze
Victoria University of Wellington, New Zealand
Differentiation of sets and applications to probability and statistics
February 1, 2006

E. Khamaladze
Victoria University of Wellington, New Zealand
Distribution free method of testing exponentiality, with application to curious historic data
February 3, 2006

Y. Nardi
Hebrew University of Jerusalem, Israel
Maxima of empirical (asymptotically Gaussian) random fields
February 22, 2006

E. Kong
National University of Singapore
Variable selection for the single-index model
October 2, 2006

G. Pan
National Sun Yat Sen University, Taiwan
Asymptotics of eigenvectors of large sample covariance matrices
October 25, 2006

A. Dukkipati
Indian Institute of Science, Bangalore, India
Some results on generalized measures of information and corresponding maximum and minimum entropy prescriptions
October 25, 2006

M. Viana
University of Illinois at Chicago, USA
Data analytic aspects of the canonical decomposition theorem for finite groups
December 13, 2006

F. D'Alché-Buc
CNRS, Genopole & Université d'Evry
Kernelizing output tree-based methods: application to biological network completion
(joint work with Pierre Geurts, IBISC and Université de Liège)
November 20, 2006

This year one PASCAL-meeting took place on May 8, 2006. Furthermore the SIM group organised several informal meetings (14) with statisticians. For the first three meetings in the Spring of 2006 guests have been invited to give a talk:

C. Höhenrieder
University of Duisberg-Essen, Germany
Analysis of financial data including the volatility of the volatility
May 10, 2006

K.I. Kim
TU/e, The Netherlands
Effects of dependencies in high-dimensional multiple testing problems
May 24, 2006

E. Zoldin
University of Duisberg-Essen, Germany
Approximating interest rate data
May 31, 2006

The meetings of Autumn 2006 took place on: September 6, September 13, September 27, October 4, October 11, October 18, November 8, November 22, December 6, December 13 and December 20, 2006.

EURANDOM Postdoc and PhD seminar (EPPS)

A. Fey
Zhang's sandpile model
January 12, 2006

M. Holmes
Senile random walks
(joint work with A. Sakai)
February 9, 2006

A. Sakai
Memory-2 random-walk models
March 9, 2006

L. Mohammadi
The nonnegative garrote estimator in classification and regression
June 8, 2006

B. D'Auria
Infinite servers queues in random environments
June 1, 2006

F. Rigat
Evaluating the effect of low-frequency stimulation on the connectivity of cultured neuronal networks
June 21, 2006

M. van Wieren
Artificial cells, self-replicating vesicular lipid-bi-layers
October 18, 2006

N. Lalam
Pseudo maximum likelihood estimation for gene regulatory networks
October 26, 2006

N. Brunel
Estimation of ODEs for the identification of cell regulatory networks
November 8, 2006

S. Blachère
The Green distance
November 30, 2006

Beta Chair 2006
From March until June 2006 Professor U. Yechiali from Tel Aviv University (Israel) has been appointed Beta Chair by the Beta Research School for Operations Management and Logistics. During this period he worked at EURANDOM on 'Queues with varying speed of the server' and on 'Polling models'. He also gave two talks on May 2 and May 3, 2006. Title: *A random walk through my O.R. life*.

6.3. EURANDOM visitors in 2006

January 2006				
15-17	Ph. Robert	INRIA	France	QPA
29-06 Febr.	W. Khmaladze	Victoria University	New Zealand	SIM
February 2006				
06-15	J. Kahn	ENS	France	SIM
21-24	S. Kuhnt	Dortmund University	Germany	SIM
19-24	M. Haviv	Hebrew University	Israel	QPA
March 2006				
19-19 June	U. Yechiali	Tel Aviv University	Israel	Beta Chair
07-15	Z. Palmowski	Wroclaw University	Poland	QPA
10-17	S. Zachs	University of Binghamton	USA	QPA
11-18	V. Kulkarni	University of North-Carolina	USA	QPA
12-08 June	V. Sharma	Indian Institute of Science	India	QPA
15-25	M. Luczak	London School of Economics	United Kingdom	RSS
18-11 April	A. Sapozhnikov	University College of Cork	Ireland	QPA
19-31	S. Rolles	Technische Universität Munich	Germany	RSS
19-31	F. Merkl	University of Munich	Germany	RSS
27-30	S. Kuhnt	Dortmund University	Germany	SIM
April 2006				
09-14	Y.Q. Zhao	Carleton University	Canada	QPA
17-28	P. Collet	Polytechnique Paris	France	RSS
29-14 May	V. Shneer	Heriot-Watt University	United Kingdom	QPA
May 2006				
30-03 June	J. Blanchet	Harvard University	USA	QPA
30-01 June	K. Sigman	Columbia University New York	USA	QPA
June				
06-14	N. Likhanov	Russian Academy of Sciences	Russia	QPA
18-30	Y. Kerner	Hebrew University of Jerusalem	Israel	QPA
19-23	G. Weiss	University of Haifa	Israel	QPA
26-31 October	S. Bar-Lev	University of Haifa	Israel	QPA
July				
10-15	F. Caravenna	University of Zurich	Switzerland	RSS
August				
21-01 September	A. Klenke	Universität Mainz	Germany	RSS
30	L. Ormeçi	Koç University Istanbul	Turkey	QPA
30-31	F. D'Alché-Buc	Université d'Evry	France	SIM
September				
01-01 October	O. Kella	Hebrew University of Jerusalem	Israel	QPA
18-26	A. Sakai	University of Bath	United Kingdom	RSS
20-01 October	A. Bovier	WIAS Berlin	Germany	RSS
23-28	R.D. Foley	Georgia Institute of Technology	USA	QPA
25-29	B. Zwart	Georgia Institute of Technology	USA	QPA
October				
02-06	D. Kroese	University of Queensland	Australia	QPA
16-19	A. Greven	Friedrich-Alexander University	Germany	RSS
18-21	P. Contucci	Università di Bologna	Italy	RSS
November				
16-22	E. Olivieri	Università degli Studi Roma II	Italy	RSS
16-22	E. Scoppola	Università degli Studi Roma Tre	Italy	RSS
16-22	A. Gaudilliere	Università degli Studi Roma Tre	Italy	RSS
20	F. D'Alché-Buc	Université d'Evry	France	SIM
21-29	G. Maillard	EPFL	Switzerland	RSS

21-25	A. Richards	Heriot-Watt University	United Kingdom	QPA
22-27	J. Gärtner	Technische Universität Berlin	Germany	RSS
December				
06-14	M. Viana	University of Illinois at Chicago	USA	SIM

In total **41** researchers visited EURANDOM in 2006 (from several days up to 2 months). Total residence time: 73 weeks.

Distribution over the programmes:

Programme	Number of visits	Weeks
QPA	21	38
RSS	15	18
SIM	06	04
Beta Chair	01	13
TOTAL	**43**	**73**

Visit of Professor Uri Yechiali - March 18 until June 16, 2006
Professor Yechiali has given the following lectures in Eindhoven and Twente: Double Colloquium: A Random Walk through My O.R. Life. In addition, he has given a lecture in the University of Tilburg. Furthermore Uri Yechiali has done joint research with Onno Boxma and Jan van der Wal (TU/e) on queueing models in which a single server cyclically visits several queues, serving customers in a batch in each visited queue [1]. Together with Onno Boxma, Uri Yechiali has written a survey on Poisson processes [2]. Together with EURANDOM PhD student Maria Vlasiou, he has done joint research on polling models in which the number of servers is not one (as is usually assumed) but infinite [3]. Following a visit and a lecture in Eurandom by Professor Karl Sigman from Columbia University, Yechiali and Sigman developed new insight into an important performance measure for the classical M/G/1 queueing system. A new method of proof, using the so-called RCL approach, has been employed and extensions have been derived. A paper [4] has been submitted for publication. Finally Professor Yechiali has had numerous scientific discussions with Beta and EURANDOM researchers and visitors.

Publications:
[1] Onno Boxma, Jan van der Wal and Uri Yechiali (2006). Polling with batch service.
[2] Onno Boxma and Uri Yechiali. Poisson processes, ordinary and compound. To appear in: The Encyclopedia of Statistics in Quality and Reliability (Wiley, 2007).
[3] Maria Vlasiou and Uri Yechiali. M/G/∞ polling systems with random visit times. EURANDOM report (2007).
[4] Uri Yechiali and Karl Sigman. Stationary remaining service time conditional on queue length. EURANDOM report 2006-027.

7. (INTER)NATIONAL COOPERATION and FUNDING

7.1. (Inter)national Cooperation

As the previous sections already show, international cooperation is flourishing through, a.o. the workshops and the visitor programme. Many international organisations are supporting the activities of EURANDOM by sending their junior and senior researchers to attend a workshop or to spend some 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 organise workshops. Through members of the Scientific Council and members of the Steering Committees, as well as scientists who are 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.

Professor W.Th.F. den Hollander chairs the ESF Scientific Programme on 'Random Dynamics in Spatially Extended Systems' involving 13 European countries. This programme continues until the summer of 2007. Also in the proceedings of the Les Houches Summer School on "Mathematical Statistical Physics", presenting a road map on the field, among others Professor W.Th.F. den Hollander played an important role.

EURANDOM participates in the Network of Excellence PASCAL (Pattern Analysis, Statistical Modelling and Computational Learning), "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 the EURO-NGI project 'Design and Engineering of the Next Generation Internet', the main target of which 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". Also in EURO-FGI, the following Network of Excellence, EURANDOM is participating via the scientific director and advisors of the QPA programme.

EURANDOM is one of the four partners in the NEST (New and Emerging Science and Technology) activity MATHFSS (Shaping New Directions in Mathematics for Science and Society, 2005-2007). This 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. The first workshop at EURANDOM took place in March 2006 (Risk Measures & Risk Management for High-Frequency Data, see paragraph 6.1); the second one will be in April 2007.

There is a close cooperation with German researchers through the Dutch-German Bilateral Research Group on 'Mathematics of Random Spatial Models from Physics and Biology, which, after positive mid-term review, was granted a second period of three years. Although the German Schwerpunkt 'Interagierende stochastische Systeme hoher Komplexität' has been ended, cooperation with German scientists continues, especially in the RSS programme.

7.2 Cooperation in The Netherlands

EURANDOM has formal agreements of cooperation with three national research schools in Mathematics in The Netherlands: MRI (Mathematical Research Institute), EIDMA (the Euler Institute for Discrete Mathematics), and the Thomas Stieltjes Institute for Mathematics.

There are intensive links with the Department of Mathematics, the Department of Technology Management and the Department of Mechanical Engineering in Eindhoven through joint appointments, joint seminars, joint visitors, researchers working together etc. Some postdocs are involved in teaching activities at the TU/e.

In 2006 EURANDOM continued tightening the network with Alumni. Some alumni are still linked to EURANDOM via a Research Fellowship. This applies especially to some former postdocs, who found tenured positions at Dutch universities.

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. However, grants are 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. Furthermore, EURANDOM is in the process of being recognised by CNRS as an "Unité Mixte Internationale".

During the year 22 junior researchers were (co-)financed by external funds. These funds came from NWO - Netherlands Organisation for Scientific Research - (11), including the BRICKS (Basic Research in Informatics for Creating the Knowledge Society) programme (1), (directly and/or via appointments at TU/e or other universities), 1 from STW (Technology Foundation - the Dutch funding agency for university research), 1 from FWO (Research Foundation Flanders, Belgium), 3 from the European Commission (1 directly: a Marie Curie Individual Fellowship and 2, partly, via 2 different EC (European Commission) Networks of Excellence), 2 from Philips Electronics Nederland BV (1 PhD position for cooperation in the area of Cable Access Networks and 1 PD in a contract with Philips and a programme of the Ministry of Economic Affairs), 1 in a contract with Vodafone and 2 in joint appointments with the Departments of Mathematics and Computer Science and of Technology Management, both at TU/e. Some of the projects are continuations of earlier collaboration, such as the project on Batteries as well as the project on Cable Networks with Philips.

The European Commission Networks of Excellence Euro-NGI (Design and Engineering of the Next Generation Internet) and PASCAL (Pattern Analysis, Statistical Modelling

and Computational Learning) both financed a workshop in 2006 and paid for visits of young researchers to colleagues abroad and/or for their workshop participation in 2006. The MATHFSS (Mathematics for Science and Society) project, support action of the New and Emerging Science and Technology (NEST) programme of the EC, also sponsored a workshop.

Furthermore, workshops in 2006 were (co-)financed by Beta Research School, ECMI (European Consortium for Mathematics in Industry), the ESF (European Science Foundation) scientific programme RDSES (Phase Transitions and Fluctuation Phenomena for Random Dynamics in Spatially Extended Systems), KNAW (Royal Netherlands Academy of Arts and Sciences), NWO, SenterNovem, the Sonderforschungsbereich (SFB) 701, STW, the Thomas Stieltjes Institute for Mathematics, and the Volkswagen Stiftung. One long term visit, by U. Yechiali, was funded by an NWO-Visitor Grant.

8. FACILITIES

8.1. Computing

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. Until the end of 2006, EURANDOM had 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. In view of the fact that almost all journals can be found and read electronically, a discussion is started in order to broaden the book library slightly and reduce the journal part of the library.

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 people can participate in various kinds of sports.

9. EXPENDITURE

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

Expenditure (in K euro)

Staff	1024
Advisors	92
Travel	27
Visitors	45
Housing	122
Workshops, Seminars	68
Books, Journals, Software	13
Depreciation costs	11
General costs	46
ICT Support	29
TOTAL	1477

Furthermore post-docs with a grant (325 K Euro), visitors (20 K Euro) and workshop participants (80 K Euro) 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 425 K Euro. The total expenditure amounts 1477 K Euro.

During the Annual Excursion (June 2006) EURANDOM people made this painting, under the guidance of artist Cilian Vinke. Each part tells a story, reveals the history or expresses the feeling of the maker